Annual Report 2021

Kumamoto University

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International Research Organization for Advanced Science and Technology
Kumamoto University

The search for truth begins with the doubt of all 'truths' in which one has previously believed.

Friedrich Nietzsche

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Preface

Kumamoto University is one of Japan's leading research universities that promote world-leading research. The International Research Organization for Advanced Science and Technology (IROAST) was established in April 2016 to strengthen the university's international research capabilities in science and engineering fields. In March 2022, IROAST celebrated six years after its establishment, marking the end of the program's first phase.

In the first phase, four priority research areas (Advanced Nanomaterials Science, Green Energy, Environmental Science, and Advanced Green Biotechnology), which are the strengths of the university's science and engineering fields, were selected to promote joint research with world-class universities and research institutions related to these research fields as well as foster talented young researchers who will lead the future of the university. We invited leading researchers from overseas universities and research institutions as distinguished professors and visiting professors to promote international joint research. In addition, we conducted a program to send young researchers to overseas universities and research institutes for long periods to establish an international network.

This report summarizes the activities of IROAST in FY2021. The activities of IROAST are mainly international collaborative research; however, for the past two years, due to the COVID-19 pandemic, we have not been able to travel to and from abroad. As a result, in FY2021, we found ourselves in a temporary situation of stagnation as a research achievement, especially with regard to the publication of papers, many of which were based on research conducted in FY2020. However, by promoting international exchange online, international activities showed signs of recovery in FY2021, but have not yet recovered to the pre-pandemic level.

In spite of these difficult circumstances, I would like to express my deepest gratitude to the professors at overseas universities and research institutes and all members of IRAOST who have promoted international joint research. I would also appreciate it if you could read this report and give us your comments on the contents of IROAST's research. I hope the situation will recover to the pre-pandemic level as IROAST enters its second phase in FY2022.

Kazuki Takashima

Dr. TAKASHIMA Kazuki, Professor Emeritus
Distinguished Professor
Director of International Research Organization for Advanced Science and Technology (IROAST)
Kumamoto University, JAPAN
E-mail: takashik@gpo.kumamoto-u.ac.jp URL: http//iroast.kumamoto-u.ac.jp

IROAST Members

As of 31 March, 2022

Director / Vice-Director

Kazuki Takashima

Kei Toda

Distinguished Professors

Konstantinos Kontis

Dmitri Aleks Molodov

László Pusztai

Yufeng Zheng

Tenure-track Professor / Associate Professors

Mitsuhiro Aida

Gaochuang Cai

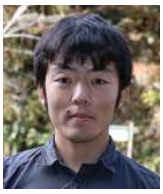
Hiroki Matsuo

Alumni

Takumi Higaki

Takashi Ishida

Ruda Lee



Atsushi Sainoki

Project Assistant Professor/ Postdoctoral Researchers

Akiko Nakamasu

Mizuki Yamada

Young Faculty Members for International Joint Research

Kei Ishida
CWMD

Mizue Munekata
FAST

Takahiro Hosono
FAST

Yuta Nakashima
FAST

*FAST: Faculty of Advanced Science and Technology, Kumamoto University

*IINa: Institute of Industrial Nanomaterials, Kumamoto University

*CWMD: Center for Water Cycle, Marine Environment and Disaster Management, Kumamoto University

Visiting Professors

U Rajendra Acharya
Ngee Ann Polytechnic
Singapore

José E. Andrade
California Institute of Technology
USA

Josep-Lluís Barona-Vilar
University of Valencia
Spain

Pouyan Boukany
Delft University of Technology
Netherlands

Olivier Boutin
CNRS/Aix Marseille University
France

Paul Bowen
The University of Birmingham
UK

Pierre Breul
CNRS/University of Clermont Auvergne
France

Maria Jose Cocero
The University of Valladolid
Spain

Marc De Boissieu
CNRS/ Université Grenoble Alpes
France

Patrice Delmas
The University of Auckland
New Zealand

Martin Dienwiebel
Karlsruhe Institute for Technology
Germany

Martino Di Serio
University of Naples Federico II
Italy

Derek Elsworth
The Pennsylvania State University
USA

Carolina Escobar
University of Castilla La Mancha
Spain

Amir A. Farajian
Wright State University
USA

Etsuko Fujita
Brookhaven National Laboratory
USA

Tomonari Furukawa
University of Virginia
USA

Hamid Ghandehari
University of Utah
USA

Olivier Hamant
INRA/
ENS de Lyon
France

Christian Siegfried Hardtke
University of Lausanne
Switzerland

Jens Hartmann
Universität Hamburg
Germany

Yuichiro Himeda
National Institute of Advanced Industrial Science and Technology
Japan

Dragos Horvath
CNRS/
University of Strasbourg,
France

Ryushiro Kasahara
Fujian Agriculture and Forestry University
China

Yang Kim
Kosin University
Republic of Korea

Alexei Kuzmin
University of Latvia
Latvia

Ick Chan Kwon
Korea Institute of Science and Technology (KIST)
Republic of Korea

Youn-Woo Lee
Seoul National University
Republic of Korea

Pavel Lejček
Institute of Physics of the Czech Academy of Sciences
Czech Republic

Bo Liu
University of California at Davis
USA

Viren Ivor Menezes
Indian Institute of Technology Bombay
India

Matthieu Micoulaut
CNRS/Sorbonne University
France

Rahul Raveendran Nair
The University of Manchester
UK

Reiko Oda
CNRS/University of Bordeaux
France

Shie-Ming Peng
National Taiwan University
Taiwan

Ramesh S. Pillai
University of Geneva
Switzerland

Zoran Ren
University of Maribor
Slovenia

Christian Rentenberger
University of Vienna
Austria

Stelios Rigopoulos
Imperial College London
UK

Shirley Shen
Commonwealth Scientific and Industrial Research Organisation (CSIRO)
Australia

Atsushi Urakawa
Delft University of Technology,
Netherlands

Gioacchino Viggiani
CNRS/Université Grenoble Alpes
France

Thomas Waitz
University of Vienna
Austria

Andrew J. Whittle
Massachusetts Institute of Technology (MIT)
USA

Zhenghe Xu
Southern University of Science and Technology
China

Firuz Zare
The University of Queensland
Australia

Visiting Associate Professors

Tomoyasu Mani
University of Connecticut
USA

Hiroko Satoh
University of Zurich
Zwitzerland

Daniel P. Zitterbart
Woods Hole Oceanographic Institution
USA

Distinguished Professors (4)

Name	Period of Appointment	Position/Affiliation
Konstantinos Kontis	November 1, 2018-	Professor School of Engineering University of Glasgow, UK
László Pusztai	April 1, 2017-	Scientific Advisor Wigner Research Centre for Physics Hungary
Dmitri Aleks Molodov	December 1, 2021-	Professor Institute of Physical Metallurgy and Metal Physics, RWTH Aachen University, Germany
Yufeng Zheng	May 1, 2017-	Professor Department of Materials and Engineering College of Engineering Peking University, China

Tenure-Track Professor/Associate Professors (3)

Name	Period of Appointment	Former Position/Affiliation
Mitsuhiro Aida Professor	July 1, 2017-	Postdoctoral Researcher Department of Applied Biological Science Tokyo University of Science PhD: Kyoto University (1999)
Gaochuang Cai Associate Professor	October 1, 2021-	Assistant professor, Faculty of Engineering Department of Architecture, Fukuoka University PhD: The University of Tokyo (2016)
Hiroki Matsuo Associate Professor	June 1, 2021-	Researcher, School of Environment and Society, Tokyo Institute of Technology PhD: Kobe University (2014)

Alumni (4)

Name	Period of Appointment	Former Position/Affiliation & Current Position/Affiliation
Takumi Higaki Associate Professor	August1,2017- September 30, 2021	Research Associate Professor Graduate School of Frontier Sciences The University of Tokyo Faculty of Advanced Science and Technology (FAST), Kumamoto University PhD: The University of Tokyo (2009)
Takashi Ishida Associate Professor	June 1, 2016 - May 31, 2021	Postdoctoral Researcher Faculty of Advanced Science and Technology (FAST), Kumamoto University Faculty of Advanced Science and Technology (FAST), Kumamoto University PhD: Nara Institute of Science and Technology (2007)
Ruda Lee Associate Professor	January 1, 2017- December 31, 2021	Postdoctoral Researcher Department of Drug Discovery and Development Instituto Italiano Di Technologia, Italy Institute of Industrial Nanomaterials (IIna), Kumamoto University PhD: Korea University, Korea (2013)
Atsushi Sainoki Associate Professor	January 1, 2017- March 31, 2021	Postdoctoral Researcher Mine Design Laboratory, McGill University, Canada Faculty of Advanced Science and Technology (FAST), Kumamoto University PhD: McGill University, Canada (2014)

Project Assistant Professor (1)

Name	Period of Appointment	Former Position/Affiliation
Akiko Nakamasu Higaki Laboratory	November 1, 2019- March 31, 2022 (Postdoctoral Researcher December 1, 2017- October 30, 2019)	Research Assistant Professor Faculty of Medical Science, Kyushu University PhD: Ochanomizu University (2010)

Postdoctoral Researchers (1)

Name	Period of Appointment	Former Position/Affiliation
Mizuki Yamada Aida Laboratory	October 1, 2019-	Researcher Institute of Vegetable and Floriculture Science National Agriculture and Food Research Organization
		PhD: Niigata University (2014)

Young Faculty Members for International Joint Research (4)

Name	Period of Appointment	Partner Universities/Institutions
Takahiro Hosono Associate Professor FAST	June 1, 2019- March 31, 2022	Department of Earth and Planetary Science University of California, Berkeley USA
Kei Ishida Associate Professor CWMD	June 1, 2019- March 31, 2022	McGill University Canada
		University of California, Davis USA
Mizue Munekata Associate Professor FAST	April 1, 2019- March 31, 2022	German Aerospace Center Germany
		Institute of Aerodynamics and Flow Technology Germany
Yuta Nakashima Associate Professor FAST	December 1, 2019- March 31, 2022	The Children's Hospital of Philadelphia USA
		University of Pennsylvania USA

Visiting Professors (46)

Name	Position/Affiliation	Host Professor
U Rajendra Acharya	Senior faculty member Ngee Ann Polytechnic, Singapore	**Makiko Kobayashi** FAST
José E. Andrade	Professor California Institute of Technology, USA	**Jun Otani** FAST
Josep-Lluís Barona-Vilar	Professor University of Valencia, Spain	**Makoto Takafuji** FAST
Pouyan Boukany	Associate Professor Delft University of Technology, Netherlands	**Hamid Hosano** IINa
Olivier Boutin	Professor/Deputy Director of M2P2 CNRS/Aix Marseille University, France	**Mitsuru Sasaki** IINa
Paul Bowen	Deputy Pro-Vice-Chancellor/ Feeney Professor of Metallurgy The University of Birmingham, UK	**Yoji Mine** FAST
Pierre Breul	Professor University of Clermont Auvergne, France	**Jun Otani** FAST
Maria Jose Cocero	Professor The University of Valladolid, Spain	**Tetsuya Kida** FAST
Marc De Boissieu	Group Leader of SIMap CNRS/ Université Grenoble Alpes, France	**Ichiro Akai** IINa
Patrice Jean Delmas	Associate Professor The University of Auckland, New Zealand	**Toshifumi Mukunoki** FAST
Martin Dienwiebel	Professor Karlsruhe Institute for Technology, Germany	**Yoji Mine** FAST
Martino Di Serio	Professor University of Naples Federico II, Italy	**Shinya Hayami** FAST
Derek Elsworth	Professor The Pennsylvania State University, USA	**Atsushi Sainoki** IROAST
Carolina Escobar	Professor University of Castilla La Mancha, Spain	**Shinichiro Sawa** FAST

Amir A. Farajian	Professor Wright State University, USA	**Hamid Hosano** IINa
Etsuko Fujita	Senior Chemist Brookhaven National Laboratory, USA	**Yutaka Kuwahara** FAST
Tomonari Furukawa	Professor University of Virginia, USA	**Makoto Kumon** FAST
Hamid Ghandehari	Professor University of Utah, USA	**Hamid Hosano** IINa
Olivier Hamant	INRA Research Director RDP, ENS de Lyon, France	**Shinichiro Sawa** FAST
Christian Siegfried Hardtke	Professor University of Lausanne, Switzerland	**Shinichiro Sawa** FAST
Jens Hartmann	Professor Universität Hamburg, Germany	**Takahiro Hosono** FAST
Yuichiro Himeda	Prime Senior Researcher National Insutitute of Advanced Industrial Science and Technoligy, Japan	**Manabu Sugimoto** FAST
Dragos Horvath	CNRS Research Director (DR2) University of Strasbourg, France	**Manabu Sugimoto** FAST
Ryushiro Kasahara	Professor Fujian Agriculture and Forestry University, China	**Shinichiro Sawa** FAST
Yang Kim	Professor Emeritus Kosin University, Republic of Korea	**Shinya Hayami** FAST
Alexei Kuzmin	Leading Researcher University of Latvia, Latvia	**Laszlo Pusztai** IROAST
Ick Chan Kwon	Principal Research Scientist Korea Institute of Science and Technology (KIST) Republic of Korea	**Takuro Niidome** FAST
Youn-Woo Lee	Professor Seoul National University, Republic of Korea	**Mitsuru Sasaki** IINa

Pavel Lejček	Professor Institute of Physics of the Czech Academy of Sciences, Czech Republic	**Sadahiro Tsurekawa** FAST
Bo Liu	Professor University of California, Davis, USA	**Takumi Higaki** FAST
Viren Ivor Menezes	Professor Indian Institute of Technology Bombay, India	**Hamid Hosano** IINa
Matthieu Micoulaut	Professor CNRS/Sorbonne University, France	**Ichiro Akai** IINa
Rahul Raveendran Nair	Professor The University of Manchester, UK	**Shinya Hayami** FAST
Reiko Oda	Research Director CNRS/University of Bordeaux, France	**Makoto Takafuji** FAST
Shie-Ming Peng	Distinguished Chair Professor for Research National Taiwan University, Taiwan	**Shinya Hayami** FAST
Ramesh S. Pillai	Professor University of Geneva, Switzerland	**Tokio Tani** FAST
Zoran Ren	Professor University of Maribor, Slovenia	**Kazuyuki Hokamoto** IINa
Christian Rentenberger	Associate Professor University of Vienna, Austria	**Mitsuhiro Matsuda** FAST
Stelios Rigopoulos	Reader of Division “Thermofluids” (Associate Professor) Imperial College London, UK	**Hamid Hosano** IINa
Shirley Shen	Principal Research Scientist Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia	**Youji Mine** FAST
Atsushi Urakawa	Professor Delft University of Technology, Netherlands	**Manabu Sugimoto** FAST
Gioacchino Viggiani	Professor CNRS/Université Grenoble Alpes, France	**Jun Otani** FAST
Thomas Waitz	Associate Professor University of Vienna, Austria	**Mitsuhiro Matsuda** FAST

Andrew J. Whittle	Professor Massachusetts Institute of Technology (MIT), USA	**Jun Otani** FAST
Zhenghe Xu	Dean, College of Engineering, Southern University of Science and Technology China	**Makoto Takafuji** FAST
Firuz Zare	Honorary Professor The University of Queensland, Australia	**Hamid Hosano** IINa

Visiting Associate Professors (3)

Name	Position/Affiliation	Host Professor
Tomoyasu Mani	Assistant Professor University of Connecticut, USA	**Yutaka Kuwahara** FAST
Hiroko Satoh	Researcher University of Zurich (UZH), Zwitzerland	**Manabu Sugimoto** FAST
Daniel P. Zitterbart	Associate Scientist Woods Hole Oceanographic Institution, USA	**Kei Toda** FAST

*The names of each list are arranged alphabetically by last name.

Research Units (26)

Units of World-leading Researchers (14)

Unit Name	Unit Coordinator
Development of Nano and Supramolecular Materials	**Shinya Hayami** FAST
RNA Biology	**Tokio Tani** FAST
Plant Cell and Developmental Biology	**Shinichiro Sawa** FAST
Nano-Organics and Nano-Hybrids	**Makoto Takafuji** FAST
Nano-medicine and Drug Delivery System	**Hamid Hosano** IINa
Nano-medicine and Theranostics	**Takuro Niidome** FAST
Multiscale Modeling of Soil and Rock Materials Using X-ray CT	**Jun Otani** FAST
Medical Application of X-ray CT	**Toshifumi Mukunoki** FAST
-Quantification of Three Dimensional Vascular Network	
-MicroCT-based Quantification of Fibrosis and Vascularization in Pancreatic Tumor	
Advanced Structural Materials	**Yoji Mine** FAST
Microstructure Analysis and Grain Boundary Engineering	**Sadahiro Tsurekawa** FAST
Structure and Dynamics of Materials Using Quantum Beams and Data-Driven Sciences	**Ichiro Akai** IINa
Hydrological Environments	**Takahiro Hosono** FAST (**Kimpei Ichiyanagi** FAST)
Nano-materials for Energy Applications and Environmental Protection	**Tetsuya Kida** FAST (**Armando T. Quitain** Center for International Education)

Units of Young Researchers (12)

Unit Name	Unit Coordinator
Quantitative Bioimaging	**Takumi Higaki** IROAST
Development of novel therapeutic strategy using iron targeted upconversion nanoparticles for Parkinson's disease	**Ruda Lee** IROAST
Deep Learning for Hydrology	**Kei Ishida** CWMD
Environmental Impacts of Ionic Solutes	**Shin-Ichi Ohira** FAST
Radio Astronomy	**Keitaro Takahashi** FAST
Plant Stem Cells and Regeneration	**Mitsuhiro Aida** IROAST
Development of microbially-aided carbon sequestration technology	**Atsushi Sainoki** IROAST
Advanced Biomedical Evaluation System	**Makiko Kobayashi** FAST
Bio-inspired Functional Molecular System	**Yutaka Kuwahara** FAST
Nanomaterials processing for medical, cosmetic, and environmental applications	**Mitsuru Sasaki** IINa
Ferroelectric Photovoltaics	**Hiroki Matsuo** IROAST (**Yuji Noguchi** FAST)
Next-Generation Design of Structures	**Gaochuang Cai** IROAST

*FAST: Faculty of Advanced Science and Technology, Kumamoto University
*IINa: Institute of Industrial Nanomaterials, Kumamoto University
*CWMD: Center for Water Cycle, Marine Environment and Disaster Management, Kumamoto University

Operation and Management of IROAST

1. IROAST Steering Committee Activities

We held our IROAST Steering Committee meetings 11 times in the academic year of 2021 to discuss and determine various regulations and agenda items required for operating and managing IROAST successfully. In particular, the committee has discussed and approved implementation of the following research support programs and provided support to many researchers.

2. IROAST Research Support Programs

We have several research support programs running in parallel to promote research programs under international collaboration, aiming to build international joint research networks and offer/gain benefit from circulating knowledge through minds around the world.

IROAST Young Faculty Members for International Joint Research

We select outstanding young faculty members from the Faculty of Advanced Science and Technology, the Institute of Industrial Nanomaterials, the Magnesium Research Center, and the Center for Water Cycle, Marine Environment and Disaster Management and invite them to IROAST for three or four years, and give them opportunities to conduct international joint research at overseas universities and institutions for at least one year in total. The COVID-19 pandemic has prevented them from traveling overseas since 2020, but we are promoting international joint research online, and each has achieved satisfactory results through that avenue.

IROAST International Joint Research Travel Support

We select distinguished faculty members from the Faculty of Advanced Science and Technology, the Institute of Industrial Nanomaterials, the Magnesium Research Center, and the Center for Water Cycle, Marine Environment and Disaster Management and send them to universities and institutions overseas to conclude MOUs for promoting their international joint research and/or to perform their joint research there. Unfortunately, the COVID-19 pandemic has interrupted this support project since 2020.

IROAST Visiting Professor and Visiting Professor Candidate Invitations

We invite Visiting Professors and Visiting Professor candidates to IROAST to promote joint research with their host researchers. The purpose is to build international joint research networks and to open international seminars that attract young researchers, including graduate students, to cutting-edge research activities. This program has also been suspended since 2020.

IROAST Research Awards (for IROAST faculty members only)

To encourage and reward innovative research activities, we select and award outstanding and promising IROAST faculty members by evaluating their research activities from the previous academic year.

IROAST Proofreading/Publication Support

We offer financial support for proofreading/publication to IROAST-affiliated researchers to increase the number of papers emanating from the fields of science and technology at Kumamoto University.

IROAST Research Internship Program

We provide hands-on research opportunities for highly motivated undergraduate and graduate students and young postdoctoral researchers keen to pursue advanced scientific research. In 2021, we offered online internships.

Young Faculty Member Support Program for New IROAST Major Research Areas

We have launched a new support program for young researchers who are taking on pioneering and high-potential research toward new major research areas at IROAST. The focus will be on young researchers in the fields of science and technology who are the potential to make great strides on the international stage.

IROAST Start-up Program to Create an Inter-Departmental Joint Research Hub

We have embarked on a new program aiming to support bold and sustainable research that targets new areas through creating research networks by linking departments in different fields. The program promotes cross-disciplinary and interdisciplinary fusion research to harness the University's strengths in science and technology. Five faculty members were selected to launch and coordinate joint research groups.

IROAST Symposia

We invite keynote speakers from overseas and domestic universities to hold international symposiums two to three times a year. In 2021, three symposia took place either online or in a hybrid of online and in-person events.

IROAST Seminars

International researchers invited through the IROAST Visiting Professor and Visiting Professor Candidate Invitation program mentioned above give talks at IROAST Seminars organized by their host professors. In 2021, we had a visiting professor come to Japan and hold a seminar at the University, and also hosted online joint seminars with visiting professors' laboratories. In addition, as a multidisciplinary international joint research support program with the International Research Center for Medical Sciences (IRCMS), we held a seminar at which presentations were made by joint research groups supported by the program.

IROAST Workshop for Research Capability Building

Aiming to improve the research skills of the University's researchers and students, we organized a three-session workshop with a cumulative total of more than 100 participants. Each session covered three topics: how to write an effective abstract, which is essential for writing

papers; how to send out information via social media and e-mail; and how to use appropriate English expressions that are often used incorrectly by Japanese.

3. Enhancing IROAST's public relations activities

To promote IROAST's activities widely, we renewed our website, introduced social media (Twitter, Instagram, Facebook, YouTube), and published pamphlets both in Japanese and English to provide information about what we do.

A symposium, organized by IROAST and held in Japanese, was announced to government offices, companies, universities, and high schools in Kumamoto Prefecture, attracting participants not only from within the University but outside it as well.

4. Preparing for the second phase (AY2022 to AY2027)

IROAST, which will enter its second phase in AY2022, has the following two goals: 1) to establish a research hub through which we can circulate knowledge through great minds in science and technology that will lead the post-COVID-19, post-SDG world and generate new innovations; and 2) to develop an environment that serves as a hub for great minds that attracts outstanding researchers from Japan and abroad.

We will engage in international research activities that focus on the science and technology needed to build a society that provides safety, security, and well-being. The goal is to realize Society 5.0, which will support the next generation of natural sciences.

5. Statistics for IROAST Research Activities

The following tables indicate several indices to evaluate our research activities.

◆ Indices for Self-evaluation of IROAST Research Activities

Indices for Self-Evaluation **(Numerical Target)**	2017	2018	2019	2020	**2021**
Number of Papers **(30 papers per year)**	26	43	72	112	**102**
Rate of Internationally Collaborated Papers **(~80%~)**	88.5	79.1	81.9	83.0	**77.5**
Rate of Top 10% Papers **(~20%~)**	15.4	16.3	20.8	23.2	**7.8**
Field Weighted Citation Index **(>1.1)**	1.33	1.31	1.59	2.41	**0.90**
Number of Concluded MOU **(>20 for the first term)**	8	13	16	16	**21**
Number of Visiting Professors **(~40~)**	26	37	41	44	**49**
Number of Distinguished Professors **(4)**	2	3	4	3	**5**
Number of International Symposia including KU-KAIST Joint Symposium **(>1)**	1	5	3	1	**3**
Number of International Seminars including IROAST&IRCMS Joint Seminars **(~20~)**	20	23	20	2	**7**

Indices for Self-Evaluation **(Numerical Target)**	2017	2018	2019	2020	**2021**
Number of Invited Researchers **(~25~)**	25	28	22	–	**–**
Number of Researchers Visiting Overseas Universities and Institutions **(~20~)**	21	18	15	–	**–**
Number of Internship Students	**–**	3	13	–	**8**

Note) The number of papers and other paper-related data for 2018-2021 were obtained from the Web of Science by requesting the IR office in April 2022.

◆ Summary of Research Fund

FY2021

Categories	Number of Grants	Amount (x 1000 Yen)
JSPS Grant-in-Aid	9	37,037
Commissioned Research	1	3,210
Contract Research	1	1,674
Donated Grant	1	900
Total	12	42,821

FY2020

Categories	Number of Grants	Amount (x 1000 Yen)
JSPS Grant-in-Aid	8	32,560
Commissioned Research	1	1,300
Private Research Grant	2	1,000
Total	11	34,860

FY2019

Categories	Number of Grants	Amount (x 1000 Yen)
JSPS Grant-in-Aid	4	23,400
Commissioned Research	1	2,200
Private Research Grant	2	950
Donated Grant	1	1,000
Total	8	27,550

*Amended some numbers for the last three years based on a revised criterion.

Research Activities

1. IROAST Researchers

No.	Name	Project Title
1-1	**László Pusztai**	Nanoscale assemblies in hydrogen-bonded liquids and in amorphous materials
1-2	**Mitsuhiro Aida**	Plant developmental biology
1-3	**Gaochuang Cai**	Design for structural safety and sustainability (DfS^3)
1-4	**Takumi Higaki**	Quantitative Bioimaging
1-5	**Takashi Ishida**	Deciphering the molecular basis of the plant morphogenesis
1-6	**Ruda Lee**	Enhanced Nano Drug Delivery System for Overcoming Cancer
1-7	**Hiroki Matsuo**	Development of ferroelectric materials for energy storage and conversion
1-8	**Akiko Nakamasu**	Theoretical modeling for the understanding of plant structure formations
1-9	**Mizuki Yamada**	Analysis of auxin signaling regulation in the apical region development of the plant embryo

No.1-1	Nanoscale assemblies in hydrogen-bonded liquids and in amorphous materials		
Name	László Pusztai		
Affiliation (home)	Wigner Research Centre for Physics, Budapest, Hungary Email: pusztai.laszlo@wigner.hu	Title	Scientific Advisor
Research Field	Nanomaterial Science		
Period of appointment	Month 04, 2021-Month 03, 2022 (I was not able to show up in Japan)		
Host Professor	Ichiro Akai		
Affiliation	Institute of Industrial Nanomaterials, KU Email: iakai@kumamoto-u.ac.jp	Title	Professor

In FY 2021 my activities have been very much determined by the COVID-19 pandemic that prevented me from staying one single day at IROAST. What I can report below is (i) work that has been mostly done before FYI 2020 but has been completed in FY 2021, and (ii) the very much retarded activities that has been possible to maintain remotely.

1. Research achievements

My primary research goal in general may be described in short as '**understanding disordered structures'.** Accordingly, my main activity (still, in general) is the investigation of the microscopic structure of liquids, amorphous materials and disordered crystals. We combine experimental data, such as total scattering structure factors (TSSF) from X-ray and neutron diffraction (XRD and ND, respectively) and EXAFS spectra, with computer modeling tools, such as Reverse Monte Carlo (RMC) and molecular dynamics (MD) simulations. As a result of such an approach, large sets (containing tens of thousands) of atomic coordinates ('particle configurations') in simulation boxes are provided that are consistent (within errors) with experimental data. These configurations are then subjected to various geometrical analyses, so that specific questions concerning the structure of a material may be answered. Below I describe some selected results from the year of 2021 (only publications where the name of IROAST appears).

(i) Temperature dependent structure and dynamics of ethanol-water (CH_3-CH_2-OH)/H_2O) mixtures over a wide concentration range. New X-ray and neutron diffraction experiments have been performed on ethanol−water mixtures as a function of decreasing temperature, so that such diffraction data are now available over the entire composition range. Extensive molecular dynamics simulations show that the all-atom interatomic potentials applied are adequate for gaining insight into the hydrogen-bonded network structure, as well as into its changes on cooling. Various tools have been exploited for revealing details concerning hydrogen bonding, as a function of decreasing temperature and ethanol concentration, like determining the H-bond acceptor and donor sites, calculating the cluster-size distributions and cluster topologies, and computing the Laplace spectra and fractal dimensions of the networks. It is found that 5-membered hydrogen-bonded cycles are dominant up to an ethanol mole fraction $x_{eth} = 0.7$ at room temperature, above which the concentrated ring structures nearly disappear. Percolation has been given special attention, so that it could be shown that at low temperatures, close to the freezing point, even the mixture with 90% ethanol ($x_{eth} = 0.9$) possesses a three-dimensional (3D) percolating network. Moreover, the water subnetwork also percolates even at room temperature, with a percolation transition occurring around $x_{eth} = 0.5$.

Related publication: Pothoczki, S; Pethes, I; **Pusztai, L**; Temleitner, L; Ohara, K; Bakó, I; Properties of Hydrogen-Bonded Networks in Ethanol–Water Liquid Mixtures as a Function of Temperature: Diffraction Experiments and Computer Simulations; *The Journal of Physical Chemistry B*; **125(23),** 6272-6279 (2021); DOI: 10.1021/acs.jpcb.1c03122.

(ii) Temperature-dependent structure of 1-propanol—water (CH_3-CH_2-CH_2-OH)/H_2O) liquid mixtures. — Aqueous mixtures of 1-propanol have been investigated by high-energy synchrotron X-ray diffraction upon cooling. X-ray weighted total scattering structure factors of 6 mixtures, from 8 mol% to 89 mol% alcohol content, as well as that of pure 1-propanol are reported from room temperature down to the freezing points of the liquids. Molecular dynamics simulations have been performed, in order to interpret measured data. The all atom OPLS-AA potential model was used for 1-propanol, combined with both the SPC/E and the TIP4P/2005 water models: both combinations provide a semi-quantitative description of the measured total structure factors at low and high alcohol contents, while the agreement is qualitative for the mixture with 71 mol% of 1-propanol. From the simulated particle configurations, partial radial distribution functions were calculated. Furthermore, detailed description of the hydrogen bonded network is provided, in terms of hydrogen bond numbers, analysis of proton donor–acceptor ratios, size distributions of hydrogen bonded clusters and ring size statistics. Strong temperature dependence of the percolation threshold, as well as of the participation of the number of doubly hydrogen bonded molecules in cyclic entities, has been found for the mixture with 89 mol% of 1-propanol. Above an alcohol content of 20 mol%, 5-fold rings are the most frequent cyclic entities, with a strong temperature dependence in terms of the number of rings.

Related publication: Pethes, I; **Pusztai, L**; Ohara, K; Temleitner, L; Temperature-dependent structure of 1-propanol/water mixtures: X-ray diffraction experiments and computer simulations at low and high alcohol contents; *J. Mol. Liq.*, **340**, 117188 (2021) https://doi.org/10.1016/j.molliq.2021.117188

(iii) Cations in polar solvents. We showed how the dipole moment of a single molecule in a cluster can be calculated and used for describing the polarization effect. Additionally, we reviewed the accuracy of the calculation of the dipole moment of several simple protic and aprotic molecules. It was shown that the dipole moment of polar (water, methanol, formamide, acetone and acetonitrile) molecules in the neighborhood of a cation is increased primarily by polarization from the bare electrostatic charge of the cation, although the effective value of the latter is somewhat reduced by "back donation" of electrons from neighboring polar molecules. In other words, the classical picture may be viewed as if a point charge slightly smaller than the nominal charge of the cation would be placed at the cation site. It was found that the geometrical arrangement of the polar molecules in the first solvation shell is such that their mutual polarization reduces the dipole moments of individual molecules, so that in some cases they become smaller than the dipole moment of the free protic or aprotic molecule. We conjectured, for the first time, that this behavior, namely the roughly 10%–20% decrease of the dipole moment of water in the first shell of cations, with the cation itself removed, is essentially a manifestation of the Le Chatelier–Braun principle. We also remark that if the cation-molecule bond order is too large then the calculated dipole moment for these complexes can be questionable, due to the questionable definition of a single molecule within the "supermolecule"-like cluster.

Related publication: Bakó, I; Csókás, D; Mayer, I; Pothoczki, S; **Pusztai, L**; The influence of cations on the dipole moments of neighboring polar molecules; *Int J. Quant. Chem.*,

(iv) Structural studies of ^{1}H-containing liquids by polarized neutrons. Following a demonstration of how neutron diffraction with polarization analysis may be applied for the accurate determination of the coherent static structure factor of disordered materials containing substantial amounts of proton nuclei (Temleitner et al., Phys. Rev. B 92, 014201, 2015), we now focus on the incoherent scattering. Incoherent contributions are responsible for the great difficulties while processing standard (non-polarized) neutron diffraction data from hydrogenous materials, hence the importance of the issue. Here we report incoherent scattering intensities for liquid acetone, cyclohexane, methanol and water, as function of the ^{1}H/H ratio. The incoherent intensities are determined directly by polarized neutron diffraction. This way, possible variations of the incoherent background due to the changing chemical environment may be monitored. In addition, for some of the water samples, incoherent intensities as a function of the wavelength of the incident neutron beam (at 0.4, 0.5 and 0.8 Å) have also been measured. It is found that in each case, the incoherent intensity can be described by a single Gaussian function, within statistical errors. The (full) width (at half maximum) of the Gaussians clearly depends on the applied wavelength. On the other hand, the different bonding environments of hydrogen atoms do not seem to affect the width of the Gaussian.

Related publication: Temleitner, L; **Pusztai, L**; Cuello, G; Stunault, A; Structural studies of ^{1}H-containing liquids by polarized neutrons: Chemical environment and wavelength dependence of the incoherent background *J. Mol. Liq.*, **350**, 118535 (2022) https://doi.org/10.1016/j.molliq.2022.118535

Talks at meetings, seminars:
No meetings, unfortunately, due to the virus situation.

2. Overview and significance of the research collaboration with Kumamoto University

During FY 2021, I've collaborated mostly with my host professor, Dr. Hosokawa, and his co-worker at the Department of Physics, Dr. Nakajima, a young tenured-track fellow – with both of them, only remotely.

A manuscript with Prof. Hosokawa has been prepared during FY2021.

The joint research work with Dr. Nakajima, on high pressure diffraction measurements of alcohol-water liquid mixtures, produced the first publication in the calendar year 2021. A joint KAKENHI proposal with him has been submitted last Autumn.

3. Prospect for further research collaboration with Kumamoto University

The high pressure work, for which I obtain vital help and assistance from Dr. Nakajima, is still expected to expand – provided that we can conduct proper joint research in the near future. Follow-up publications with Prof. Hosokawa on the structure of amorphous materials will continue to appear for a while (there is one manuscript submitted at the moment).

4. List of co-authored papers published between April 2021 and March 2022

Pothoczki, S; Pethes, I; **Pusztai, L**; Temleitner, L; Ohara, K; Bakó, I; Properties of Hydrogen-Bonded Networks in Ethanol–Water Liquid Mixtures as a Function of Temperature: Diffraction Experiments and Computer Simulations; *The Journal of Physical Chemistry B*; **125(23),** 6272-6279 (2021); DOI: 10.1021/acs.jpcb.1c03122.

Pethes, I; **Pusztai, L**; Ohara, K; Temleitner, L; Temperature-dependent structure of 1-propanol/water mixtures: X-ray diffraction experiments and computer simulations at low and high alcohol contents; *J. Mol. Liq.*, **340**, 117188 (2021) https://doi.org/10.1016/j.molliq.2021.117188

Bakó, I; Csókás, D; Mayer, I; Pothoczki, S; **Pusztai, L**; The influence of cations on the dipole moments of neighboring polar molecules; *Int J. Quant. Chem.*, 2021:e26758 (2021) https://doi.org/10.1002/qua.26758

Temleitner, L; **Pusztai, L**; Cuello, G; Stunault, A; Structural studies of ^{1}H-containing liquids by polarized neutrons: Chemical environment and wavelength dependence of the incoherent background *J. Mol. Liq.*, **350**, 118535 (2022) https://doi.org/10.1016/j.molliq.2022.118535

No.1-2	Plant developmental biology		
Name	Mitsuhiro Aida		
Affiliation	IROAST Email: m-aida@kumamoto-u.ac.jp	Title	Professor
Research Field	Advanced Green Bio		

1. Research achievements

Our research aim is to elucidate molecular and genetic mechanisms that regulate the activity of shoot meristem, a group of dividing cells that is responsible for production of plant aerial organs, such as leaves, stems, and floral organs, which are collectively called shoot organs. In dicotyledonous plants, the shoot meristem is initially formed during embryogenesis in a boundary region between the two cotyledon primordia, and after germination, it maintains a group of stem cells at its center and continuously provides new cells that give rise to shoot organs from its periphery.

This fiscal year we reported the roles of regulatory factors that are expressed in the boundary region between cotyledons. The CUP-SHAPED COTYLEDON (CUC) transcription factors are essential for shoot meristem formation as well as setting up cotyledon primordium boundary region so that the primordia are develop into two distinct organs. We found that the CUC proteins are essential for activation of genes encoding key biosynthetic enzymes for the plant hormone auxin. We also analyzed *EPFL2* encoding a signaling peptide and found that this gene is expressed in the cotyledon boundary region and is required for cotyledon primordium growth as well as proper levels of auxin response in the primordium tips. Together our results highlight the importance of the cotyledon boundary region for auxin-dependent cotyledon development.

2. International research collaboration

International collaborative work was made with Keiko U Torii (Howard Hughes Medical Institute and University of Texas at Austin, USA) and Rüdiger Simon (Heinrich-Heine University, Germany), leading to a publication that describing a role for the *EPFL2* gene during embryogenesis (ref. 5). Other collaborative work has been carried out with Jose Ireapan Reyes Olalde, a research fellow from Consejo Nacional de Ciencia y Tecnología (CONACYT) of Mexico, to elucidate hormonal control of gynoecium development, which led to an oral presentation in the 63rd annual meeting of the Japanese Society of Plant Physiologists, March 22, 2022. A collaboration with Yoshihisa Ikeda from Palacký University (Czech Republic) has led to a publication of the roles of AP2 related transcription factors in the shoot development (ref 3) and details of this activity is described elsewhere (Research Unit “Plant Stem Cells and Regeneration” section).

3. Prospect for further research collaboration

The following collaborative research is in progress in FY2022.

- ✓ Elucidation of mechanisms regulating fruit development in collaboration with Stefan de Folter in CINVESTAV, LANGEBIO, Mexico.
- ✓ Investigation of the roles of the AP2-class transcription factors ESR1 and ESR2 in shoot formation and tissue regeneration in collaboration with Yoshihisa Ikeda in Palacky University in Olomouc.

4. List of journal papers (with IROAST as your affiliation) published between April 2021 and March 2022.

1. Yamada M, Tanaka S, Miyazaki T, Aida M. Expression of the auxin biosynthetic genes *YUCCA1* and *YUCCA4* is dependent on the boundary regulators *CUP-SHAPED*

COTYLEDON genes in the *Arabidopsis thaliana* embryo. **Plant Biotechnol** 39, 37-42, doi: 10.5511/plantbiotechnology.21.0924a.

2. Suzuki, R., Yamada, M., Higaki, T., Aida, M., Kubo, M., Tsai, A.Y-L., Sawa, S. (2021) *PUCHI* regulates giant cell morphology formation during root-knot nematode infection in *Arabidopsis thaliana*. **Frontiers in Plant Science.** 12, 755610. https://doi.org/10.3389/fpls.2021.755610
3. Ikeda Y, Králová M, Zalabák D, Kubalová I, Aida M (2021). Post-embryonic lateral organ development and adaxial–abaxial polarity are regulated by the combined effect of *ENHANCER OF SHOOT REGENERATION 1* and *WUSCHEL* in Arabidopsis shoots. **Int. J. Mol Sci** 22, 10621. doi: 10.3390/ijms221910621
4. Takahama A, Aida M. Visualization and quantification of cortical microtubules in the apical region of the *Arabidopsis thaliana* embryo (2021). **Cytologia** 86, 181-182. doi: 10.1508/cytologia.86.181
5. Fujihara R, Uchida N, Tameshige T, Kawamoto N, Hotokezaka Y, Higaki T, Simon R, Torii KU, Tasaka M, Aida M (2021). The boundary-expressed *EPIDERMAL PATTERNING FACTOR-LIKE2* gene encoding a signaling peptide promotes cotyledon growth during *Arabidopsis thaliana* embryogenesis. **Plant Biotechnol** 38, 317-322. doi: 10.5511/plantbiotechnology.21.0508a
6. Yamamoto K, Tasaka M, *Aida M. "Genetic interactions between the CUP-SHAPED COTYLEDON and the BELLRINGER genes indicate their overlapping functions in carpel boundary development in Arabidopsis thaliana," Plant Morphol, 33 (1), 95-100, 2021

5. List of Awards, Grants, and Patents, if any

Mitsuhiro Aida, Grant-in-Aid for Scientific Research on Innovative Areas (The Japan Society for the Promotion of Science), Principles of pluripotent stem cells underlying plant vitality, "Establishment of plant hormone microenvironment during shoot stem cell formation," April 2020-March 2022.

No.1-3	Design for structural safety and sustainability (DfS^3)		
Name	Gaochuang Cai		
Affiliation	IROAST Email: cai@kumamoto-u.ac.jp	Title	Associate Professor
Research Field	Environmental Science		

Details of activities

1. Research achievements

Since October 2021, the following main achievements have been archived,

(1) Development of reinforced CFT columns toward strong earthquake

The seismic behavior of RCFT columns has been experimentally investigated and the design approach of the CFT columns has been proposed including a simplified model for predicting the load-carrying and deformation capacity of the columns.

(2) Development of assessment methods of bolted precast RC walls under simulated seismic loads

As a demountable and sustainable structure, a steel bolted precast RC wall system has been developed and its seismic performance has been experimentally numerically investigated.

(3) Experimental investigation of seismic performance of high resilient RC beam-column joints

With debonded high-strength steel bars, we have developed an innovative RC beam-column joints with high resilience after being subjected to strong earthquakes. The related calculation models are being developed by analyzing the resistance mechanism and failure modes, and a finite element method analysis.

(4) Seismic performance and key damage control approach of RC frames infilled by masonry walls

The seismic performance of the frames with different filled masonry walls has been experimentally and numerically studied. A capacity and deformation assessment model has been developed for evaluating the seismic behavior of the frames.

2. International research collaboration

International collaboration topics/joint research institution

(1). Properties and modeling of Textile reinforced concrete under aggressive environment/ ENISE, École Centrale de Lyon (ECL), University of Lyon

(2). AI-based performance evaluation and optimization of steel-concrete composite structures under strong earthquake / City, University of London.

(3). Structural performance and design methods of demountable structures Technischen Universität Darmstadt

(4). Seismic performance and design of bolted precast RC walls/Sichuan University

(5). Bond-slip and models of CFRP bars in ultra-high-strength concrete/Zhengzhou University

(6). Seismic performance and design of high resilient RC beam-column joints / Sichuan University

(7). Seismic performance and key damage control approach of RC frames infilled by masonry wall: an experimental and numerical study / Southwest Jiaotong University

(8). Seismic performance and design of concrete columns confined by steel-FRP composite tube / Dalian University of Technology

(9). Basic research on a smart sensor eco-formwork system for I-Construction of concrete structures / Zhejiang university

3. Prospect for further research collaboration

The following mentioned research collaboration in Section 2 will be continued. According to the communication up to now, the prospected NEW collaborations are listed below,

(1) Topic: Resilience of structural systems subject to earthquakes, Digital signal processing, and pattern recognition

PI/Institution: Assoc. Prof. Salvatore Salamone, Smart Structures Research Group (SSRG) at the University of Texas at Austin, U. S.

(2) Topic: Digital and Autonomous Construction (IDAC)
PI/Institution: Professor Kay Smarsly, Institute of Digital and Autonomous Construction, Hamburg University of Technology, Germany.

4. List of journal papers (with IROAST as your affiliation) published between April 2021 and March 2022.
Since the researcher has just joined Kumamoto University in October 2021, the following publications with the affiliation of IROAST have been submitted to several international journals,

(1). **G.C Cai***, T. Fujinaga, A. Si Larbi (2021). Cyclic behaviour of CFT columns reinforced with LBHSRs, *Bulletin of Earthquake Eng.* (Under review).
(2). F. Zhao, F. Xiong, **G.C. Cai***, A. Si Larbi (2021). Experimental and numerical study of full-scale PC wall panels with bolted connections subjected to cyclic loads. *Journal of Building engineering,* (Under review).
(3). Y. Sun, **G.C Cai*** (2021). Lateral capacity and deformation ability of RCCCs under large cyclic loads, *ASCE-J. Struct. Eng.* (Under review).
(4). Y. Wang, G. Chen, **G.C Cai*** et al. (2021) Constitutive models of circular GFRP-steel tube confined concretes under cyclic axial compression, *Engineering Structures*, (Under review).
(5). Q. Su, **G.C Cai***(2021) Damage controlling of infilled RC frames under simulated seismic loads: An experimental study, *Engineering Structures,* (Under review).
(6). Y.L Wang, **G.C Cai*** et al. Seismic performance of square GFRP-steel tube confined concrete columns, *Journal of Building Engineering,* (Under review).

Besides, the following books/papers are under preparation,

(1). **G.C. Cai***, T. Noguchi. By-products reuse in the cement and concrete industry, CRC press. (Contracted, about 350 pages, will be finished in August 2022)
(2). **G.C. Cai***, A. Si Larbi (2021). Cyclic behaviour of XRCFT columns under simulated seismic loads, Target journal: *Structures.*
(3). **G.C. Cai***, W. Liu, A. Si Larbi (2021). Monotonic and cyclic tensile properties and a simplified calculation model of reinforced textile reinforced mortars (RTRM), Target journal: *Buildings*.
(4). H. Zhu, Y. He, **G.C. Cai***, Y. Zhang, L. Chen, Bond performance between CFRP rebars and ultra-high-performance concrete, Target journal: *Construction Buildings Materials*
(5). **G.C. Cai***, Y.J. He (2021). Seismic performance and evaluation of FRP-strengthened RC columns: A critical review, Target journal: *Structures.*

5. List of Awards, Grants, and Patents, if any
Since October 2021, the following JSPS applications have been submitted,

(1). JSPS Invitation Fellowships for research in Japan, AI-based design and optimization of composite structures under strong earthquakes, submitted.
(2). JSPS Postdoctoral fellowships for research in Japan, Resilient RC structures, submitted.
(3). JSPS Postdoctoral fellowships for research in Japan, A smart concrete performance assessment system, submitted.
(4). JSPS Postdoctoral fellowships for research in Japan, AI design and optimization of concrete structures, submitted.

No.1-4	Quantitative Bioimaging		
Name	Takumi Higaki		
Affiliation	IROAST (-Sep 2021); FAST (Oct 2021-) Email: thigaki@kumamoto-u.ac.jp	Title	Professor
Research Field	Advanced Green Bio		

Details of activities

Since I was moved to the Faculty of Advanced Science and Technology from IROAST in October 2021, this report describes my achievements from April 2021 to September 2021.

Recent advances in bioimaging equipment have enabled biological scientists to easily acquire large amounts of bioimage data within a short period of time. Following this influx of information, biologists are now engaging in bioimage informatics, an emerging area of bioinformatics. I worked on the development of a new system to monitor and measure the plant epidermal cell shapes with metal-nano-ink and artificial intelligence (AI). It is known that most epidermal cells in dicotyledonous plant leaves change from a simple brick shape to a complex jigsaw puzzle shape as they grow. This distinctive jigsaw puzzle cell shape transformation has attracted attention not only in the field of basic biology, but also in applied research fields such as the design of artificial structures. The technique of monitoring cell shape changes by tracking cells over time is a fundamental and important technique in the study of cell shape changes. Until now, tracking and measuring shape changes in leaf epidermal cells required special techniques and expensive microscopy equipment. In this study, we found that by applying metal-nano-ink to the leaf surface, the shape of cells can be clearly visualized even with a relatively inexpensive metallurgical microscope. Furthermore, they developed an AI system that automatically recognizes cells from microscope images and measures their shapes (Figure). The widespread use of this technology is expected to dramatically advance our understanding of the shaping mechanism of plant cells. This work was published in 'Frontiers in Plant Science' in September 2021.

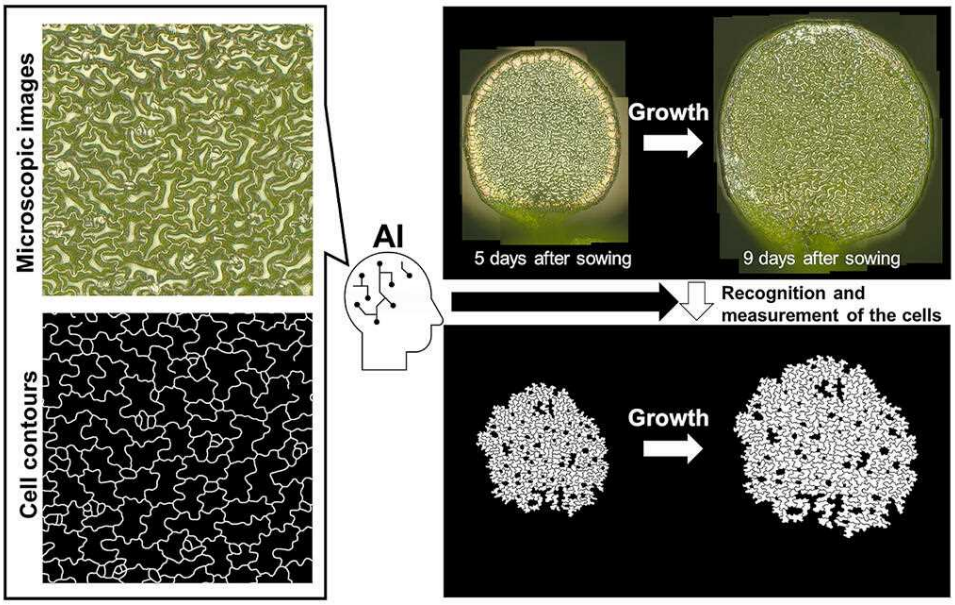


Figure. Conceptual diagram of the developed technology. Cell recognition and measurement were automated using microscopy images and the corresponding AI model (lower right). This image was provided for the following website; https://sj.jst.go.jp/news/202111/n1130-03k.html.

Publications between April 2021 and September 2021

Suzuki R, Yamada M, Higaki T, Aida M, Kubo M, Tsai AY, Sawa S,"PUCHI regulates giant cell morphology during root-knot nematode infection in Arabidopsis thaliana" Front Plant Sci 12, 755610. (Published: 06 Oct 2021) https://doi.org/10.3389/fpls.2021.755609

Kikukawa K, Sato R, Iwamoto M, Higaki T, "Wide-range segmentation of cotyledon epidermal cells for morphometrical analysis and mechanical simulation," Cytologia, 86: 189-194. 2021. (Published: 25 Sep 2021) https://doi.org/10.1508/cytologia.86.189

Kikukawa K, Yoshimura K, Watanabe A, Higaki T (2021) Metal-nano-ink coating for monitoring and quantification of cotyledon epidermal cell morphogenesis. Front Plant Sci 12: 745980. (Published: 21 Sep 2021) https://doi.org/10.3389/fpls.2021.745980

Kamon E, Noda C, Higaki T, Demura T, Ohtani M (2021) Calcium signaling contributes to xylem vessel cell differentiation via post-transcriptional regulation of VND7 downstream events. Plant Biotech 38: 331-337 (Published: 18 Sep 2021) https://doi.org/10.5511/plantbiotechnology.21.0519a

Fujihara R, Uchida N, Tameshige T, Kawamoto N, Hotokezaka Y, Higaki T, Simon R, Torii KU, Tasaka M, Aida M (2021) The boundary-expressed EPIDERMAL PATTERNING FACTOR-LIKE2 gene encoding a signaling peptide promotes cotyledon growth during Arabidopsis thaliana embryogenesis. Plant Biotech 38: 317-322. (Published: 18 Sep 2021) https://doi.org/10.5511/plantbiotechnology.21.0508a

Sato F, Iba K, Higaki T (2021) Involvement of the membrane trafficking factor PATROL1 in the salinity stress tolerance of Arabidopsis thaliana. Cytologia 86: 119-126. (Published: 25 June 2021) https://doi.org/10.1508/cytologia.86.119

Higaki T, Sato F, Iba K (2021) Environmental responses of the membrane trafficking factor PATROL1 in the Arabidopsis stomatal complex. Cytologia 86: 101-102. (Published: 25 June 2021) https://doi.org/10.1508/cytologia.86.102

Kimura T, Haga K, Nomura Y, Higaki T, Nakagami H, Sakai T (2021) Phosphorylation of NONPHOTOTROPIC HYPOCOTYL3 affects photosensory adaptation during the phototropic response. Plant Physiol 187: 981–995. (Published: 17 June 2021) https://doi.org/10.1093/plphys/kiab281

Matsumoto H, Kimata Y, Higaki T, Higashiyama T, Ueda M (2021) Dynamic rearrangement and directional migration of tubular vacuoles are required for the asymmetric division of the Arabidopsis zygote. Plant Cell Physiol 62: 1280–1289. (Published: 02 Jun 2021) https://doi.org/10.1093/pcp/pcab075

Kunita I, Morita MT, Toda M, Higaki T (2021) A three-dimensional scanning system for digital archiving and quantitative evaluation of Arabidopsis plant architectures. Plant Cell Physiol 62: 1975-1982. (Published: 22 May 2021) https://doi.org/10.1093/pcp/pcab068

No.1-5	Deciphering the molecular basis of the plant morphogenesis.		
Name	Takashi Ishida		
Affiliation	IROAST (-May 2021); FAST (Jun 2021-) Email: ishida-takashi@kumamoto-u.ac.jp	Title	Assistant Professor → Associate Professor
Research Field	Advanced Green Bio		

Details of activities

1. Research achievements

The mitotic cell cycle is a crucial cellular process to ensure cell proliferation in eukaryotes. Although the general mechanisms of the cell cycle progression are conserved across the kingdoms of fungi, animals and plants, the regulatory machinery and its underlying molecular basis likely differ in some ways.

In order to decipher the molecular insights into the plant cell cycle progression, we analyzed an Arabidopsis mutant *high ploidy 2* (*hpy2*) and found that *HPY2* encodes a homolog of NSE2/MMS21, a component of a widely conserved Structural Maintenance of Chromosomes protein (SMC) 5/6 complex (Ishida et al., Plant Cell 2009). Literature has revealed that yeast and animal NSE2/MMS21 mutants were defective in chromosome segregation, maintenance of chromosome structure and DNA damage responses. Consistent with this, we observed by live imaging analyses that fluorescent protein-tagged HPY2 co-localizes with chromosomes during mitosis. Further, we found that the lesion of HPY2 induced atypical pattern of chromosome movement during mitosis. These results obtained in this FY suggest that HPY2 is involved in the regulation of chromosome segregation

We prepared additional alleles of *hpy2* mutants and characterized them in the context of cell cycle regulation and genome integrity. Among the new mutants, an allele, namely *hpy2-cr1*, contained a frame-shift mutation lacking >80% of HPY2 protein displayed comparable phenotypes that were observed in *hpy2-1* stronger mutant allele. Moreover, we found a usefulness of *hpy2-cr1* that the sequence is easily distinguished from that of wild-type. Owing to this, we think that the use of the allele will be advantageous for the multiple types of genetic analyses and that the investigations will shed light to the functional analyses of SMC5/6 complex.

Coordinated cell proliferation and cell differentiation are essential processes in multicellular organisms. To achieve these functions, organisms have developed scrupulously designed cell-to-cell communication systems over the course of evolution. Plants have established unique ligand-receptor-based signaling modules, such as the CLAVATA (CLV) pathway, which comprises the CLV3 peptide hormone and leucine-rich repeat (LRR) domain-containing transmembrane receptors. In the shoot meristem of *Arabidopsis thaliana*, the CLV signaling modules play roles in the repression of cell proliferation. However, the molecular basis for the CLV-like signaling systems functioning in the root is to be elucidated. In order to decipher the molecular mechanisms revolving around the CLV-like systems in root, we have conducted genetic analyses using multiple mutants for the components of the signaling pathway to assess the genetic relationships. Resulted in the pharmacological analyses, we found a novel genetic pathway that modulate the root growth. Further, we found multiple molecules that are involved in the signaling. In this FY, we prepared a manuscript reporting above findings and submitted it (under revision).

In addition, we conducted functional analyses to clarify the biological relevance of plant-specific peptide hormones. CLE family peptides are representative plant peptide hormone and some of the members are known to be involved in multifaceted biological processes including developmental

and physiological regulations in the plant life cycle, though most of the members are not yet to be elucidated. A major problem in research on small peptide hormone-encoding genes is the limited number of loss-of-function mutants available due to their small gene size. We have previously generated and published a collection of mutants for CLE-peptide-encoding genes in *Arabidopsis thaliana* generated by CRISPR/Cas9-Mediated gene targeting (Yamaguchi et al., Plant Cell Physiol 2017).

In this FY, we asked biological relevance of several CLE peptides using the mutant collection. For instance, we discovered that a CLE peptide are involved in novel functions related to plant durability. We have submitted a manuscript related to this study and the manuscript is under revision (accepted in April 2022). In addition, we discovered a group of CLE peptides are involved in the regulation of stem cell function and organogenesis, whose manuscript has been submitted to Frontiers in Plant Science (Accepted in April 2022). These studies were done as international collaborative researches,

The functional characterization of peptide family that are composed of multiple number of highly redundant sequence and function is particularly challenging. We have tried to generate higher-order multiple mutants using CRISPR-Cas9 technology and succeeded it. Our analyses using the mutants revealed that the group of CLE peptides is involved in multifaceted biological processes including developmental regulation and response to biotic/abiotic stimuli. Manuscripts reporting these findings are currently under reviewing or in preparation.

Media

2021 年 4 月 9 日　熊本大など　菌由来の除草剤開発化学工業日報
(Related to a publication: Ishida et al., Scientific Reports 2021)

Patents

Oct. 12, 2021 United States Patent, Patent number: US 11,142,497 B2, Plant growth suppression agent, and plant growth suppression method using same
Hayato Ishikawa, Tokio Tani, Shinichiro Sawa, **Takashi Ishida**, Yusuke Fukushima, Jun Inagaki

2. International research collaboration

Although there is no publication accomplished by international collaboration in this FY, several international collaborative studies are ongoing. In particular, 5 manuscripts reporting the functional analyses regarding small genes in plants that are performed as international collaboration are under review (2 out of 5 are accepted in April 2022).

3. Prospect for further research collaboration

In FY2021, I have started several international collaborations on genome editing in plants. Our pipeline for rapid generation of Arabidopsis mutant will provide us opportunities for further collaborations; in particular, generation of the higher-order loss-of-function mutants using the technique will solve the redundancy problem in the molecular genetic studies. Our ongoing project using the method (related to the 3rd section of research achievements) will be published in the near future and will proved the usefulness of the method.

No.1-6	Enhanced Nano Drug Delivery System for Overcoming Cancer		
Name	Ruda Lee		
Affiliation	IROAST (-Dec 2021); IIna (Jan 2022-) Email: aeju-lee@kumamoto-u.ac.jp	Title	Associate Professor
Research Field	Advanced Green Bio		

1. Research achievements

The growing interest in applying nanotechnology to cancer is largely attributable to its uniquely appealing features for drug delivery, diagnosis, and imaging. Along with enormous progress in the field of cancer nanomedicine, we have also gradually realized the challenges and opportunities that lie ahead. To overcome the limitations, I focused on active targeted drug delivery materials for enhancing target ability and stimuli-responsive drug delivery systems for controlled drug release.

In FY2021, my lab focused on 1) developing nucleus targeted drug delivery system, 2) overcoming multi-drug resistance, 3) multi-receptor targeted drug delivery, and 4) in situ click chemistry. Depending on the target diseases, we designed a tailored nano-drug delivery system. Various NPs were successfully developed and evaluated in vitro and in vivo. Each NPs showed its characteristics and worked adequately under a specific environment (low pH, reactive oxygen species). Primarily, we developed a nucleus target delivery carrier and proved the efficacy to know down the gene expression. There was some research on which nucleus can target delivery. However, most of them were small inorganic NPs. It causes various side effects and shows high organ toxicity. My research group developed a non-toxic and minimized the off-target rate compared to previous research. One undergraduate student developed a stable polymer-based liposome. It showed high stability as well as overcoming multi-drug resistance effects. The manuscript is under preparation, and the NPs will upgrade during the student's master's periods. Furthermore, we found another strategy for increasing drug delivery efficacy. We hypothesized the possibility of enhancing treatment effects by dual ligand targeted modified NPs. AS we expected, dual ligand delivery efficacy was higher than the single ligand modified NPs. The manuscript is under preparation for submission.

2. International research collaboration

In FY2021, I suggested making strong collaboration with US and Korea. First, I applied for a CRDF grant with a new collaborator of Dana Faber Cancer Institute, and we were granted it for two years. It's a new project for developing virus-neutralized vaccines and real-time imaging sensors to monitor treatment responses. We are now working on creating/evaluating new imaging sensors and searching for the following grant applications. Second, the IROAST visiting Professor, Dr. Ick Chan Kwon, and I collaborate to develop a new click chemistry-mediated drug delivery system. One undergraduate student took this project and finalized the chemical synthesis. For a year, we actively discussed the project and troubleshot the materials. From FY2022, the student entered the graduate school semester and will perform in vitro experiments.

Furthermore, different countries' researchers and I were preparing to begin a new research collaboration. Dr. Chinmaya (India) and Dr. Manash (USA) had good knowledge of organoid research, and I started to join the research team. We published a review pare and began to organize

grant applications. Following the FY2020, the research exchange was not easy because of COVID-19. However, I got permission from IROAST and went to Korea to perform collaborative research. The results were under analysis and expected to publish in FY2022.

3. Prospect for further research collaboration

In FY2022, I have the plan to collaborate with a researcher at the Department of Biomedical Engineering, University of Utah (USA). The researcher had various experiences in microfluidics, so we have a plan to design the proper types of microfluidic chips for single-cell imaging. It will be a new collaborative project which I organize with Korea-Japan-US to apply for grants in FY2023. In July, I have a plan to apply for JSPS FOSTERING (A) grant with the US team for learning microfluidic technology. This opportunity can give me a chance to upgrade my research at single-cell level analysis. Furthermore, the IROAST Research Unit team members (Korea-Japan-Australia) will apply for Australia Ideas Grant. We failed the grant but the reviewer's comments sound right on the edge of getting it. So, we will modify the proposal and will apply again in May 2022.

4. List of journal papers (with IROAST as your affiliation) published between April 2021 and March 2022.

① Chinmaya Mahapatra, **Ruda Lee**, Manash K. Paul. Emerging role and promise of nanomaterials in organoid research. Drug Discovery Today, 27, 890-899. March 2022.

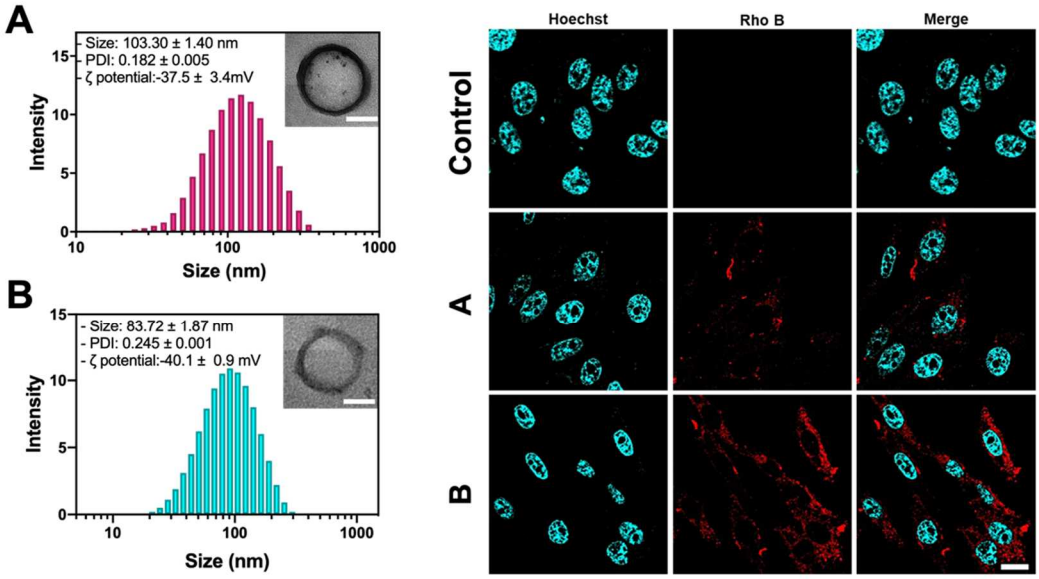
② Kang Pa Lee, Suji Baek, Myeong Sik Yoon, Ji Soo Park, Bok Sil Hong, Sang Ju Lee, Seung Jun Oh, Seung Hae Kwon, **Ruda Lee**, Dae Ho Lee, Kang-Seo Park, Byung Seok Moon. Potential anticancer effect of aspirin and 2'-hydroxy-2,3,5'-trimethoxychalcone-linked polymeric micelles against cervical cancer through apoptosis. Oncology Letters, 23, 31, November 2021.

③ Sajid Fazal, **Ruda Lee***. Biomimetic Bacterial Membrane Vesicles for Drug Delivery Applications. Pharmaceutics, 13, 1430. September 2021.

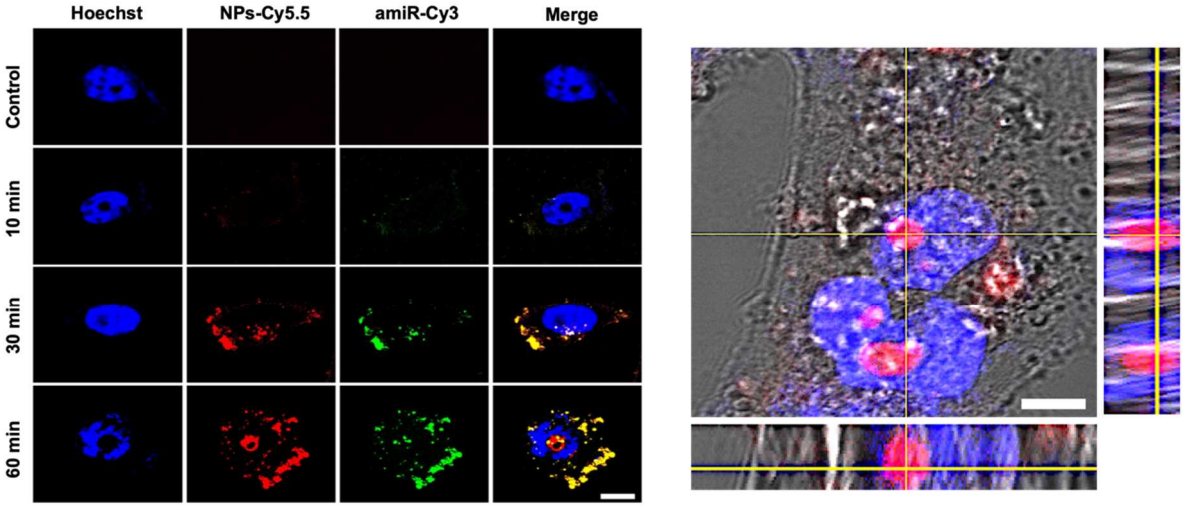
5. List of Awards, Grants, and Patents

① PI: Ruda Lee

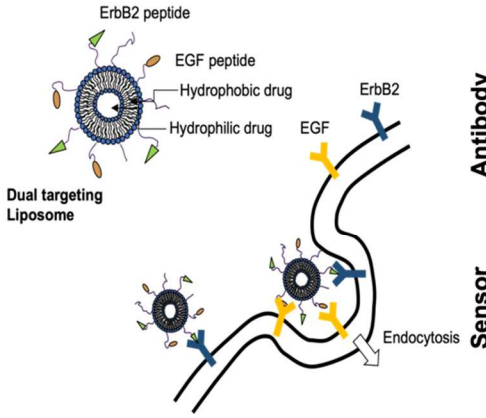
Japan Agency for Medical Research and Development (AMED), FY 2021 Infectious Diseases and Immunology Research: U.S.-Japan Cooperative Medical Sciences Program Collaborative Awards, "Investigating DNA origami vaccine efficacy in infectious diseases", FY2021-FY2023

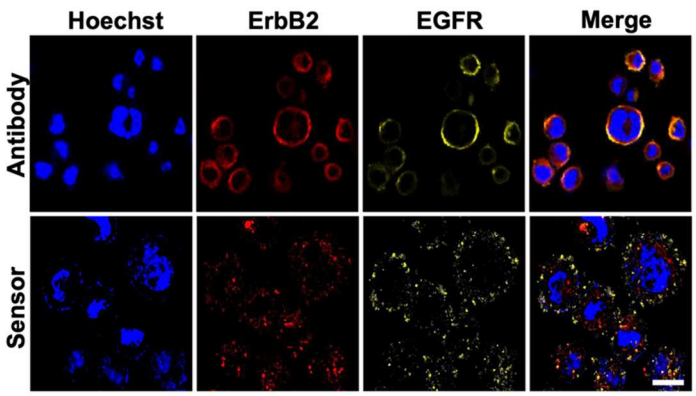


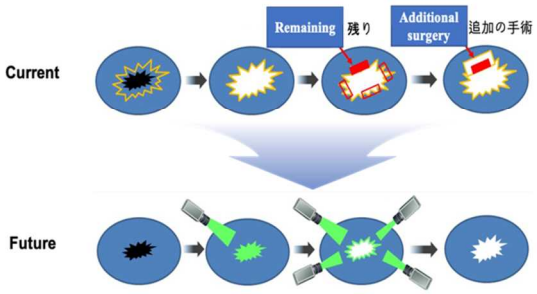
1. Overcoming multi-drug resistance

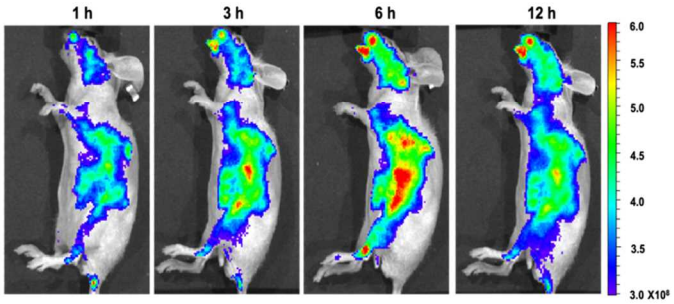


2. Nucleus targeted gene delivery carrier









3. Students supervising

No.1-7	Development of ferroelectric materials for energy storage and conversion		
Name	Hiroki Matsuo		
Affiliation	IROAST Email: matsuo_h@cs.kumamoto-u.ac.jp	Title	Associate Professor
Research Field	Nano Material Science / Green energy		

1. Research achievements

The goal of our research is to develop ferroelectric materials that are applicable to efficient energy storage and conversion. In this term, we conducted research focusing on a) the development of ferroelectrics for high energy-density ceramic capacitors and b) the photovoltaic effect of heavily doped ferroelectrics.

a) Development of ferroelectrics for high energy-density ceramic capacitors

We worked on the development of ferroelectric materials with a high energy storage density that utilize an interaction between lattice defects and spontaneous polarization. We found that Cu-doped $BaTiO_3$ ceramics after an appropriate thermal annealing and an electrical treatment exhibited a shifted polarization (P)-electric field (E) hysteresis loop as a result of the formation of strong an internal electric field. Our density functional theory calculations revealed that the internal electric filed was derived from a strong interaction between the ferroelectric polarization and defect dipoles comprised with Cu atom and oxygen vacancy. A resultant effective dielectric permittivity was about two times as large as that of typical undoped $BaTiO_3$ ceramics and the energy density was significantly improved without sacrificing an energy storage efficiency. A paper reporting these results has been published to a preprint server (DOI: doi.org/10.21203/rs.3.rs-1429045/v1).

b) Photovoltaic effect of heavily doped ferroelectrics

Ferroelectric materials exhibit a characteristic photovoltaic effect that can generate photovoltage far exceeding their bandgap energy and light polarization-dependent photocurrent. In this term, photovoltaic properties of 5% Mn-doped $BiFeO_3$ (Mn-BFO) ferroelectric thin films were analyzed. The Mn-BFO thin films exhibited a large photovoltaic response compared with undoped $BiFeO_3$ thin films under visible light irradiation. We found the Mn-BFO thin films exhibited an open circuit voltage of 14 V which was much higher than bandgap energy of the material and a large photocurrent anisotropy depending on incident light polarization. Quantitative analyses for the photovoltaic polarization dependent photocurrent suggested that the photocurrent anisotropy can be furtherly enhanced by increasing a ferroelastic domain wall density. I believe the enhanced ferroelectric photovoltaic effect will be applicable to light polarization detect applications. A paper on this achievement is in preparation.

Besides, the research on the ferroelectric photovoltaic effect in Mn-doped $BaTiO_3$ (Mn-BT) ferroelectric single crystals has also stared as a collaboration research with a Korean single-crystal production company.

2. International research collaboration

An international collaboration research on ferroelectric photovoltaics was launched in Nov. 2021. This collaboration research is comprised with researchers of Kumamoto University and Ceracomp Co. Ltd. which is a Korean company producing ferroelectric oxide single crystals by a special growth method called solid-state crystal growth. The goal of this collaboration is to develop ferroelectric materials with a large photovoltaic response. Ceracomp Co. Ltd., supplied heavily transition metal-doped ferroelectric single crystals to Kumamoto University. Structural analyses and photovoltaic measurements for the single crystals have been performed in Kumamoto University.

3. Prospect for further research collaboration

For deeper understanding of photocarrier dynamics in the ferroelectric photovoltaic effect, further collaboration with researchers who specialize in spectroscopic measurements is being planned. The new collaboration will provide information of photocarrier lifetime in ferroelectric materials and role of the impurity levels in the photovoltaic effects.

4. List of journal papers

Hiroki Matsuo*, Masashi Utsunomiya, Yuji Noguchi* "Utilizing ferrorestorable polarization in energy storage ceramic capacitors" (2022). Preprint (under review)
DOI: https://doi.org/10.21203/rs.3.rs-1429045/v1

Yuji Noguchi*, Hiroki Matsuo* "Polarizaion and Dielectric Properties of $BiFeO_3$-$BaTiO_3$ Superlattice-Structured Ferroelectric Films"
Nanomaterials, 11, 1857 (2021).
DOI: https://doi.org/10.3390/nano11071857

5. List of Awards

The 18th JACG Best Presentation Awards
"Gap-State Engineering for Ferroelectric Photovoltaic Effect in $BiFeO_3$ Epitaxial Thin Film"
Japanese Association for Crystal Growth (JACG). Dec. 13 2021.

No.1-8	Theoretical modeling for the understanding of plant structure formations		
Name	Akiko Nakamasu		
Affiliation	IROAST Email: akikonakamasu@gmail.com	Title	Project Assistant Professor
Research Field	Advanced Green Bio		

1. Research achievements

In this fiscal year, I tried following themes and grasped the directions of them. I'd like to thank to IROAST members for helping of these achievements.

1) Collaborative research for modeling of pattern formation phenomena.
2) Modeling for understanding of morphogenesis (especially in leaf formations).
3) Mathematical modeling and analysis of dynamical pattern.

1) is about pigmentation pattern formation on zebrafish body trunk. I explained the effects of connexon defects in *leopard* mutant by a mathematical model constructed more than ten years ago. Then 2) is treated about combination of positional information for morphogenesis. In this theme, the difference in proportions of leaf shape was explained by an algorithm for expansive growth with bias. Then loss and gain of shaping robustness could be observed depending on the characteristics of the pattern as positional information on the blade. 3) is about dynamics observed by a combination of spatial inhomogeneity with spatial pattern.

2. International research collaboration

I participated to an international webinar series "From Cellular Dynamics to Morphology II" as a speaker, and to an international meeting Pacifichem @ Honolulu (hybrid event on site and virtual) to give a contribution talk. Though, it was difficult to conduct new international collaborative researches for my over-capacity.

3. Prospect for further research collaboration

I'd like to collaborate with experimental biologists in the fields of pigmentation pattern formation in animal, and plant biology.

4. List of journal papers published between April 2021 and March 2022.

1) "Correspondences between parameters in a reaction-diffusion model and connexin functions during zebrafish stripe formation." to an open access journal Frontiers in Physics 18 January 2022.
2) "An algorithm for expansive growths with uniaxial gradients can explain different proportions in two-dimensional leaf shapes" to Frontiers in Cell and Developmental Biology. (under preparation of resubmission)
3) "Dynamics obtained by an equally spaced pattern interacting with spatial inhomogeneity" (under preparation)

5. List of Awards, Grants, and Patents, if any

It was a last year of following grants

1) Grant-in-Aid for Scientific Research on Innovative Areas (The Japan Society for the Promotion of Science), Periodicity and its modulation in plant and "Theoretical understandings of leaf diversity caused by modulations of spatial periodicity on leaf peripherals." June 2020-March 2022.
2) Research grant from Shimazu Science Foundation "Study on displacable effects of spatial inhomogeneity on Turing pattern." February 19, 2020- December 2021.
   *This is for a collaborative research with T.Higaki and H. Izuhara.

I regret that potential collaborative researches could not conducted in the former Research Area, even though modeling techniques and mathematical analysis for pattern formations have been required in this area.

No.1-9	Analysis of auxin signaling regulation in the apical region development of the plant embryo		
Name	Mizuki Yamada		
Affiliation	IROAST Email: myamada@kumamoto-u.ac.jp	Title	Postdoctoral Researcher
Research Field	Advanced Green Bio		

Details of activities

1. Research achievements

The aerial organs of plants (leaves, stems, flowers etc..) are generated from the shoot meristem, which is initially established during embryogenesis. In dicotyledonous plants, the apical region of the embryo is separated into two cotyledon primordia, and shoot meristem is formed in boundary region between cotyledon primordia. The *CUP-SHAPED COTYLEDON* (*CUC*) genes are known to act as key regulators of this process and are required for it. Besides the *CUC* genes, phytohormone auxin, which is involved in various developmental processes in plants, also plays important roles in embryogenesis. However, the relationship between *CUC* genes and auxin is not well understood. I am investigating the regulation of auxin signaling patterns by *CUC* genes in the apical region of the *Arabidopsis thaliana* embryos.

In FY2021, I reported the relationship between *CUC* genes and auxin biosynthetic genes (Yamada et al., 2022). Among auxin biosynthetic genes, the expression levels of *YUC1* and *YUC4*, which are expressed in the cotyledon boundary of the embryo, were reduced in the *cuc* loss-of-function mutant embryos. This result suggested that the auxin biosynthesis in cotyledon boundary of the embryos is dependent on the activity of the *CUC* genes. Moreover, I found that the *CUC* genes also regulate the spatial pattern of auxin response in the apical region of the embryo and that this regulation contributes to normal development. These results were reported at the 85th annual meeting of BSJ and will be published in a paper in FY2022.

Besides the auxin related genes, I am trying to find additional genes which work as *CUC* downstream factors by the transcriptome analysis (collaboration with Dr. Minoru Kubo; NAIST). In FY2021, I listed the several new candidate genes in comparison with other published datasets. Our group and I have already started to investigate some of candidate genes.

2. International research collaboration

NA

3. Prospect for further research collaboration

From the results of embryo transcriptome analysis, I will find the various new candidate genes involved in the tissue differentiation in the apical region of embryo. I will have to collaborate with researchers who are expert in those genes.

4. List of journal papers

Yamada M, Tanaka S, Miyazaki T, Aida M (2022). Expression of the auxin biosynthetic genes *YUCCA1* and *YUCCA4* is dependent on the boundary regulators *CUP-SHAPED COTYLEDON* genes in the *Arabidopsis thaliana* embryo. Plant Biotechnol 39, 37-42. doi: 10.5511/plantbiotechnology.21.0924a

Suzuki R, **Yamada M**, Higaki T, Aida M, Kubo M, Tsai AY, Sawa S (2021). *PUCHI* regulates giant cell morphology during root-knot nematode infection in *Arabidopsis thaliana*. Front Plant Sci 12, 755610. doi: 10.3389/fpls.2021.75561

5. List of Awards, Grants, and Patents, if any

NA

2. Young Faculty Members for International Joint Research

No.	Name	Project Title
2-1	**Takahiro Hosono**	Coseismic hydro-environmental changes after the 2016 Kumamoto earthquake
2-2	**Kei Ishida**	Development of Hybrid Downscaling Method of Future Climate Projections
2-3	**Mizue Munekata**	Development and Application of Simultaneous Measurement Technique of Pressure and Temperature by Luminescent Paint Using Modulated Excitation Light
2-4	**Yuta Nakashima**	Bio-sensing and bio-imaging for cellular behavior

No.2-1	Coseismic hydro-environmental changes after the 2016 Kumamoto earthquake		
Name	Takahiro Hosono		
Affiliation	Faculty of Advanced Science and Technology Email: hosono@kumamoto-u.ac.jp	Title	Professor
Research Field	Environmental Science		
Period of Travel	―		
Host Researcher	Dr. Michael Manga		
Affiliation	Department of Earth and Planetary Science, University of California, Berkeley	Title	Professor

1. Overview and significance of the international research collaboration

I made two major international research collaborations during 2021. One is the field survey in Iceland with research meeting with Prof. Dr. Sigurdur Reynir Gislason in Institute of Earth Sciences, Askja, University. The other is writing international papers with a topic shown in the title under continuous collaboration with international team. Both collaboration research achieved very good results.

2. Research achievements and progress of the international joint research

1.1. Field survey in Iceland

To understand volcano-tectonic influence on surface hydrochemical signatures, water sampling was conducted along round-trip survey in Iceland (Fig. 1) during August and September 2021 for one month. I successfully sampled many different kind of water samples such as stream waters, groundwaters, spring waters and geothermal fluids (Figs. 2 and 3) and brought them back to Japan for subsequent analysis. During my stay in Iceland I met Prof. Dr. Sigurdur Reynir Gislason, who is famous scientist widely known as one of pioneers of Carbfix project (Fig. 4), to have discussion about water-rock interactions and associated carbon fixation processes and their impact in hydrochemical evolutions. All these activities are financially supported and performed in a framework proposed by JSPS Fostering Joint International Research (A) (2020-2023, 19KK0291).

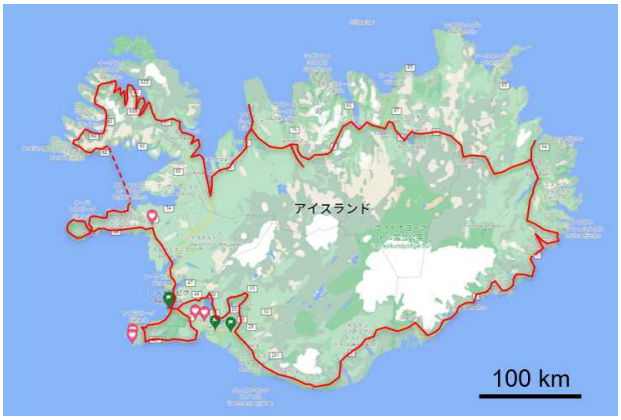


Fig. 1 Tracking route of field survey

Fig. 2 Water sampling from hot spring cave

Fig. 3 Water sampling in river

Fig. 4 Meeting with Prof. Sigurdur R. Gislason

1.2. Journal paper writing

In last year I have delivered Journal Special Issue 'Coseismic hydro-environmental changes: Insights from recent earthquakes' in the Journal of Hydrology as a head editor editing 23 papers submitted from various countries with a help of international team including Department of Earth and Planetary Science, University of California, Berkeley. I still continued writing a rest of paper for publication on separated journals such as Tanimizu et al. (2021) which we could not included in journal special issue. We successfully completed the work.

Aizawa, M., Mizota, C., **Hosono, T.**, Shinjo, R., Furukawa, Y., Nobori, Y., 2022. Lead isotopic characteristics of gun bullets prevailed during the 19th century in Japan: Constraints on the provenance of lead source from the United Kingdom and Japan. Journal of Archaeological Science: Reports, 41, 103268. https://doi.org/10.1016/j.jasrep.2021.103268

Hosono, T., Yamanaka, C., 2021. Origins and pathways of deeply derived carbon and fluids observed in hot spring waters from non-active volcanic fields, western Kumamoto, Japan. Earth, Planets and Space, 155, 73. https://doi.org/10.1186/s40623-021-01478-1

Mizota, C., Hansen, R., **Hosono, T.**, Okumura, A., 2022. Museum-archived and recent acquisition nitrates from the Atacama Desert, Chile, South America: refinement of the dual isotopic compositions ($\delta^{15}N$ vs. $\delta^{18}O$). Isotopes in Environmental and Health Studies, 58, 1-17. https://doi.org/10.1080/10256016.2021.1990913

Rahman, A.T.M.S., **Hosono, T.**, Tawara, Y., Fukuoka, U., Hazart, A., Shimada, J., 2021. Multiple-tracers-aided surface-subsurface hydrological modeling for detailed characterization of regional catchment water dynamics in Kumamoto area, southern Japan. Hydrogeology Journal, 29, 1885-1904. https://doi.org/10.1007/s10040-021-02354-8

Romero-Mujalli, G., Hartmann, J., **Hosono, T.**, Louvat, P., Okamura, K., Delmelle, P., Amann, T., Böttcher, M.E., 2022. Hydrothermal and magmatic contributions to surface waters in the Aso caldera, southern Japan: Implications for weathering processes in volcanic areas. Chemical Geology, 588, 120612. https://doi.org/10.1016/j.chemgeo.2021.120612

Tanimizu, M., Sugimoto, N., **Hosono, T.**, Kuribayashi, C., Morimoto, T., Ito, A., Umam, R., Nishio, Y., Nagaishi, K., Ishikawa, T., 2021. Application of B and Li isotope systematics for detecting chemical disturbance in groundwater associated with large shallow inland earthquakes in Kumamoto, Japan. Geochemical Journal, 55, 241-250. https://doi.org/10.2343/geochemj.2.0633

3. Prospect for further research collaboration with the visited university/institution

I am planning to make a short research stay at University of Rome, Italy during June and September in 2022, with a financial support from JSPS Fostering Joint International Research (A) (2020-2023, 19KK0291). We are planning to make a research collaboration including

seminar presentation and field survey that hopefully generate co-authoring papers.

5. List of journal papers (with IROAST affiliation) published between April 2021 and March 2022.

Shown above.

5. List of Awards, Grants, and Patents received between April 2021 and March 2022.

Awards
T. Hosono, 2020 IROAST Research Awards, 22 June 2021

Grants
T. Hosono, JSPS Fostering Joint International Research (A), 2020-2023, 19KK0291

Financial support from IROAST
T. Hosono, IROAST Research Awards, 500,000 JPY
T. Hosono, Research Support for Young Faculty Member for International Joint Research, 2,000,000 JPY

I appreciate very much for these two financial supports from IROAST. These supports were definitely efficient to promote field survey and to maintain laboratory equipment to enhance research activities using analytical machines including ion chromatography and isotope ratios mass spectrometry.

No.2-2	Development of Hybrid Downscaling Method of Future Climate Projections		
Name	Kei Ishida		
Affiliation	Center for Water Cycle, Marine Environment and Disaster Management, Kumamoto University（CWMD） Email: keiishida@kumamoto-u.ac.jp	Title	Associate Professor
Research Field	Environmental Science		
Period of Travel	―		
Host Researcher	Ali Ercan		
Affiliation	University of California, Davis	Title	Assistant Research Professor

1. Overview and significance of the international research collaboration

Climate change is a large concern in many countries in the world now. To investigate impacts of climate change, future climate projections are used. Future climate projections are basically simulated results by means of general circulation models based on future climate scenarios. However, the resolutions of future climate projections are generally too coarse for regional-scale analysis. Therefore, downscaling technique is frequently utilized to obtain the projections at a finer resolution. There are mainly two types of downscaling techniques: Dynamical downscaling and statistical downscaling. Both of them have pros and cons. Therefore, hybrid downscaling technique, which is combined approach of dynamical and statistical downscaling, is sometimes utilized. In this international joint research, we will develop a new hybrid downscaling technique to improve estimations of climate change impacts at regional-scale.

2. Research achievements and progress of the international joint research

We developed a new hybrid downscaling technique improve the accuracy of precipitation estimates at a regional scale. First, we conducted dynamical downscale by means of a regional atmospheric model. Then, we applied statistical downscaling using the convolutional neural network (CNN). The precipitation estimates obtained by the hybrid downscaling saucerful improved the accuracy of precipitation at the target area. We wrote an academic paper based on the results. The academic paper was published in an international journal, Journal of Hydrology: Regional Studies.

3. Prospect for further research collaboration with the visited university/institution

We will continue this international research collaboration. We could not have meeting in person for last two years due to COVID-19. However, we hope that we can have a meeting in person in the near future. Meanwhile, we will continue to have online meetings. Then, we will keep this collaboration to improve the hybrid downscaling technique further.

4. List of journal papers (with IROAST as your affiliation) published between April 2021 and March 2022.

Kei Ishida, Masato Kiyama, Ali Ercan, Motoki Amagasaki, Tongbi Tu, "Multi-time-scale input approaches for hourly-scale rainfall–runoff modeling based on recurrent neural networks" Journal of Hydroinformatics 23(6), 1312–1324.
https://doi.org/10.2166/hydro.2021.095

Kazuki Yokoo, Kei Ishida*, Ali Ercan, Tongbi Tu, Takeyoshi Nagasato, Masato Kiyama, Motoki

Amagasaki, “Capabilities of deep learning models on learning physical relationships: Case of rainfall-runoff modeling with LSTM”, Science of The Total Environment, 802, 149876, 2022. https://doi.org/10.1016/j.scitotenv.2021.149876 (*corresponding)

5. List of Awards, Grants, and Patents received between April 2021 and March 2022.

Awards

Intelligence, Informatics and Infrastructure Outstanding Potential Paper Award (2021)
Subcommittee on AI Application in Structural Engineering
November 29, 2021

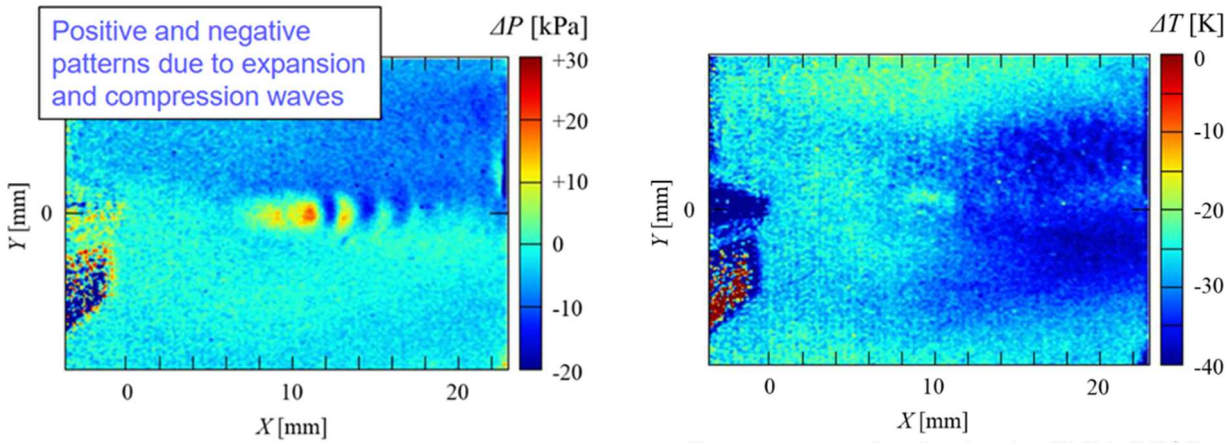
No.2-3	Development and Application of Simultaneous Measurement Technique of Pressure and Temperature by Luminescent Paint Using Modulated Excitation Light		
Name	Mizue Munekata		
Affiliation	Faculty of Advanced Science and Technology Email: munekata@kumamoto-u.ac.jp	Title	Associate Professor
Research Field	Green Energy/ Environmental Science		
Period of Travel	None		
Host Researcher	Christian Klein		
Affiliation	German Aerospace Center Institute of Aerodynamics and Flow Technology	Title	Team Leader TSP/PSP

Pressure Sensitive Paint (PSP) measurement technique is based on the dependence of the intensity or decay time of its luminescence on pressure, brought about by oxygen quenching. PSP is usually exited by light at an appropriate wavelength (e.g. UV-Light) and its pressure dependent luminescence intensity or lifetime is detected by a camera system (CCD or CMOS). In the method based on the luminescent lifetime, two basic types of measurement exist: The first type is the time-domain lifetime method, which is mostly used in various PSP applications. For this method a pulsed light is used to excite the paint and the pressure dependent time constant is determined from decay curve of luminescence intensity. The second type is the frequency-domain fluorescence lifetime imaging (FLIM) where modulated light is used to excite the paint and the PSP luminescence is simultaneously detected to calculate pressure dependent phase shift or amplitude. Only few applications were reported using this method.

Recently, a new CMOS image sensor has been developed by CSEM and PCO for frequency-domain FLIM system and equipped in the pco.flim camera for fluorescence lifetime imaging in microscopy. In this study, the frequency-domain lifetime PSP technique (FLIM-PSP) is investigated using a larger model for industrial applications.

We planned to test the FLIM-PSP technique with the pco.flim camera for industrial models in Germany. However, we could not test it because of COVID-19. Therefore my team in Kumamoto Univ. have developed a new technique with FLIM for measurement of temperature and pressure.

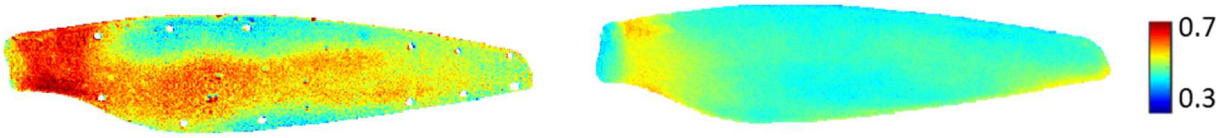
The simultaneous measurement of temperature and pressure with FLIM technique is named FLIM-PTSP. The FLIM-PTSP technique is more effective, because it is the life time method by a high speed camera (CMOS) . We have succeeded in developing and verifying the simultaneous measurement method of pressure distribution and temperature distribution(FLIM-PTSP) by the wall imping jet model[(1)] without using temperature sensor. However, in order to apply it to the industrial model, it is necessary to investigate to further increase the temperature sensitivity and temperature sensitivity. We hope to have collaboration tests using the FLIM camera at DLR in Germany in the near future.



(a) Pressure distribution (b) Temperature distribution

Fig.1 Simultaneous measurement of pressure and temperature by FLIM-PTSP

On the other hand, we tried PSP coating on a 3D model by a 3D automatic coater to coat uniformly. Hand spray is used generally to coat on models. Applying to a uniform thickness requires considerable training. However, by constructing a program for automatically applying by inputting shape information into the operation program of the 3D automatic coater, it was possible to develop a coating method with good reproducibility and to show its effectiveness[(2),(3)]. In the future, we will measure the pressure distribution on the surface of the propeller during drone flight using a propeller coated with PSP paint with the 3D automatic coater, and try to evaluate the pressure distribution characteristics of the drone and develop a highly efficient propeller.



(a) Hand spray (b) 3D automatic coater

Fig.2 Distributions of pressure sensitivity on the propeller surface; The standard deviation of pressure sensitivity is 9.3% for hand spray and 1.9% for 3D automatic coater.

(1) Moriya, T., Tsutsumi, K., Jinwaki, N., Munekata, M., Yoshikawa, H., “A study on pressure and temperature distribution measurement by FLIM technique”, Proceedings of the 49th symposium of visualization, No.058, 2021.
(2) Munekata, M., Kobayashi, Y., Michiuchi, D., Nakatsuma, K., Miyaji, K., Masumoto, K., Yoshikawa, H., “Pressure-sensitive paint coating with 3D automatic coater”, 17th Interdisciplinary Molecular Imaging Forum, P18, 2021.
(3) Nakatsuma, K., Michiuchi, D., Munekata, M., Kobayashi, Y., Miyaji, K., “Coating device and coating method”, Japanese Patent Application No. 2022-007423, January 20, 2022.

No.2-4	Bio-sensing and bio-imaging for cellular behavior		
Name	Yuta Nakashima		
Affiliation	Faculty of Advanced Science and Technology Email: yuta-n@mech.kumamoto-u.ac.jp	Title	Associate Professor
Research Field	Advanced Green Bio		
Period of Travel	―		
Host Researcher	Dr. Douglas A. Coulter Dr. Hajime Takano		
Affiliation	The Children's Hospital of Philadelphia & University of Pennsylvania（UPenn）	Title	Professor Assistant Professor

The objective of this project is to develop the palm-size medical diagnostic devices apply to detection of disease and post-surgical management based by cell behavior. The development of the desired medical devices is need to fundamental technique shown below.

* Microfabrication technique for fabricating cell size and palm-size structure.
* Cell handling technique
* Sensing technique for cell produced signals such as protein, exosome, RNA, etc. on the devices.
* Imaging technique for detecting the morphology, movement, behavior, etc. of cells on the devices.

In my laboratory, microfabrication technique and cell handling technique are already possessed. Host researchers has a lot of knowledges about in vitro and in vivo sensing/detection/imaging techniques for cell and tissue evaluation. We will promote joint research to achieve the objective medical devices by integrating our technologies.

In this season, we discussed how to proceed with our collaborative research through multiple web meeting. While we were able to gain understanding of each other's current status (including COVID-19), further discussion was needed to discuss the study and its details. The inability to discuss while looking at actual equipment and technology was a major obstacle to promoting collaborative research. On the other hand, introduction of measuring instruments, development of sensing technique, and fabrication of microdevices were carried out for preparing the collaborative research. In the next fiscal year, we would like to promote collaborative research overseas to further deepen our research.

List of journal papers

*Corresponding author

[1] Yuta Nakashima*, Mami Akaike, Masaki Kounoura, Keita Hayashi, Kinichi Morita, Yuji Oki, Yoshitaka Nakanishi, “Evaluation of osteoblastic cell behavior upon culture on titanium substrates photo-functionalized by vacuum ultra-violet treatment,” Experimental Cell Research, 410, 112944, 2022.

[2] Yoshitaka Nakanishi, Hajime Yamaguchi, Yusuke Hirata, Yuta Nakashima, Yukio Fujiwara, “Micro-abrasive glass surface for producing microplastics for biological tests,” Wear, 477, 203816, 2021.

[3] Hajime Yamaguchi, Katsunori Higuchi, Koshi Sakata, Tetsuya Akiyama, Keiji Kasamura, Yuta Nakashima, Yoshitaka Nakanishi, “Hydrophilic sealing material for live centers in machine tools,” Wear, 477, 203838, 2021.

[4] Souichiro Fukuyama, Seitaro Kumamoto, Seiya Nagano, Shoma Hitotsuya, Keiichiro Yasuda, Yusuke Kitamura, Masaaki Iwatsuki, Hideo Baba, Toshihiro Ihara, Yoshitaka Nakanishi, and Yuta Nakashima*, "Detection of cancer cells in whole blood using a dynamic deformable microfilter and a nucleic acid aptamer," Talanta, 228, 122239, 2021.

List of books

[1] 中島雄太, "第 14 章　インキュベータ内での培養動物細胞リアルタイムモニタリング," 動物細胞の培養システム～技術と市場～ (監修 : 井上國世), pp. 162-168, 2021. ISBN978-4-7813-1619-2

List of grants

[1] JST FOREST, ¥ 20,000,000-, Apr. 2022 – Mar. 2025. (Principal Investigator)
[2] Gap Funding, 九州・大学発ベンチャー振興会議, ¥ 1,500,000-, 2021. (Principal Investigator)
[3] Research and Development Grants, Fukuoka Financial Group, ¥ 1,500,000-, Dec. 2020 – Mar. 2022. (Principal Investigator)
[4] Gap Funding, Higo Bank, ¥ 5,000,000-, Sep. 2020 – Mar. 2023. (Principal Investigator)
[5] KAKENHI (Grant-in-Aid for Challenging Research (Exploratory)), ¥ 6,370,000-, Apr. 2020 – Mar. 2021. (Principal Investigator)
[6] KAKENHI (Grant-in-Aid for Scientific Research (B)), ¥ 17,420,000-, Apr. 2019 – Mar. 2023. (Principal Investigator)
[7] KAKENHI (Grant-in-Aid for Challenging Research (Exploratory)), ¥ 600,000-, Apr. 2021 – Mar. 2023. (Co-Investigator)
[8] KAKENHI (Grant-in-Aid for Scientific Research (B)), ¥ 1,800,000-, Apr. 2020 – Mar. 2023. (Co-Investigator)
[9] Environmental Restoration and Conservation Agency of Japan, ¥ 9,100,000-, Apr. 2019 – Mar. 2022. (Co-Investigator)
[10] KAKENHI (Fund for the Promotion of Joint International Research (Fostering Joint International Research (B))), ¥ 2,500,000-, Apr. 2019 – Mar. 2025. (Co-Investigator)

List of social contributions

[1] Committee Member
Research for Innovation & Synthesis of Technology in Kumamoto
Jun 23, 2021 – Mar. 31, 2022
[2] Editorial committee
38th Sensorsymposium, IEEJ (The Institute of Electrical Engineers of Japan)
Mar. 23, 2021 – Dec. 31, 2021.
[3] Steering committee
Micro-Nano Science & Technology Division, The Japan Society of Mechanical Engineers
Apr. 14, 2021 – Mar. 31, 2022.
[4] Representative
Micro-Nano Science & Technology Division, The Japan Society of Mechanical Engineers
Apr. 14, 2021 – Mar. 31, 2022.
[5] Advisory board of Doctoral course students
Kyushu University (Graduate School of Information Science and Electrical Engineering)
Jun 12, 2019 – Mar. 31, 2022.

List of patents

[1]発明の名称：導光ユニット、吸光度測定装置、およびインキュベータ

出願番号：特願 2022-007939
出願日：令和 4 年（2022 年）1 月 21 日
発明者：中島雄太
出願人：国立大学法人熊本大学、西川計測株式会社

3. Visiting Professors

No.	Name	Project Title
3-1	**Rajendra Udyavara Acharya** HP: Makiko Kobayashi	Advanced Biomedical Evaluation System
3-2	**Josep-Lluis Barona-Vilar** HP: Makoto Takafuji	Development of Photo-Sensing Polymer Hybrid with Nano-Dispersed Photo-Functional Molecular Gels
3-3	**Pierre Breul** HP: Jun Otani	Visualization of inner soil behavior in double sheet pile with surface friction properties using X-ray CT and numerical simulation using DEM
3-4	**Maria Jose Cocero** HP: Tetsuya Kida	Biomass to Green Energy Conversion Technologies
3-5	**Patrice Jean Delmas** HP: Toshifumi Mukunoki	Image processing and analysis on Geotechnical and Geoenvironmental Engineering
3-6	**Derek Elsworth** HP: Atsushi Sainoki	Development of a method to simulate the mechanical behaviour of rock discontinuity during fluid injection
3-7	**Tomonari Furukawa** HP: Makoto Kumon	Study on intelligent mobile robot to escort with intention inference
3-8	**Olivier Hamant** HP: Shinichiro Sawa	Plant Cell and Developmental Biology
3-9	**Kwon, Ick Chan** HP: Takuro Niidome	Nano-medicine and Theranostics
3-10	**Reiko Oda** HP: Makoto Takafuji	Fabrication of Nano-to-Submicron-sized Exclusive Pods and Their Spatial Functionalization
3-11	**Zoran Ren** HP: Kazuyuki Hokamoto	Fabrication of various porous materials through explosive and other processes and the evaluation of such porous materials under high-rate impact loading
3-12	**Gioacchino (Cino) Viggiani** HP: Jun Otani	Application of X-ray CT
3-13	**Tomoyasu Mani** HP: Yutaka Kuwahara	Utilization of photons and spins in Functional Materials
3-14	**Daniel P. Zitterbart** HP: Kei Toda	Understanding the role of oceanic chemoattractants in marine animal navigation

HP: Host Professor

No.3-1	Advanced Biomedical Evaluation System		
Name	U Rajendra Acharya		
Affiliation	Ngee Ann Polytechnic Email: rajendra_udyavara_acharya@np.edu.sg	Title	Senior Research Fellow
Research Field	Nanomaterial Science/ Advanced Green Bio		
Host Professor	Makiko Kobayashi		
Affiliation	Kumamoto University Email: kobayashi@cs.kumamoto-u.ac.jp	Title	Professor

1. Research achievements

Discussed the project entitled "Automated system and method of monitoring anatomical structures". We filed a PCT application (PCT/SG2020/050538) on this topic in 2020 and entered national phase to Singapore, Japan, and USA in 2022.

2. Overview and significance of the research collaboration with Kumamoto University

Cardiovascular disease (CVD) is the leading cause of death worldwide, and coronary artery disease (CAD) is a major contributor. Early-stage CAD can progress if undiagnosed and left untreated, leading to myocardial infarction (MI) that may induce irreversible heart muscle damage, resulting in heart chamber remodeling and eventual congestive heart failure (CHF). Electrocardiography (ECG) can detect established MI and may also be helpful for early diagnosis of CAD. For the latter especially, the ECG perturbations can be subtle and potentially misclassified on manual interpretation and/or traditional algorithms found in ECG machines. For automated diagnostic systems (ADS), deep learning techniques are favored over conventional machine learning techniques, due to the automatic feature extraction and selection processes involved. This paper highlights various deep learning algorithms exploited for the classification of ECG signals into CAD, MI and CHF conditions. The Convolutional Neural Network (CNN), followed by combined CNN and Long Short-Term Memory (LSTM) models, appear to be the most useful architectures for classification. A 16-layer LSTM model was developed in our study and validated using 10-fold cross validation. A classification accuracy of 98.5% was achieved. Our proposed model has the potential to be a useful diagnostic tool in hospitals for the classification of abnormal ECG signals.

3. Prospect for further research collaboration with Kumamoto University

I started to serve as a distinguished professor in Kumamoto University. I shall continue to collaborate and write papers with Prof. Toshitaka Yamakawa, Prof. Masayuki Tanabe, and Prof. Makiko Kobayashi in the coming days.

4. List of co-authored papers published between April 2021 and March 2022.

N/A

No.3-2	Development of Photo-Sensing Polymer Hybrid with Nano-Dispersed Photo-Functional Molecular Gels		
Name	Josep-Lluis Barona-vilar		
Affiliation	Instituto de Historia de la Medicina y de la Ciencia López Piñero (IHMC), Universidad de Valencia, Spain Email: Jose.Luis.Barona@uv.es	Title	Professor
Research Field	Nanomaterial Science		
Host Professor	Makoto Takafuji		
Affiliation	Faculty of Advanced Science and Technology Email: takafuji@kumamoto-u.ac.jp	Title	Professor

1. Research achievements
   - The collaboration project "Development of photo-sensing polymer hybrid with nano-dispersed photo-functional molecular gels" (Bilateral Joint Research Project (OP) funded by JSPS, FY2019–FY2021) has been completed.
   - A doctoral student who participated in this project was awarded a PhD degree in March 2022.
   - One paper has been published in the international scientific journals.
   - In FY2021, Japanese and Spanish members could not visit each other because of COVID-19 pandemic.

2. Overview and significance of the research collaboration with Kumamoto University
   Although there were no mutual visits in FY2021, the joint research proceeded, and the bilateral joint research project, which started in 2019, was completed in this year. A doctoral student who participated in this project was awarded a PhD degree in March 2022.

3. Prospect for further research collaboration with Kumamoto University
   Prof. Josep BARONA is scheduled to visit Japan in the fall of FY2022 for future research collaborations.

4. List of co-authored papers published between April 2021 and March 2022.
   Non (One paper by researchers from Kumamoto University was published)

No.3-3	Visualization of inner soil behavior in double sheet pile with surface friction properties using X-ray CT and numerical simulation using DEM		
Name	Pierre Breul		
Affiliation	Polytech Clermont / Enseignant Dpt Génie Civil Email: pierre.breul@uca.fr	Title	Professor
Research Field	Nanomaterial Science/ Green Energy/ Environmental Science/ Advanced Green Bio/ Other (Geotechnical Engineering)		
Host Professor	Jun Otani		
Affiliation	Email: junotani@kumamoto-u.ac.jp	Title	Professor

1. Research achievements

As an active researcher in the field of X-ray CT and micromechanics of geomaterials, I organized a workshop as a visiting professor. During my stay in Kumamoto, I performed the following activities:

1) Regular research meeting with PhD candidate, Mr. Hideharu Sugimoto and Prof. Toshifumi Mukunoki.
2) Mr. Sugimoto has studied abroad at My lab. from April in 2022 to March in 2023 as double degree program between Polytech Clermont and Kumamoto University.

2. Overview and significance of the research collaboration with Kumamoto University

These activities will be able to contribute:

1） Enhancement of worldwide activities with X-Earth center,
2） Enhancement of international collaboration, and
3） Development of human resources which are not only faculty members but also graduate students

3. Prospect for further research collaboration with Kumamoto University

Since April 2022, Mr. Sugimoto has visited and stayed at our laboratory to study together. Now, it is possible to well discussion using ZOOM or others before study abroad so we would like to encourage bot students to go abroad by organizing online workshop. Especially, X-Earth Center of Kumamoto University has great X-ray CT scanner and it will get suitable data for DEM analysis to compare the actual phenomena and numerical results in micro scale. This kind of study will accelerate the progress of micro-macro mechanics. We do hope to prepare good data to publish one good journal paper next year.

4. List of co-authored papers published between April 2021 and March 2022.

Under writing

No.3-4	Biomass to Green Energy Conversion Technologies		
Name	Maria Jose Cocero		
Affiliation	High Pressure Research Group/Department of Chemical Engineering and Environmental Technology, Valladolid University (Spain) Email: mjcocero@iq.uva.es	Title	Professor
Research Field	Green Energy/ Advanced Green Bio		
Host Professor	Tetsuya KIDA/ Armando QUITAIN		
Affiliation	Department of Applied Chemistry & Biochemistry,Kumamoto University Email: tetsuya@kumamoto-u.ac.jp Center for International Education, Kumamoto University Email: quitain@kumamoto-u.ac.jp	Title	Professor

1. Research achievements

Due to cross-border travel restrictions related to COVID-19 pandemic, researcher and student mobilities were still not possible this academic year. However, the following research-related and online academic activities were carried out:

1.1 Supervision of an alumnus from Kumamoto University, Dr. Elaine G. Mission, under the Marie-Curie Individual Fellowship Program. She was a doctoral student under the mentorship of Prof. Tetsuya Kida and Prof. Armando Quitain. She is currently working on research related to biomass utilization using microwave and supercritical fluid technologies for 2 years until September 2022.

1.2 Online lecture in the Global Team Teaching/COIL subject related to “Perspectives on Biomass Utilization”, being offered at the Center for International Education and participated by a total of about 50 undergraduate students from Kumamoto University and Sepuluh Nopember Institute of Technology (ITS, Indonesia) and other ASEAN universities.

1.3 Application to AY2022 JSPS Bilateral Joint Research Project

1.4 Application to AY2022 JST Sakura Science Exchange Program including one participant from Valladolid University

2. Overview and significance of the research collaboration with Kumamoto University

The research collaboration on the use of green technologies (supercritical fluid and microwave) for biomass utilization with Kumamoto University (KU) started more than a decade ago with Prof. Motonobu Goto, and was renewed by Dr. Armando T. Quitain when he visited as an IROAST Young Researcher in 2017 for half a year. This collaboration also supported visits of 8 promising young students from Kumamoto under TOBITATE Ryugaku Japan Program or IJEP Scholarship, significantly broadening the global perspectives of participating students to the science and technology of this promising environment-related topic on biomass utilization.

Consultation and discussion with the students significantly helped them improved their research capability. Collaboration with prominent researchers like Prof. Maria Jose Cocero guided the students the right direction for their respective research topics. This also gave them rare opportunity to have a discussion with world-renowned and leading scientists/international researchers in this field, thereby improving their research capability and global mindset.

3. Prospect for further research collaboration with Kumamoto University
Research collaboration with Kumamoto University will be further strengthened by continuous exchange of researchers and students. With subsequent visits in the future, it is expected that a new set of students will benefit from it, and more research papers will be jointly published from this extended collaboration.

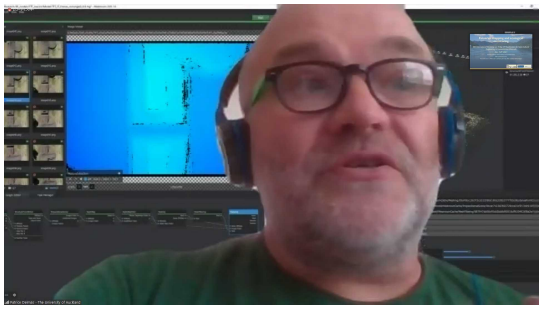
4. List of co-authored papers published between April 2021 and March 2022.
N/A

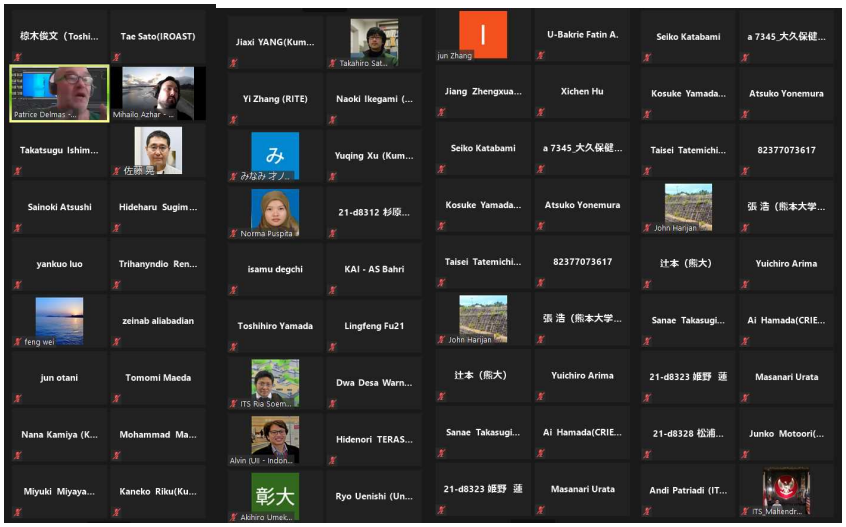
No.3-5	Image processing and analysis on Geotechnical and Geoenvironmental Engineering		
Name	Patrice Delmas		
Affiliation	The University of Auckland Email: p.delmas@auckland.ac.nz	Title	Associate Professor
Research Field	Environmental Science/Image processing		
Host Professor	Toshifumi Mukunoki		
Affiliation	Email: mukunoki@kumamoto-u.ac.jp	Title	Professor

1. Research achievements
   To upgrade Plug-in of Image J to perform EM algorithm calculation for image segmaentation.

2. Overview and significance of the research collaboration with Kumamoto University
   These activities will be able to contribute:
   1) Enhancement of worldwide activities with X-Earth center,
   2) Enhancement of international collaboration, and
   3) Development of human resources which are not only faculty members but also graduate students

As an active researcher in the field of X-ray CT and micromechanics of geomaterials, I organized *Interdisciplinary Imaging Research* in a workshop as a visiting professor on Dec. 8th, 2021.





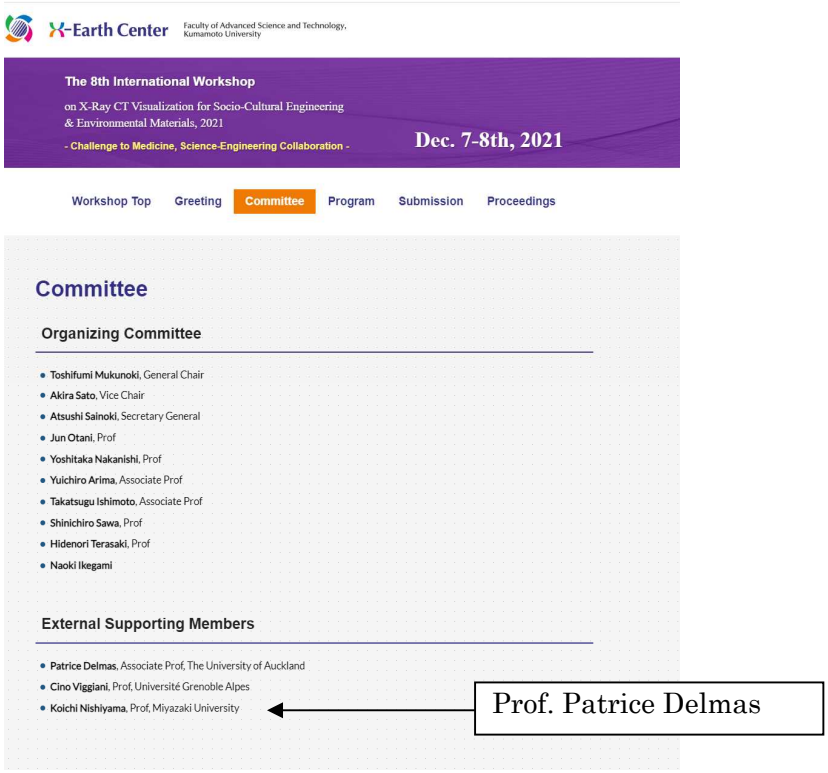


Figure 1. Committee member of IWX2021

3. Prospect for further research collaboration with Kumamoto University
Prof. Mukunoki and I applied JSPS Invitational Fellowship for Research in Japan in 2021. Unfortunately our proposal was not accepted. Now, X-Earth center has three great CT scanner so I have many opportunity to visit Kumamoto University and promote research with respect to image analysis for Prof. Mukunoki's project. Moreover, I have some good UAV and spectral camera so I can also contribute the monitor slope for natural disaster study. Prof. Mukunoki also has same idea already so I would like to come to Kumamoto with my team soon.

4. List of co-authored papers published between April 2021 and March 2022.
Under writing

No.3-6	Development of a method to simulate the mechanical behaviour of rock discontinuity during fluid injection		
Name	Derek Elsworth		
Affiliation	The Pennsylvania State University USA Email: elsworth@psu.edu	Title	Professor
Research Field	Green Energy		
Host Professor	Atsushi Sainoki		
Affiliation	Email: atsushi_sainoki@kumamoto-u.ac.jp	Title	Associate Professor

1. Research achievements

Fluid injection into a rock mass from industrial processes can cause perceivable seismic events that may raise public concern. This seismicity can be caused by injection-induced fluid pressure in the rock mass causing slip on faults. Here we provide a method to distinguish between aseismic and seismic mobilisation and to predict fault movement due to anthropogenic fluid injection. This was achieved by extending a two-dimensional fully coupled fluid and mechanical loading extended finite element model (X-FEM) via development of a dynamic analysis module as a standalone code in Matlab. This code considers fluid flow along the fault as well as into the rock mass and uses a directly proportional equivalent injected flow rate into the fault as the input. This model was validated by comparing the resultant pressure and normal and shear displacements calculated at the centre of the fault against observations from a decametre-scale in-situ experiment. The main results were that not only the mechanics of the fault could be simulated using this approach, but that the simulation correctly predicted the onset of seismicity and transition to dynamic analysis and at similar seismic magnitudes to observations. Parametric studies investigated the influence of the flow rate (when injecting a constant volume of water) and the effect of rate and state frictional parameters in representing modes of seismicity. The main conclusion is that this modelling technique using X-FEM provides an accurate method in accurately predicting modes, location and timing of fault remobilisation due to fluid injection inclusive of important precursory aseismic fault movements. These results are important, since they demonstrate the applicability of this X-FEM approach in accurately predicting the mechanics of fault reactivation and the resultant seismicity, aiding in the design and scheduling of fluid injection operations and in the optimisation of operational parameters.

2. Overview and significance of the research collaboration with Kumamoto University

Sainoki laboratory at Kumamoto University has developed a novel numerical simulation code in the framework of the Extended Finite Element Method, whereby it is possible to simulate the mechanical behaviour of a fault during fluid injection into the fault whilst considering the rock-fluid coupling behaviour with high accuracy and saving the RAM. G3 Lab at Penn State conducted an experiment in the field, where fluid was injected into a natural fault situated at a great depth. The data obtained from the experiment are used in this collaborative research to improve the accuracy of the numerical simulation code and further investigate the dynamic behaviour of the fault during fluid injection related to the occurrence of induced earthquake. Through this research collaboration, it would be possible to develop a technology that can mitigate the risk for induced seismicity during fluid injection related to various green energy-related engineering projects, such as geothermal energy development and carbon capture and sequestration, thus contributing to sustainable energy development.

3. Prospect for further research collaboration with Kumamoto University
Various experimental data can be provided by G3 Center at Penn State, which can be utilized for the numerical simulation. By combining the XFEM-based numerical simulation with the experimental data, further investigation on the fluid injection-induced fault-slip can be achieved, thus contributing to the development of safe and sustainable green energy technologies.

4. List of co-authored papers published between April 2021 and March 2022.
Schwartzkopff, A.K., Sainoki, A., Elsworth, D., 2021. Numerical simulation of mixed aseismic/seismic fault-slip induced by fluid injection using coupled X-FEM analysis, IJRMMS, 147, 104871 (Impact Factor = 7.135)

No.3-7	Study on intelligent mobile robot to escort with intention inference		
Name	Tomonari Furukawa		
Affiliation	Department of Mechanical and Aerospace Engineering, University of Virginia, USA Email: tf4rp@virginia.edu	Title	Professor
Research Field	Robotics and computational/experimental mechanics		
Host Professor	Makoto Kumon	Title	Professor
Affiliation	Faculty of Advanced Science and Technology Email: kumon@gpo.kumamoto-u.ac.jp		

1. Research achievements:

There have been several achievements through the invitation. In summary, achievements include:

1. Experimental results: As proposed in the project, the primary aim of this invitation was to develop an intelligent mobile robot that escorts with intention inference. We developed an identical system at Kumamoto University so that we could do experiments collaboratively. We conducted experiments and collected data.
2. Mapping capability: In order for safe navigation, a robot escort needs to develop and update a map. This necessitates the capability of Simultaneous Localization and Mapping (SLAM). As Kumon has been working on the detection of loop closure for SLAM, we worked on the mapping capability as part of the escorting robot project.
3. Vision capability: In addition to mapping, the escorting robot needs high-precision vision since it observes human behavior and its environment. As Furukawa has been working on high-precision vision based on photometric stereo, we also worked on the vision capability as part of the escorting robot project.

2. Overview and significance of the research collaboration with Kumamoto University

Kumon and Furukawa started their collaboration in 2007 when Kumon came to University of New South Wales (UNSW) where Furukawa worked at that time for his sabbatical. Their collaboration has continued for nearly 15 years, and the topics of collaboration during the period include not only robot escorting, robotic mapping and robotic vision but also sound localization, drones and multi-robot cooperation. Furukawa visited Kumamoto University as JSPS Fellow in 2013 and 2021. He also visited Kumamoto University as IROAST Visiting Professor in 2017, 2018 and 2019. Kumon had his sabbatical with Furukawa in 2007 (UNSW) and 2019 (VT/UVA). In addition, there were several other visits. The collaboration has resulted in over 10 refereed papers. Kumon's graduate student studied with Furukawa at VT for a few months as an exchange student, and Furukawa's graduate student also studied with Kumon at Kumamoto University for a few months under the National Science Foundation (NSF) program. It is a rare case that the collaboration continued intensively for such a long time.

3. Prospect for further research collaboration with Kumamoto University

We keep exploring external funding and leverage external funding for their collaboration. Kumon was Senior Personnel of Furukawa's NSF project on sound localization and invited to VT. Furukawa was also invited to Kumamoto University through Kumon's grant. We keep exploring external funding to support their collaboration in addition to the IROAST program.

4. List of co-authored papers published between April 2021 and March 2022.

Y. Qin, M. Kumon and T. Furukawa, "Estimation of a Human-Maneuvered Target Incorporating Human Intention," Sensors, Vol. 21, No. 16: 5316, 2021. https://www.mdpi.com/1424-8220/21/16/5316

No.3-8	Plant Cell and Developmental Biology		
Name	Olivier Hamant		
Affiliation	INRAE, CNRS Email: olivier.hamant@ens-lyon.fr	Title	Professor
Research Field	Advanced Green Bio		
Host Professor	Sinichiro Sawa		
Affiliation	GSST/IRCAEB Email: sawa@kumamoto-u.ac.jp	Title	Professor

1. Research achievements

We hypothesized that plant stem integrity depends on the epidermal resistance to mechanical stress, and we have identified about stem integrity requires a load-bearing epidermis by using Arabidopsis genetic approach.

2. Overview and significance of the research collaboration with Kumamoto University

Kumamoto University has launched IRCAEB in GSST for agricultural research. Our collaboration is related to agricultural perspective, and this collaboration is quite important for the development of Agricultural Research Activity in KU.

3. Prospect for further research collaboration with Kumamoto University

Now, our university have IRCAEB in GSST, and many plant researchers are working. Professor Hamant is one of the leader in the plant science field, and we could collaborate not only in science or grant application but also education between KU and Europe.

4. List of co-authored papers published between April 2021 and March 2022.

N/A

No.3-9	Nano-medicine and Theranostics		
Name	Ick Chan Kwon		
Affiliation	Biomedical Research Institute, Korea Institute of Science and Technology (KIST), Korea Email: ikwon@kist.re.kr	Title	Principal Research Scientist
Research Field	Nanomaterial Science		
Host Professor	Takuro Niidome		
Affiliation	Faculty of Advanced Science and Technology Email: niidome@kumamoto-u.ac.jp	Title	Professor

1. Research achievements

In the last decades, the development of nanocarriers for the efficient delivery of drugs offers a wide range of biotechnology applications. Due to the advantage of the size, nanomaterials have been shown to be robust drug delivery systems and may be useful for encapsulating drugs and enabling more precise targeting with a controlled release by various external stimulation (ex. pH, ROS, Temperature, and so on). Nanomedicine has revolutionized existing cancer therapies through the improvement of pharmacological kinetics and dynamics. As well, image-guided drug delivery can be used for various purposes, ranging from simple and straightforward biodistribution studies to extensive and elaborate experimental setups aiming to enable “personalized medicine”, and to improve the efficacy of combined modality anticancer therapy. Despite the enormous progress in the field of nanotherapeutics, the use of artificially synthesized nanocarriers still faces several challenges, including rapid clearance from blood circulation, off-target effects, and ineffective nanoparticles (NPs) transfer in patients with advanced forms of cancer. Furthermore, NPs will encounter multiple physiological barriers that influence their effectiveness, such as blood circulation, NPs-protein interaction, extravasation into tumor tissue or the tumor microenvironment (TME), phagocytic sequestration, and renal clearance.

Prof. Kwon is an expert in smart nanomaterials for bioimaging. He gave us information for state-of-art diagnosis and drug delivery systems and lots of advice for our research unit. His support will be a great basis for our research activities for the development of novel therapeutic approaches. Although he could not come to IROAST and have a chance to talk together due to the pandemic of COVID-19 in 2020, in 2021, we are going to have chances to talk through the web system, and exchange information about our research work and the progress of this research field in the world.

2. Overview and significance of the research collaboration with Kumamoto University

Under pandemic, we couldn’t contact face-to-face. However, the border starts to be opened and travel will be possible soon. Dr. Kwon wishes that the IROAST’s research support for young researchers and interdisciplinary collaboratives are kept expanding.

Since 2019, Dr. Kwon provide polymers that were developed/patented by Dr. Kwon. The provided polymers were modified in the Lee lab for advanced application. His research team kept support to modified polymers and evaluated the properties. Furthermore, Dr. Kwon keeps advising for immune cell-mediated delivery for suggesting a new paradigm in the field of lung inflammatory diseases. Dr. Kwon and Lee's lab keep closely discussing the project every month with involved students and step forward to reach the final goal.

3. Prospect for further research collaboration with Kumamoto University

Dr. Kwon was invited for joining the WPI project of IRCMS. If Kumamoto University will be granted the WPI program, he will contribute delivering nanodiamonds to the developmental stage of each organ. The project is a world-first trial and many international researchers in different fields will be gathering at Kumamoto and performing interdisciplinary research.

No.3-10	Fabrication of Nano-to-Submicron-sized Exclusive Pods and Their Spatial Functionalization		
Name	Reiko Oda		
Affiliation	Centre national de la recherche scientifique (CNRS), Université de Bordeaux, France Email: r.oda@cbmn.u-bordeaux.fr	Title	Research Director
Research Field	Nanomaterial Science		
Host Professor	Makoto Takafuji		
Affiliation	Faculty of Advanced Science and Technology Email: takafuji@kumamoto-u.ac.jp	Title	Professor

1. Research achievements

- The second term of joint research project, Laboratoire International Associé "Chiral Nanoobjects for Photonic Application (LIA-CNPA)" supported by Agence Nationale de la Recherche (ANR) France, is proceeding.
- The collaboration project "Fabrication of nano-to-submicron-sized exclusive pods and their spatial functionalization" (Grants-in-Aid for Fostering Joint International Research (B) funded by JSPS, FY2017–FY2021) is progressing well, but the decision was made to extend the project through FY2022 to allow for reciprocal visits.
- Dr. Nanami Hano, a member of the research unit "Nano-organics and Nano-hybrids", has joined Reiko Oda's group as a JSPS Overseas Research Fellow from March, 2022. She will accommodate in UB for two years and may accelerate our collaborations.
- Two co-authored papers have been published in the international scientific journals.
- In FY2021, Japanese and French members could not visit each other because of COVID-19 pandemic.

2. Overview and significance of the research collaboration with Kumamoto University

Although we were not able to realize mutual visits in FY2021, we have been able to implement our joint studies so far without delay. Research results were published in two papers in the distinguished international journals, and several research presentations were made at domestic and international conferences. The project, in which young researchers and graduate students participated, also contributed to the development of young researchers. In particular, Dr. Nanami Hano, a member of the research unit "Nano-organics and Nano-hybrids", joined to Dr. Reiko ODA's laboratory as a JSPS Overseas Research Fellow for two years from March 2022, which is expected to accelerate our collaborations.

3. Prospect for further research collaboration with Kumamoto University

We have applied for the research fund (Bilateral Joint Research Projects, JSPS) with other members of the University of Bordeaux and plan to further expand our joint research framework with the University of Bordeaux. The renewal of the exchange agreement with the University of Bordeaux is planned in FY2022, and we believe that the contribution of our research exchanges will be significant.

4. List of co-authored papers published between April 2021 and March 2022.
   1) Enantioselective self-assembled nanofibrillar network with glutamide-based organogelator
      N. Nagatomo, H. Oishi, Y. Kuwahara, M. Takafuji, R. Oda, T. Hamada H. Ihara
      Nanomaterials, Vol. 11(6), 1376, **2021**. DOI: 10.3390/nano11061376. Special issue "Self-assembled nanostructures for molecular recognition" (Special editors: Makoto Takafuji and Hirotaka Ihara)

   2) Lanthanide ion-doped silica nanohelix: a helical inorganic network acts as a chiral source for metal ions
      T. Harada, H. Yanagita, N. Ryu, Y. Okazaki, Y. Kuwahara, M. Takafuji, S. Nagaoka, H. Ihara, R. Oda
      Chemical Communications (RSC), Vol. 57, pp. 4392-4395, **2021**. DOI: 10.1039/d1cc01112j

No.3-11	Fabrication of various porous materials through explosive and other processes and the evaluation of such porous materials under high-rate impact loading		
Name	Zoran Ren		
Affiliation	Faculty of Mechanical Engineering, University of Maribor Email: zoran.ren@um.si	Title	Professor
Research Field	Nanomaterial Science/ Green Energy/ Environmental Science/ Advanced Green Bio/ Other (Materials processing)		
Host Professor	Kazuyuki Hokamoto		
Affiliation	Institute of Industrial Nanomaterials Email: hokamoto@mech.kumamoto-u.ac.jp	Title	Professor

1. Research achievements

Due to the continuing pandemic, we could not realize the planned research exchanges, which reflected in reduced combined research activities. We have taken advantage of the online communication to keep in touch, which led to the successful publication of one joint article in high-ranked international journal. We plan to return to regular research exchanges in the second half of 2022 and in 2023.

2. Overview and significance of the research collaboration with Kumamoto University

The joint research work objective is to continue to perform frontier research of cellular structure designs on different length scales for their broader use in the next generation of engineering (lightweight structures, energy absorbers), medical (vascular stents and scaffolds), sports (cellular textiles, vibration mitigation) and other products. The collaborative research effort ledas to significant advances in design, production technology, geometrical and mechanical characterization of new metamaterials with cellular structures with the efficient application of theoretical, analytical, experimental, and computational research methods. The research focuses on developing new cellular metamaterials designs with specifically tailored (individualized) mechanical properties (stiffness, damping, energy absorption, etc.) by a careful combination of cell topology and morphology with efficient use of (multi)material combinations to achieve their best structural and functional performance in new products with advanced multifunctional properties. We adapt, upgrade, and propose new characterization methodologies using improved testing rigs supported by advanced computational simulations throughout the entire research process.

3. Prospect for further research collaboration with Kumamoto University

Kumamoto University is a very friendly academic and research institution with great facilities and excellent professors and students. Many excellent specialists work at the Institute of Industrial Nanomaterials, covering the fields essential for developing and characterizing new metamaterials. The Institute also has at its disposal some excellent and unique research equipment, like the powder gun and 2 explosion pits together with the measuring equipment, which together enables quality observations of materials behaviour at very high strain rates.

Research groups at both partner institutions have significant and complementary experiences in fabrication, characterization and computational modelling of novel engineering materials. The cooperation contributes to the effective transfer of knowledge between the partner institutions. Since the undertaken research effort is scientifically and industrially significant for both partner institutions, it is safe to assume that future research collaboration will result in important scientific findings, published in high ranking reviewed scientific journals and possibly some new patents for industrial application.

4. List of co-authored papers published between April 2021 and March 2022.

Nishi, M., Tanaka, S., Mori, A., Vesenjak, M., Ren, Z., Hokamoto, K.
Mechanism Elucidation of High-Pressure Generation in Cellular Metal at High-Velocity Impact
(2022) Metals, 12 (1), art. no. 128.

No.3-12	Application of X-ray CT		
Name	Gioacchino (Cino) Viggiani		
Affiliation	Laboratoire 3SR, UGA, Grenoble, France Email: cino.viggiani@3sr-grenoble.fr	Title	Professor
Research Field	Advanced Green Bio		
Host Professor	Jun Otani		
Affiliation	Faculty of Advanced Science and Technology Email: junotani@kumamoto-u.ac.jp	Title	Professor

1. Research achievements

As an active researcher in the field of X-ray CT and micromechanics of geomaterials, I organized a workshop as a visiting professor. During my stay in Kumamoto, I performed the following activities:

1) Research meeting with the members of X-Earth Center (about X-ray CT applications) (please check IROAST HP)
2) International workshop on X-Earth (IWX) with the members of X-Earth Center (please check IROAST HP)
3) One of master students in Otani's lab. has studied abroad at 3SR from September in 2021 to July in 2022.

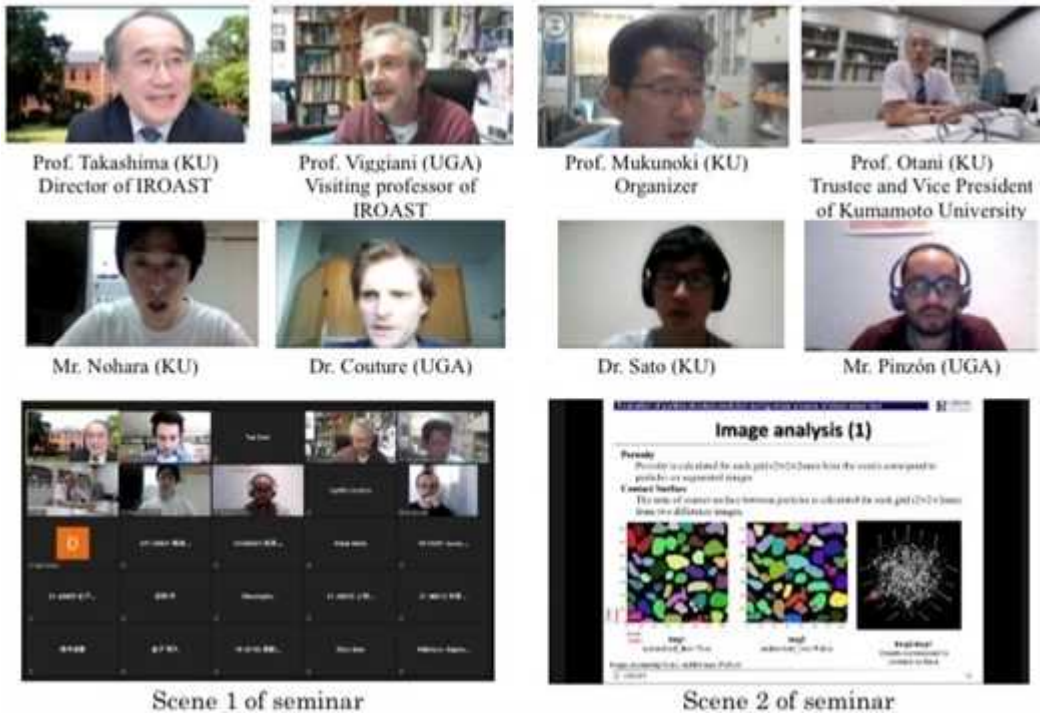


Photo.1 Screenshot of Online research meeting held on May, 2021.

2. Overview and significance of the research collaboration with Kumamoto University

These activities will be able to contribute:

1) Enhancement of worldwide activities with X-Earth center,
2) Enhancement of international collaboration, and
3) Development of human resources which are not only faculty members but also graduate students

3. Prospect for further research collaboration with Kumamoto University

In fact, we have discussed about research collaboration with Kumamoto University and Caltech in the United States, of which Prof. Andrade is now also visiting professor at IROAST. All three institutions are very active for the research on micro mechanics and the use of X-ray CT in geomaterials. I hope we will have some further steps for these joint activities next year.

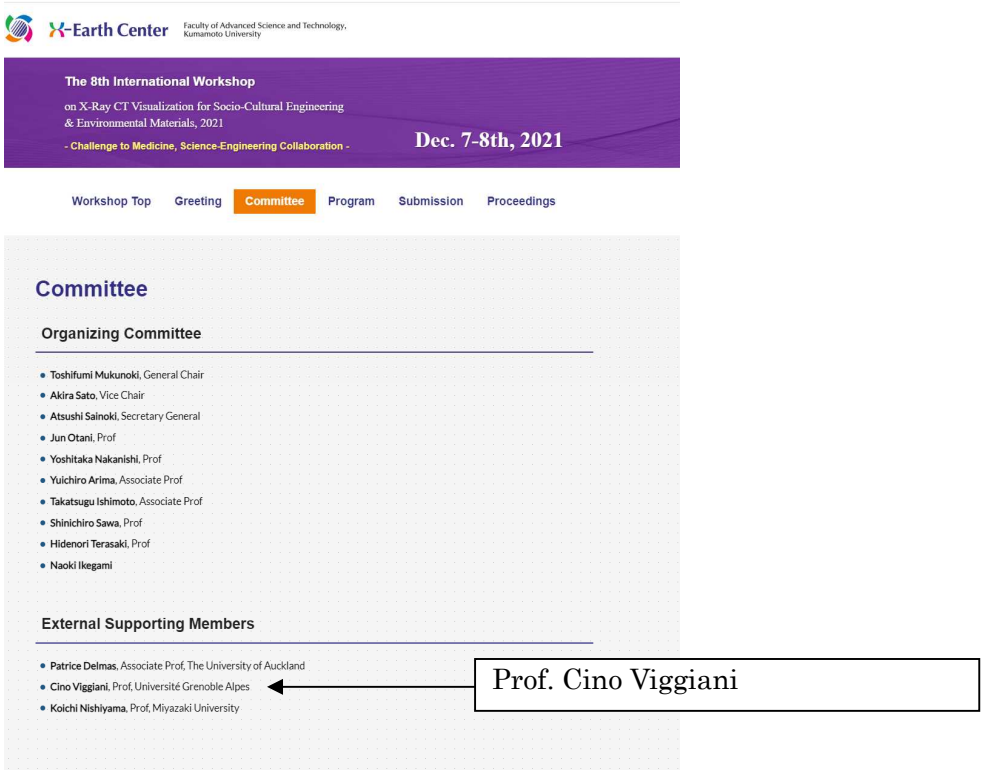


Figure 1. Committee member of IWX2021

4. List of co-authored papers published between April 2021 and March 2022.

Under writing

No.3-13	Utilization of photons and spins in Functional Materials		
Name	Tomoyasu Mani		
Affiliation	University of Connecticut USA Email: tomoyasu.mani@uconn.edu	Title	Assistant Professor
Research Field	Nanomaterial Science		
Host Professor	Yutaka Kuwahara		
Affiliation	Email: kuwahara@kumamoto-u.ac.jp	Title	Assistant Professor

1. Research achievements

I could not alternately visit to Kumamoto city this year due to the COVID-19 crisis. Prof. Kuwahara and me discussed about recent research results by e-mail and online. We submitted a paper including those results to an international journal.

2. Overview and significance of the research collaboration with Kumamoto University

Our collaboration is based on a mutual interest of developing novel functional molecules/materials, specifically those containing chiral moieties. The collaborations are two-fold: one is to help Prof. Kuwahara's work on chiraloptical properties of supramolecular assemblies and the other is to jointly investigate a new series of small emissive molecules with chiral moieties. This collaboration enables us to expand our understanding of ways to design molecules/materials with new chiral effects.

3. Prospect for further research collaboration with Kumamoto University

I sent the new compounds to Prof. Kuwahara for chiroptical analysis at the Kumamoto Univ. We expect to accelerate our collaborations for those analytical results.

4. List of co-authored papers published between April 2021 and March 2022.

Paper publication

Y. Kuwahara, M. Ito, T. Iwamoto, M. Takafuji, H. Ihara, N. Ryu, T. Mani, Chemical redox-induced chiroptical switching of supramolecular assemblies of viologens, *RSC Advances*, 2022, **12**, 2019-2025. (DOI: 10.1039/D1RA08984F)

Conference Presentation

M. Ito, Y. Kuwahara, N. Ryu, T. Mani, H. Ihara, M. Takafuji, Chiroptical properties and their stability for supramolecular assemblies of viologen-modified glutamide derivatives and their reduced derivatives, The International Chemical Congress of Pacific Basin Societies (Pacifichem 2020), *Hybrid* (online and onsite at Hawaii, USA), Dec. 21, 2021.

No.3-14	Understanding the role of oceanic chemoattractants in marine animal navigation		
Name	Daniel P. Zitterbart		
Affiliation	Woods Hole Oceanographic Institution USA Email: dpz@whoi.edu	Title	Associate Scientist
Research Field	Environmental Science		
Host Professor	Kei Toda		
Affiliation	Faculty of Advanced Science and Technology Email: todakei@kumamoto-u.ac.jp	Title	Professor

1. Research achievements

Dr. Zitterbart could not visit Kumamoto University in 2021 as well as in 2020 due to situation of COVID-19. Our collaboration is basically based on joined field research and it was difficult to conduct effectively these two years. However, Dr. Zitterbart visited Antarctic in November to perform preliminary survey for Emperor Penguin's chemmoattractants. It will lead to Antarctic joined survey in 2022. In March, Dr. Zitterbart did onboard measurement of chemicals in the North Atlantic Ocean to investigate role of oceanic chemicals in behavior of whales. Two measurement devices were used, one is developed by Dr. Toda and the other is by Dr. Zitterbart with assistance from Dr. Toda. In addition, we have validated sampling/analysis method, which we used in Antarctic Ocean, March 2020. Data obtained in Antarctic were rearranged to be ready for submitting manuscripts.

2. Overview and significance of the research collaboration with Kumamoto University

This is the international collaboration among USA, Japan, Germany, and Sweden. World top researchers joined from the field of physical remote monitoring, chemical analysis, acoustical oceanography, and ocean animal behavior.

3. Prospect for further research collaboration with Kumamoto University

Dr. Zitterbart and Dr. Toda are actively working on extending the collaboration. This is expressed in jointly planned field experiments (up to 6 in the next 3 years) and in coordinated Research proposals across Japanese and US funding agencies to fund our field experiments. After initiation of a student exchange program, we plan to have concurrent PhD students in this research fields at both institutions.

4. List of co-authored papers published between April 2021 and March 2022.

None from April 2021 to March 2022.

4. Research Units

No.	Unit Name	Unit Coordinator
4-1	**Development of Nano and Supramolecular Materials**	Shinya Hayami
4-2	**RNA Biology**	Tokio Tani
4-3	**Plant Cell and Developmental Biology**	Shinichiro Sawa
4-4	**Nano-Organics and Nano-Hybrids**	Makoto Takafuji
4-5	**Nano-medicine and Drug Delivery System**	Hamid Hosano
4-6	**Nano-medicine and Theranostics**	Takuro Niidome
4-7	**Multiscale Modeling of Soil and Rock Materials Using X-ray CT**	Jun Otani
4-8	**Medical Application of X-ray CT)**	Toshifumi Mukunoki
	-Quantification of Three Dimensional Vascular Network	
	-MicroCT-based Quantification of Fibrosis and Vascularization in Pancreatic Tumor	
4-9	**Advanced Structural Materials**	Yoji Mine
4-10	**Microstructure Analysis and Grain Boundary Engineering**	Sadahiro Tsurekawa
4-11	**Structure and Dynamics of Materials Using Quantum Beams and Data-Driven Sciences**	Ichiro Akai
4-12	**Hydrological Environments**	Takahiro Hosono

4-13	**Nano-materials for Energy Applications and Environmental Protection**	Tetsuya Kida
4-14	**Quantitative Bioimaging**	Takumi Higaki
4-15	**Development of novel therapeutic strategy using iron targeted upconversion nanoparticles for Parkinson's disease**	Ruda Lee
4-16	**Deep Learning for Hydrology**	Kei Ishida
4-17	**Environmental Impacts of Ionic Solutes**	Shinichi Ohira
4-18	**Radio Astronomy**	Keitaro Takahashi
4-19	**Plant Stem Cells and Regeneration**	Mitsuhiro Aida
4-20	**Development of microbially-aided carbon sequestration technology**	Atsushi Sainoki
4-21	**Advanced Biomedical Evaluation System**	Makiko Kobayashi
4-22	**Bio-inspired Functional Molecular System**	Yutaka Kuwahara
4-23	**Nanomaterials processing for medical, cosmetic, and environmental applications**	Mitsuru Sasaki
4-24	**Ferroelectric Photovoltaics**	Hiroki Matsuo
4-25	**Next-Generation Design of Structures**	Gaochuang Cai

No.4-1	Development of Nano and Supramolecular Materials		
Research Field	Nano Material Science/ Green Energy/ Environmental Science/ Advanced Green		
Unit Coordinator			
Name	Shinya HAYAMI		
Affiliation	Faculty of Advanced Science and Technology Email: hayami@kumamoto-u.ac.jp	Title	Professor
Unit Members			
Name	Affiliation/Title		
Shintaro IDA	IINa Professor		
Jorge BELTRAMINI	Nanomaterials Centre (NANOMAC); Australian Institute for Bioengineering and Nanotechnology (AIBN), The University of Queensland, Australia Associate Professor-Senior Research Fellow, IROAST Visiting Professor		
Yang KIM	Kosin University, Korea Professor, IROAST Visiting Professor		
Rahul Raveendran NAIR	Materials Physics, National Graphene Institute and School of Chemical Engineering and Analytical Science, The University of Manchester, UK Professor, IROAST Visiting Professor		
Martino DI SERIO	University of Naples Federico II, Italy Professor, IROAST Visiting Professor		
Michio KOINUMA	IINa Associate Professor		

1. Overview of achievements

Graphene oxide (GO) has been considered as only a precursor for graphene but also one of the most promising materials because of its excellent properties such as photoluminescence, ferromagnetism, electrodes and water permeation. As it is now, it is said that GO has wider range of applications than graphene. GO has two important advantages: (1) it can be produced using inexpensive graphite as stating material by cost-effective chemical methods with a high yield, and (2) it is highly hydrophilic and can form stable aqueous colloids to facilitate the assembly of macroscopic structures by simple and cheap solution processes. These advantages indicate that GO can be easily applicate and scale up to industrial level. Therefore, it is important for industrial development to study GO.

Recently, we focused on (i) elastic material, (ii) magnetic material, (iii) 3D raphene oxide as an electrolyte, (iv) anti-corona by using GO nanosheet and its derivatives in 2021.

2. Presentations & Publications published between April 2021 and March 2022

Recrystallization solvent dependent elastic/plastic flexibility of an n-dodecyl-substituted tetrachlorophtalimide, S. Kusumoto, R. Suzuki, M. Tachibana, Y. Sekine, Y. Kim, S. Hayami Chem. Commun., in press. DOI: 10.1039/D2CC00663D

Energy Conversion and Storage in Fuel Cells and Super-Capacitors from Chemical Modifications of Carbon Allotropes: State-of-Art and Prospect, Md. S. Islam, Y. Shudo, S. Hayami Bull. Chem. Soc. Jpn., 95(1), 1-25 (2022). DOI: 10.1246/bcsj.20210297

High Proton Conductivity of 3D Graphene Oxide Intercalated with Aromatic Sulfonic Acids M. A. Rahman, Md.S. Islam, M.Fukuda, J. Yagyu, Z. Feng, Y. Sekine, L. F. Lindoy, J. Ohyama, S. Hayami, ChemPlusChem, in press. DOI: 10.1002/cplu.202200003

Microwave-assisted catalytic conversion of chitin to 5-hydroxymethylfurfural using polyoxometalate as catalyst, Md. S. Islam, M. Nakamura, N. N. Rabin, M. A. Rahman, M. Fukuda, Y. Sekine, J. N. Beltramini, Y. Kim, S. Hayami, RSC Adv., 12(1), 406-412 (2022). DOI: 10.1039/D1RA08560C

High water adsorption features of graphene oxide: Potential of graphene oxide-based desert plantation, Md.S. Islam, J. Yagyu, Y. Sekine, S. Sawa, S. Hayami, Mater. Adv., 3, 3418-3422 (2022). DOI: 10.1039/D2MA00126H

Enhanced mixed proton and electron conductor at room temperature from chemically modified single-wall carbon nanotubes, N. N. Rabin, Md.S. Islam, M. Fukuda, J. Yagyu, R. Tagawa, Y. Sekine, S. Hayami, RSC. Adv., 12(14), 8632-8636 (2022). DOI: 10.1039/D2RA00521B

A Ferroelectric Metallomesogen Exhibiting Field-Induced Slow Magnetic Relaxation, R. Akiyoshi, H. Zenno, Y. Sekine, M. Nakaya, M. Akita, D. Kosumi, L. F. Lindoy, S. Hayami, Chem. Eur. J., 28(5), 1-7 (2021). DOI: 10.1002/chem.202103367

Flexibility Control of Two-Dimensional Coordination Polymers by Crystal Morphology: Water Adsorption and Thermal Expansion, R. Ohtani, H. Yoshino, J. Yanagisawa, H. Ohtsu, D. Hashizume, Y. Hijikata, J. Pirillo, M. Sadakiyo, K. Kato, Y. Shudo, S. Hayami, B. L. Ouay, M. Ohba, Chem. Eur. J., 27(72), 18135-18140 (2021). DOI: 10.1002/chem.202103404

Microwave aided conversion of cellulose to glucose using polyoxometalate as catalyst, M. Nakamura, Md. S. Islam, M. A. Rahman, N. N. Rabin, M. Fukuda, Y. Sekine, J. N. Beltramini, Y. Kim, S. Hayami, RSC Adv., 11(55), 34558-34563 (2021). DOI: 10.1039/D1RA04426E

Thermochromism in a dinuclear copper complex by spin state changes at various temperatures, T. Hamaguchi, Y. Matsuda, N. Satomi, R. Ishikawa, S. Hayami, I. Ando, S. Kawata, Polyhedron, 211, 115540 (2021). DOI: 10.1016/j.poly.2021.115540

Engineering ferromagnetism in Ni(OH)2 nanosheets using tunable uniaxial pressure in graphene oxide/reduced graphene oxide, Y. Shudo, Md. S. Islam, H. Zenno, M. Fukuda, M. Nakaya, N. N. Rabin, Y. Sekine, L. F. Lindoy, S. Hayami, Phys. Chem. Chem. Phys., 23(42), 24233-24238 (2021). DOI: 10.1039/D1CP03387E

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Sekine, M. Nakamura, S. Hayami, Chem. Lett., 50(12), 1945-1948 (2021). DOI: 10.1246/cl.210501

Lethal Interactions of SARS-CoV-2 with Graphene Oxide: Implications for COVID-19 Treatment, M. Fukuda, Md. S. Islam, R. Shimizu, H. Nassar, N. N. Rabin, Y. Takahashi, Y. Sekine, L. F. Lindoy, T. Fukuda, T. Ikeda, S. Hayami, ACS Appl. Nano Mater., 4(11), 11881-11887 (2021). Supplementary Cover, DOI: 10.1021/acsanm.1c02446

Crystal Structures and Spin Crossover of Iron (III) Cocrystal Formed via Halogen Bonding, H. Zenno, R. Akiyoshi, M. Nakamura, Y. Sekine, S. Hayami, Chem. Lett., 50(6), 1259-1262 (2021). DOI: 10.1246/cl.210101

The coordination chemistry of benzhydrazide with lanthanide(III) ions: hydrothermal in situ ligand formation, structures, magnetic and photoluminescence sensing properties, C. Theppitak, F. Kielar, W. Dungkaew, M. Sukwattanasinitt, L. Kangkaew, S. Sahasithiwat, H. Zenno, S. Hayami, K. Chainok, RSC Adv.,11(40), 24709-24721 (2021). DOI: 10.1039/D1RA03106F

A plastically bendable and polar organic crystal, S. Kusumoto, A. Sugimoto, D. Kosumi, Y. Kim, Y. Sekine, M. Nakamura, S. Hayami, CrystEngComm., 23(33), 5560-5563 (2021). DOI: 10.1039/D1CE00724F

Enhanced Fuel Cell Performance Using Ultrafast, Out-of-Plane Proton-Conducting, 3D Graphene Oxide as an Electrolyte, J. Yagyu, Md. S. Islam, Y. Shudo, M. Fukuda, H. Ushijima, J. Ohyama, S. Ida, L. F. Lindoy, S. Hayami, ACS Appl. Energy Mater., 4(6), 6296-6301 (2021). DOI: 10.1021/acsaem.1c01086

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Encapsulation and Controlled Release of Antimalarial Drug Using Surface Functionalized Mesoporous Silica Nanocarriers, H. Hirayama, S. A. Amolegbe, Md. S. Islam, M. A. Rahman, N. Goto, Y. Sekine, S. Hayami, J. Mater. Chem. B, 9, 5043-5046 (2021). DOI: 10.1039/D1TB00954K

High proton conductivity from titanium oxide nanosheets and their variation based on crystal phase, H. Yasutake, Md. S. Islam, M. A. Rahman, J. Yagyu, M. Fukuda, Y. Shudo, K. Kuroiwa, Y. Sekine, S. Hayami, Bull. Chem. Soc. Jpn., 94(7), 1840-1845 (2021). DOI: 10.1246/bcsj.20210139

Hydrogen Bond-Induced Abrupt Spin Crossover Behaviour in 1-D Cobalt(II) Complexes-the Key Role of Solvate Water Molecules, H. Zenno, F. Kobayashi, M. Nakamura, Y. Sekine, L. F. Lindoy, S. Hayami, Dalton. Trans., 50, 7843-7853 (2021). DOI: 10.1039/D1DT01069G

1D Mn(III) coordination polymers exhibiting chiral symmetry breaking and weak ferromagnetism, A. Hara, S. Kusumoto, Y. Sekine, J. Harrowfield, Y. Kim, S. Hayami, M. Nakamura, Dalton. Trans., 16(50), 5428-5432 (2021). DOI: 10.1039/D1DT00569C

Supramolecular Modulation of Spin Crossover in an Fe(II) Dinuclear Triple Helicate, A. R. Craze, H. Zenno, M. C. Pfrunder, J. C. McMurtrie, S. Hayami, J. K. Clegg, F. Li, Inorg. Chem., 60(9),

6731-6738 (2021). DOI: 10.1021/acs.inorgchem.1c00553

Crystallization of Diamond from Graphene Oxide Nanosheets by a High Temperature and High Pressure Method, M. Fukuda, Md. S. Islam, Y. Sekine, T. Shinmei, L. F. Lindoy, S. Hayami ChemistrySelect, 6(14), 3399-3402 (2021). DOI: 10.1002/slct.202100574

Engineering tunable conductivity, p-n junction and light-harvesting semi-conductivity of graphene oxide by fixing reduction mood only, M. R. Karim, M. N. Uddin, M. A. Shaikh, M. S. Rahaman, I. A. Siddiquey, M. A. Arafath, M. S. Islam, S. Hayami, K. A. Alamry, A. M. Asiri, M. M. Rahman J. Taiwan Inst. Chem. Eng., 120, 325-335 (2021). DOI: 10.1016/j.jtice.2021.03.019

Metal complex lipids for fluid-fluid phase separation in co-assembled phospholipid membranes, R. Ohtani, Y. Anegawa, H. Watanabe, Y. Tajima, M. Kinoshita, N. Matsumori, K. Kawano, S. Yanaka, K. Kato, M. Nakamura, M. Ohba, S. Hayami, Angew. Chem. Int. Ed., 60(24), 13603-13608 (2021). DOI: 10.1002/anie.202102774

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Spin crossover phenomena in long chain alkylated complexes, R. Akiyoshi, R. Ohtani, L. F. Lindoy, S. Hayami, Dalton. Trans., 15(50), 5065-5079 (2021). DOI: 10.1039/D1DT00004G

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Magnetism in a helicate complexes arising with the tetradentate ligand, H. Ohmagari, M. Nakaya, K. Tanaka, H. Zenno, R. Akiyoshi, Y. Sekine, Y. Zhang, K. S. Min, M. Hasegawa, L. F. Lyndoy, S. Hayami, Dalton. Trans., 50(2), 494-498 (2021). DOI: 10.1039/D0DT03990J

Light-induced excited spin state trapping in iron(III) complexes, M. Nakaya, R. Ohtani, L. F. Lindoy, S. Hayami, Inorg. Chem. Front., 8(2), 484-498 (2021). DOI: 10.1039/D0QI01188F

Spin State Modulation in Cobalt(II) Terpyridine Complexes by Co-crystallization with 1,3,5-Triiodo-2,4,6-trifluorobenzene, F. Kobayashi, K. Iwaya, H. Zenno, M. Nakamura, L. F. Lindoy, S. Hayami, Bull. Chem. Soc. Jpn., 94(1), 158-163 (2021). DOI: 10.1246/bcsj.20200246

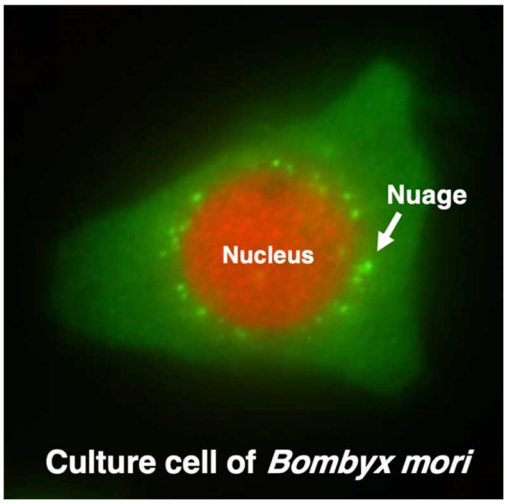
3. Application & acquisition status of KAKENHI and other external grants

KAKENHI Grant-in-Aid for Scientific Research (A) JP17H01200 and Grant-in-Aid for Exploratory Research 20K21213.

4. Application & acquisition status of industrial property rights
non

No. 4-2	RNA Biology		
Research Field	Advanced Green Bio		
Unit Coordinator			
Name	Tokio TANI		
Affiliation	Faculty of Advanced Science and Technology Email: ttani@kumamoto-u.ac.jp	Title	Professor
Unit Members			
Name	Affiliation/Title		
Ramesh Shanmughom PILLAI	Department of Molecular Biology, University of Geneva, Switzerland Professor, IROAST Visiting Professor		
Takashi IDEUE	Faculty of Advanced Science and Technology (FAST), Kumamoto University Assistant Professor		

1. Overview of achievements



The scientific goal of the collaborative project with Prof. Ramesh Pillai is to understand how germline-specific RNA-protein granules called nuage are assembled in a cell. Nuage is non-membrane cytoplasmic electron-dense structure localized near nuclear membrane (a left picture). Nuage is a French word that means “cloud”, as the shape of Nuage is similar to a cloud in the sky under the microscopic observation. Nuage is implicated in the biogenesis of small RNAs called Piwi-interacting RNAs (piRNAs) involved in suppression of transposon induction in germline cells. Using the cultured germline cells established from silk worm Bombyx mori, we have screened for compounds that can either enhance or decrease nuage formation, and have identified Borrelidin that enlarged Nuage and NSC95397 that inhibit Nuage formation. In 2020, as the collaborative work with Prof. Pillai, we analyzed the action mechanisms of these compounds to understand the function of Nuage in piRNA biogenesis. As a result, we revealed that Borrelidin and NSC95397 are kinase and phosphatase inhibitors, respectively, and demonstrated that Nuage formation is regulated by phosphorylation of factors in Nuage. Also, Pillai’s laboratory has developed a systematic imaging-based screen for such Nuage-localizing signals (NuLS). Identification of NuLS peptides will allow the two studies to come together and synergize, as Ramesh group will be able to look for phosphorylation site motifs in the NuLS that might modulate its activity. Knowledge of the NuLS peptides might help us screen for putative kinase and phosphatase regulators of nuage formation. Thus, the collaboration between University of Geneva and Kumamoto University is critical for a complete success of this project.

2. Presentations & Publications published between April 2021 and March 2022
Sequestration of RBM10 in Nuclear Bodies: Targeting Sequences and Biological Significance., Ling-Yu Wang, Sheng-Jun Xiao, Hiroyuki Kunimoto, Kazuaki Tokunaga, Hirotada Kojima, Masatsugu Kimura, Takahiro Yamamoto, Naoki Yamamoto, Hong Zhao, Koji Nishio, Tokio Tani, Koichi Nakajima, Kishiko Sunami, Akira Inoue., Int. J. Molecular Science, 2021, 22(19), 10526; https://doi.org/10.3390/ijms221910526

No.4-3	Plant Cell and Developmental Biology		
Research Field	Advanced Green Bio		
Unit Coordinator			
Name	Sinichiro SAWA		
Affiliation	Faculty of Advanced Science and Technology /International Research Center for Agricultural & Environmental Biology Email: sawa@kumamoto-u.ac.jp	Title	Professor
Unit Members			
Name	Affiliation/Title		
Olivier HAMANT	INRA, RDP, ENS Lyon, France Research Director, IROAST Visiting Professor		
Carolina ESCOBAR	Department of Environmental Sciences, School of Environmental Sciences and Biochemistry, University of Castilla La Mancha, Spain Assistant Professor, IROAST Visiting Professor		
Christian Siegfried HARDTKE	Department of Plant Molecular Biology, University of Lausanne, Switzerland Professor, IROAST Visiting Professor		
Mitsuhiro AIDA	IROAST Professor		
Takumi HIGAKI	IROAST Associate Professor		
Yuki YOSHIDA	FAST Project Assistant Professor		
Hidehiko SUNOHARA	FAST Visiting Assistant Professor		

1. Overview of achievements

Meloidogyne incognita is one of the most detrimental root-knot nematode pests in the world, infecting almost all plant species. We have performed RNA seq analyses during gall development. Some of the gene expression were up-regulated, and these gene analyses are now going on. On the other hand, plant attractant of plant parasitic nematodes were purified, and identified.

In addition, we examined the role for shoot organ boundary region in plant development. We characterized the effect of the boundary expressed *CUC1, CUC2* and *STM* genes on auxin biosynthetic genes and found that the *CUC* genes but not *STM* are required for expression of *YUC1* and *YUC4*, the two major auxin biosynthetic genes expressed in the boundary region. Another boundary expressed gene, *EPFL2*, which encodes a signaling peptide, participates in the promotion of

cotyledon growth as well as auxin response at the cotyledon tips. The results together suggest an important role for the boundary region as a signaling center that coordinates shoot organ development.

We also examined the impact of the jigsaw puzzle-like morphogenesis of the pavement cells in the cotyledon organogenesis. To monitor the cell morphogenesis during the cotyledon expansion, we developed a technique for tracking and measuring changes in the shape of epidermal cells that make up the surface of leaves at a low cost and with high accuracy using metal nano ink and artificial intelligence-based image analysis. Using this experimental system, we are currently analyzing various mutants and overexpressing lines to explore the relationship between cell morphogenesis and organ morphogenesis.

2. Presentations & Publications published between April 2021 and March 2022

Yanagawa, Y., Ratna, N. P., Krishanti, A., Sugiyama, A., Chrysanti, E., Komara, S., Kubo, M., Furumizu, C., Sawa, S., Dara, S. K., and Kobayashi M. (2021) Control of Fusarium and nematodes by entomopathogenic fungi for organic production of Zingiber officinale. **Journal of Natural Medicines**. 76. 291-297.

Suzuki, R., Yamada, M., Higaki, T., Aida, M., Kubo, M., Tsai, A.Y-L., Sawa, S. (2021) *PUCHI* regulates giant cell morphology formation during root-knot nematode infection in *Arabidopsis thaliana*. **Frontiers in Plant Science.** https://doi.org/10.3389/fpls.2021.755610

Tsai, A, Y-L., McGee, R., Dean, G.H., Haughn, G. W., Sawa, S. (2021) Seed Mucilage: Biological Functions and Potential Applications in Biotechnology. **Plant Cell Physiol.** 62. 1847-1857.

Tsai, A, Y-L., Iwamoto, Y., Tsumuraya, Y., Oota, M., Konishi, T., Ito, S., Kotake, T., Ishikawa, H., and Sawa, S. (2021) Root-knot nematode chemotaxis is positively regulated by L-galactose sidechains of mucilage carbohydrate rhamnogalacturonan-I. **Science Advances**, 7, eabh4182, DOI: 10.1126/sciadv.abh4182

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Furumizu, C., and Sawa, S. (2021) The RGF/GLV/CLEL Family of Short Peptides Evolved Through Lineage-Specific Losses and Diversification and Yet Conserves Its Signaling Role Between Vascular Plants and Bryophytes. **Frontiers in Plant Science**. https://doi.org/10.3389/fpls.2021.703012

Terada, S., Kubo, M., Akiyoshi, N., Sano, R., Nomura, T., Sawa, S., Ohtani, M., and Demura, T. (2021) Expression of Peat Moss *VASCULAR RELATED NAC-DOMAIN* Homologs in *Nicotiana benthamiana* Leaf Cells Induces Ectopic Secondary Wall Formation. **Plant Mol. Biol.** 106. 309-317.

Suzuki, R., Ueda, T., Wada, T., Ito, M., and Sawa, S. (2021) Identification of genes involved in *Meloidogyne incognita*-induced gall formation processes in *Arabidopsis thaliana.* **Plant Biotech.** 38. 1-8.

Ishida,T., Yoshimura, H., Takekawa, M., Higaki, T., Ideue T., Hatano, M,. Igarashi M., Tani, T., Sawa, S., and Ishikawa, H. (2021) Discovery, characterization and functional improvement of kumamonamide as a novel plant growth inhibitor that disturbs plant microtubules. **Sci. Rep.** 11. 6077.

Yuan, N., Furumizu, C., Zhang, B., and Sawa, S. (2021) Database mining of plant peptide homologues. **Plant Biotech.** 38. 137-143.

Toyoda, S., Oota, M., Ishiakwa, H., and Sawa, S. (2021) Calcium sulfate and calcium carbonate as root-knot-nematode attractants and possible trap materials to protect crop plants. **Plant Biotech.** 38. 157-159.

Truong NM, Chen Y, Mejias J, Soulé S, Mulet K, Jaouannet M, Jaubert-Possamai S, Sawa S, Abad P, Favery B, Quentin M. (2021) The *Meloidogyne incognita* Nuclear Effector MiEFF1 Interacts With *Arabidopsis*Cytosolic Glyceraldehyde-3-Phosphate Dehydrogenases to Promote Parasitism. **Frontiers in Plant Sci**.**12**: 641480. doi: 10.3389/fpls.2021.641480

Fukunaga, H., Kitada, Y., Kawamura, N., and Sawa, S. (2021) A new form of the mycoheterotrophic plant Lecanorchis nigricans var. patipetala (Orchidaceae) from Tokyo, Japan. **Orchid Digest.** 85: 48-50.

Mejias, J., bazin, J., Truong, N-M., Chen, Y., Marteu, N., Bouteiller, N., Sawa, S., Crespi, M. D., Vaucheret, H., Abad, P., Favery, B., and Quentin, M. (2021) The Root-Knot Nematode Effector MiEFF18 interacts with the Plant Core Spliceosomal Protein SmD1 Required for Giant Cell Formation. **New Phytol.** 229. 3408-3423.

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Ikeda Y, Králová M, Zalabák D, Kubalová I, Aida M (2021). Post-embryonic lateral organ development and adaxial–abaxial polarity are regulated by the combined effect of *ENHANCER OF SHOOT REGENERATION 1* and *WUSCHEL* in Arabidopsis shoots. **Int. J. Mol Sci** 22, 10621. doi: 10.3390/ijms221910621

Takahama A, Aida M. Visualization and quantification of cortical microtubules in the apical region of the *Arabidopsis thaliana* embryo (2021). **Cytologia** 86, 181-182. doi: 10.1508/cytologia.86.181

Fujihara R, Uchida N, Tameshige T, Kawamoto N, Hotokezaka Y, Higaki T, Simon R, Torii KU, Tasaka M, Aida M (2021). The boundary-expressed *EPIDERMAL PATTERNING FACTOR-LIKE2* gene encoding a signaling peptide promotes cotyledon growth during *Arabidopsis thaliana* embryogenesis. **Plant Biotechnol** 38, 317-322. doi: 10.5511/plantbiotechnology.21.0508a

Kunita, I., Morita, M. T., Toda, M., & Higaki, T. (2021). A three-dimensional scanning system for digital archiving and quantitative evaluation of *Arabidopsis* plant architectures. **Plant Cell Physiol.** 62. 1975-1982.

Matsumoto, H., Kimata, Y., Higaki, T., Higashiyama, T., & Ueda, M. (2021). Dynamic rearrangement and directional migration of tubular vacuoles are required for the asymmetric

division of the *Arabidopsis* zygote. **Plant Cell Physiol.** 62. 1280-1289.

Sato, F., Iba, K., & Higaki, T. (2021) Involvement of the membrane trafficking factor PATROL1 in the salinity stress tolerance of *Arabidopsis thaliana*. **Cytologia** 86. 119-126.

Kimura, T., Haga, K., Nomura, Y., Higaki, T., Nakagami, H., & Sakai, T. (2021). The phosphorylation status of NPH3 affects photosensory adaptation during the phototropic response. **Plant Physiol.** 187. 981-995.

Kamon, E., Noda, C., Higaki, T., Demura, T., & Ohtani, M. (2021). Calcium signaling contributes to xylem vessel cell differentiation via post-transcriptional regulation of VND7 downstream events. **Plant Biotech.** 21-0519.

Kikukawa, K., Yoshimura, K., Watanabe, A., & Higaki, T. (2021). Metal-nano-ink coating for monitoring and quantification of cotyledon epidermal cell morphogenesis. **Frontiers in Plant Science**. 2169.

Okubo-Kurihara, E., Ali, A., Hiramoto, M., Kurihara, Y., Abouleila, Y., Abdelazem, E. M., Kawai, T., Makita, Y., Kawashima, M., Esaki, T., Shimada, H., Mori, T., Hirai, M.Y., Higaki, T., Hasezawa, S., Shimizu, Y., Masujima, T. & Matsui, M. (2022). Tracking metabolites at single-cell resolution reveals metabolic dynamics during plant mitosis. **Plant Physiol.** in press.

Sakai, Y., Higaki, T., Ishizaki, K., Nishihama, R., Kohchi, T., & Hasezawa, S. (2022). Migration of prospindle before the first asymmetric division in germinating spore of Marchantia polymorpha. **Plant Biotech.** 39. 5-12.

3. Application & acquisition status of KAKENHI and other external grants

Acquisition

Shinichiro Sawa
Principal Investigator
1. Kakenhi, Grant-in-Aid for Young Scientists (A)
2. Kakenhi, Grant-in-Aid for Exploratory Research
3. Kakenhi, Grant-in-Aid for Scientific Research on Innovative Areas
4. JSPS, Fostering Joint International Research (B)
5. Research grant from The Yanmar Environmental Sustainability Support Association
6. Research grant from Sugar Industry Association

Co-PI
1. Kakenhi, Grant-in-Aid for Scientific Research on Innovative Areas
(PI; Taku Demura, NAIST)
2. Kakenhi, Grant-in-Aid for Young Scientists (B)
(PI; Akira Yamawo, Hirosaki Univ.)
3. JSPS, Bilateral Programs, Joint Research Projects
(PI; Yasuhiro Kadota, Riken)
4. AMED, 21ak0101158h0001
(PI; Shogo Misumi)

Mitsuhiro Aida
Principal Investigator
1. Kakenhi, Grant-in-Aid for Scientific Research on Innovative Areas

Takumi Higaki
Principal Investigator
2. Kakenhi, Grant-in-Aid for Scientific Research on Innovative Areas
3. Kakenhi, Grant-in-Aid for Scientific Research（B）
Co-PI
1. Kakenhi, Grant-in-Aid for Scientific Research on Innovative Areas
(PI; Masanobu Kano)
2. JST CREST
(PI; Minako Ueda)

4. Application & acquisition status of industrial property rights

整理番号：２００２８ＡＡ０８（日本）
出願番号：特願 2021-024793
出願日：　令和 3 年 2 月 19 日(2021/02/19)
発明の名称：植物寄生性センチュウ防除剤　（線虫抵抗性に関わる遺伝子およびその利用）
出願人：　国立大学法人　熊本大学
発明者：　澤進一郎; 春原英彦; 佐藤　豊; 土川一行

No.4-4	Nano-Organics and Nano-Hybrids		
Research Field	Nano Material Science		
Unit Coordinator			
Name	Makoto TAKAFUJI		
Affiliation	Faculty of Advanced Science and Technology Email: takafuji@kumamoto-u.ac.jp	Title	Professor, PhD

Unit Members

Name	Affiliation/Title
Yutaka KUWAHARA	Faculty of Advanced Science and Technology (FAST) Kumamoto University Assistant Professor
Nanami HANO	Faculty of Advanced Science and Technology (FAST) Kumamoto University Post-doctor
Hirotaka IHARA	Faculty of Advanced Science and Technology (FAST) Kumamoto University Professor Emeritus, Visiting Professor National Institute of Technology, Okinawa College President
Reiko ODA	CNRS, Université de Bordeaux, France Research Director *IROAST Visiting Professor*
Josep-Lluis BARONA-VILAR	Instituto de Historia de la Medicina y de la Ciencia López Piñero (IHMC), Universidad de Valencia, Spain Professor *IROAST Visiting Professor*
Zhenghe XU	College of Engineering, Southern University of Science and Technology, China Dean Department of Chemical and Materials Engineering, University of Alberta, Canada Teck Professor *IROAST Visiting Professor*
Etsuko FUJITA	Chemistry Division, Brookhaven National Laboratory, USA Senior Scientist Emeritus *IROAST Visiting Professor*

1. Overview of achievements

1-1. Enhancement of International Collaboration with University of Bordeaux (**UB**)
French Republic (France)

The second term of the joint research project of the University of Bordeaux (UB) with Kumamoto University (KU) and Kyoto University since 2015, which has been called the Laboratoire international associé (LIA) - 'Chiral nanostructures for photonic applications' (CNPA) approved by the Agence Nationale de la Recherche (ANR), France, is proceeding. In this project, Prof. H. Ihara and Dr. R. Oda (Visiting Professor of IROAST) are co-PIs on the Japanese and French sides, respectively, and Prof. M. Takafuji and Dr. Y. Kuwahara are associated as core members. In 2021, Japanese and French members could not visit each other due to the COVID-19 pandemic.

The joint KAKEN research project with Dr. Oda of Grants-in-Aid for Fostering Joint International Research (B) funded by JSPS since 2017 has continued. In this project, Prof. M. Takafuji and Prof. H. Ihara are a PI and a core member, respectively, of the Japan side. The project with Dr. Y. Ferrand and Dr. C. Olivier, who are LIA members of the French side, is ongoing from 2018. We received mixed compounds from the French side and sent back essential compounds purified by our special technique.

Dr. Nanami Hano, a member of the research unit “Nano-organics and Nano-hybrids”, has joined Reiko Oda’s group as a JSPS Overseas Research Fellow from March, 2022. She will accommodate in UB for two years and may accelerate our collaborations.

Three joint papers have been published with researchers of **UB** in international journals in FY2021.

1-2. Maintaining International Collaboration with Universitat de València (**UV**)
Kingdom of Spain (Spain)

The Bilateral Joint Research Project with the University of Valencia supported by JSPS has been completed. One research paper on this topic has been published in FY2021. Japanese and Spanish members could not alternately visit this year. We will discuss for further collaboration in the future.

1-3. Maintaining International Collaboration with University of Geneva (**UG**)
Swiss Confederation (Switzerland)

Japanese and Swiss members could not alternately visit this year.

1-4. Maintaining International Collaboration with Brookhaven National Laboratory (**BNL**)
United States of America

Japanese and American members could not alternately visit this year.

1-5. Maintaining International Collaboration with University of Connecticut (**UC**)
United States of America

Japanese and American members could not alternately visit this year.

One joint paper has been published with researchers of **UC** in international journals in FY2021.

1-6. Maintaining International Collaboration with Lanzhou Institute of Chemical Physics (**LICP**), CAS
People’s Republic of China

After the Bilateral Joint Research Project of JSPS, we have continued the collaboration with Prof. H. Qiu’s group of Lanzhou Institute of Chemical Physics (LICP), Chinese Academy of Sciences (CAS), China. Prof. Ihara has been selected as a President's

International Fellowship Initiative Visiting Scientist from Chinese Academy of Sciences from 2019, associated with this collaboration with the LICP. However, Japanese and Chinese members could not alternately visit this year.

One joint paper has been published with researchers of the **LICP**, in international journals in 2021.

1-7. Maintaining International Collaboration with Beijing University of Chemical Technology (**BUCT**),
People's Republic of China

Japanese and Chinese members could not alternately visit this year.

1-8. Enhancement of International Collaboration with University of Dhaka (**UD**)
People's Republic of Bangladesh

Japanese and Bangladeshi members could not alternately visit this year. Prof. M. Takafuji and Prof. H. Ihara discussed with Dr. M. Shahruzzaman, Prof. M. M. Rahman and other collaborators, the University of Dhaka (UD), about the joint research project by e-mails.

Three joint papers have been published with researchers of **UD** in international journals in FY2021.

1-9. Maintaining International Collaboration with Noakhali Science and Technology University (**NSTU**), *People's Republic of Bangladesh*

Japanese and Bangladeshi members could not alternately visit this year.

Two joint papers have been published with researchers of **NSTU** in international journals in FY2021.

1-10. Maintaining International Collaboration with Baku State University (**BSU**)
Republic of Azerbaijan

Japanese and Azerbaijani members could not alternately visit this year.

1-11. Maintaining of International Collaboration with Kyrgyz-Turkish Manas University (**KTMU**)
Kyrgyz Republic

Japanese and Kirgiz members could not alternately visit this year. One assistant professor has been awarded from the Matsumae International Foundation (MIF) as an MIF fellow in 2019 and plan to visit to Kumamoto. However her visit has been postponed due to the COVID-19 pandemic.

1-12. Maintaining of International Collaboration with Vytautas Magnus University (**VMU**)
Republic of Lithuania

The Bilateral Joint Research Project of JSPS with Lithuania conducted by Prof. Ihara has been awarded, and the collaboration with Prof. A. S. Maruska of VMU has been started. Research meeting was held through remote with Zoom, but mutual visits by researchers have not been realized.

1-13. Establishment of International Collaboration with Ege University (**EU**), Atilim University (**AU**) and Hacettepe University (**HU**)
Republic of Turkey

Based on the results of young researcher exchange (post-doctor and graduate student), We have started to the discussion of collaborations. We have applied to the Bilateral Joint Research Project supported by JSPS (Japan) and TUBITAK (Turkey) for FY2022.

2. Presentations & Publications published between April 2021 and March 2022

2-1. Lanthanide ion-doped silica nanohelix: a helical inorganic network acts as a chiral source for metal ions
T. Harada, H. Yanagita, N. Ryu, Y. Okazaki, **Y. Kuwahara**, **M. Takafuji**, S. Nagaoka, **H. Ihara**, **R. Oda**
Chemical Communications (RSC), Vol. 57, pp. 4392-4395, 2021.

2-2. Hetero-network hydrogels crosslinked with silica nanoparticles for strategic control of thermal responsive property
M. M. Rahman, Md. A. Alam, **H. Ihara**, **M. Takafuji**
Soft Matter (RSC), Vol. 17, pp. 4615-4622, 2021.

2-3. Efficient removal of methylene blue dye from an aqueous solution using silica nanoparticle crosslinked acrylamide hybrid hydrogels
M. M. Rahman, J, A. Foisal, **H. Ihara**, **M. Takafuji**
New Journal of Chemistry (RSC), Vol. 45, pp. 20107-20119, 2021.

2-4. Thermally stable high-contrast iridescent structural colours from silica colloidal crystal doped with monodisperse spherical black carbon particles as maverick
K. Nakamae, **N. Hano**, **H. Ihara**, **M. Takafuji**
Materials Advances (RSC), Vol. 2, pp. 5935-5941, 2021.

2-5. Efficient extraction of quaternary ammonium alkaloids based on π-conjugated polymer coated porous silica adsorbent
H. Yu, P. Jin, F. Zhu, **M. Takafuji**, **H. Ihara**, L. Nie, H. Liu
Chemical Engineering Journal, Vol. 426, 131061, 2021.

2-6. Supramolecular assembly of glutamide attached terpyridine-lanthanide complex with enhanced chirality and high fluorescence quantum yield
N. Sultana, T. Kawahara, **Y. Kuwahara**, **H. Ihara**, **M. Takafuji**
Chemical Physics Letters, Vol. 781, 138968, 2021.

2-7. Temperature depending bioelectrocatalysis current of multicopper oxidase from a hyperthermophilic archaeon Pyrobaculum aerophilum
M. Tominaga, S. Nakao, **M. Takafuji**, E. Takamura, S. Suye, T. Satomura.
Electrochemistry Communications, Vol. 125, 106982, 2021.

2-8. A molecular shape recognitive HPLC stationary phase based on a highly ordered amphiphilic glutamide molecular gel
N. Kawamoto, Y. Hu, **Y. Kuwahara**, **H. Ihara**, **M. Takafuji**
Nanomaterials, Vol. 11(6), 1574, 2021.

2-9. Selectivity enhancement for the separation of shape-constrained isomers by particle size-derived molecular ordering and density in reversed-phase liquid chromatography
A. K. Mallik, H. Noguchi, M. M. Rahman, **M. Takafuji**, **H. Ihara**
Separation Science Plus, Vol. 4, pp. 296–304, 2021.

2-10. Remarkable enhancement of thermal stability of epoxy resin through the incorporation of mesoporous silica micro-filler
F. Yeasmin, A. K. Mallik, A. H. Chisty, F. N.Robel, Md. Shahruzzaman, P. Haque, M. M. Rahman, **N. Hano**, **M. Takafuji**, **H. Ihara**
Heylon, Vol. 7, e05959, 2021.

2-11. Enantioselective self-assembled nanofibrillar network with glutamide-based organogelator
N. Nagatomo, H. Oishi, **Y. Kuwahara**, **M. Takafuji**, **R. Oda**, T. Hamada, **H. Ihara**
Nanomaterials, Vol. 11(6), 1376, 2021.

2-12. Jute cellulose nanocrystal/poly(N,N-dimethylacrylamide-co-3-methacryloxypropyl trimethoxysilane) hydrogel for removing a cationic dye from aqueous solution by ionic interaction
M. Shahruzzaman, S. Hossain, S. F. Kabir, Md. S. Rahman, S. Sultana, A. K. Mallik, P. Haque, **M. Takafuji**, M. M. Rahman.
Journal of Science: Advanced Materials and Devices, Vol. 6, pp. 254-263, 2021.

2-13. Preparation of porous carbon nanomaterials and their application in sample preparation: A review
Y. Wang, J. Chen, **H. Ihara**, M. Guan, H. Qiu
TrAC Trends in Analytical Chemistry, Vol. 143, 116421, 2021.

2-14. Advanced Mg-Al-Ca alloys with combined properties of high thermal conductivity, high mechanical strength and non-flammability
Y. Kawamura, S. Inoue, K. Ougi, **M. Takafuji**, **H. Ihara**, T. Kiguchi, D. S. Shih
Materials Transaction, Vol. 63 (2), 118-127, 2022.

2-15. Adsorption isotherm and kinetics of methylene blue on gamma radiation assisted starch/acrylic acid/4-styrenesulfonic acid sodium salt hydrogel
Z. Hasan, S. Afroz, K. Nipa, M. S. Rahaman, S. M. M. Hasnine, T. Ahmed, S. Sultana, **M. Takafuji**, M. A. Alam
Polymer-Plastics Technology and Materials, Vol. 61, 306-324, 2022.

2-16. Selective reflection enhancement by controlling of surface-layering structure of inorganic nanoparticles on polymer microspheres
N. Hano, N. Ryu, S. Nagaoka, **H. Ihara**, **M. Takafuji**
Colloids and Surfaces A: Physicochemical and Engineering Aspects, Vol. 637, 128188, 2022.

2-17. Chemical redox-induced chiroptical switching of supramolecular assemblies of viologens
Y. Kuwahara, M. Ito, T. Iwamoto, **M. Takafuji**, **H. Ihara**, N. Ryu and T. Mani
RSC Advances (RSC), Vol. 12, pp.2019-2025, 2022.

3. Application & acquisition status of KAKENHI and other external grants

Applied (Under reviewing)

3-1. FY 2022–2023: KAKEN, Grant-in-Aid for Challenging Research (Exploratory), JSPS, PI: **M. Takafuji**

3-2. FY 2022–2024: Bilateral Joint Research Projects with France (Open Partnership), JSPS, PI: **M. Takafuji**

3-3. FY 2022–2024: Bilateral Joint Research Projects with Turkey, JSPS, PI: **M. Takafuji**

3-4. FY 2022–2024: KAKEN, Grant-in-Aid for Early-Career Scientists, JSPS, PI: **N. Hano**

3-5. FY 2022: Follow-up Services for International Students who studied in Japan (from UD), JASSO, Supervisor: **M. Takafuji**

3-6. FY 2022: MIF Fellow (from KTMU), Matsumae International Foundation, Host researcher: **M. Takafuji**

3-7. FY 2022–2024: KAKEN, Grant-in-Aid for Scientific Research (C), JSPS, PI: T. Shirosaki, Co-PI: **M. Takafuji**

Accepted (On-going project)

3-8. FY 2021–2024: KAKEN, Grant-in-Aid for Scientific Research (B), JSPS, PI: **M. Takafuji**,

Co-PI: **N. Hano**, S. Nagaoka, 13,700,000 yen.

3-9. FY 2020–2022: KAKEN, Grant-in-Aid for Scientific Research (B), JSPS, PI: **H. Ihara**, Co-PI: **M. Takafuji**, S. Nagaoka, 13,700,000 yen.

3-10. FY 2020–2022: KAKEN, Grant-in-Aid for Challenging Research (Exploratory), JSPS, PI: **H. Ihara**, Co-PI: **Y. Kuwahara**, S. Nagaoka, 5,000,000 yen.

3-11. FY 2020–2022: KAKEN, Grant-in-Aid for Scientific Research (C), JSPS, PI: **Y. Kuwahara**, Co-PI: **H. Ihara**, N. Ryu, 3,300,000 yen.

3-12. FY 2020–2022: KAKEN, Grant-in-Aid for Scientific Research (C), JSPS, PI: N. Ryu, Co-PI: **M. Takafuji**, 3,400,000 yen.

3-13. FY 2020–2022: KAKEN, Grant-in-Aid for Scientific Research (C), JSPS, PI: K. Nishiyama, Co-PI: **M. Takafuji**, S. Yoshimoto, 3,400,000 yen.

3-14. FY 2020–2021: Bilateral Joint Research Projects with Lithuania, JSPS, PI: **H. Ihara**, 5,000,000 yen.

3-15. FY 2019–2021: KAKEN, Grant-in-Aid for Scientific Research (C), JSPS, PI: T. Shirosaki, Co-PI: **M. Takafuji,** N. Ryu, 3,500,000 yen.

3-16. FY 2018–2020 (extend to 2021): Bilateral Joint Research Projects with Spain (Open Partnership), JSPS, PI: **M. Takafuji**, 5,000,000 yen.

3-17. FY 2017–2021 (extend to 2022): KAKEN, Fund for the Promotion of Joint International Research (Fostering Joint International Research (B)), JSPS, PI: **M. Takafuji**, Co-PI: **H. Ihara,** N. Ryu, **N. Hano**, 13,800,000 yen.

4. Application & acquisition status of industrial property rights

None

No.4-5	Nano-medicine and Drug Delivery System		
Research Field	Nano Material Science, Advanced Green Bio		
Unit Coordinator			
Name	Hamid HOSANO		
Affiliation	Institute of Industrial Nanomaterials Email: hamid@kumamoto-u.ac.jp	Title	Professor
Unit Members			

Name	Affiliation/Title
Nushin HOSANO	Biomaterials and Bioelectrics Division, Institute of Industrial Nanomaterials Visiting Associate Professor
Konstantinos KONTIS	School of Engineering, University of Glasgow, UK / IROAST Professor/ Dean for Global Engagement-East Asia & China / Distinguished Professor
Firuz ZARE	The University of Queensland, Australia Professor/ Discipline Leader of Power of Energy and Control Engineering / IEEE Fellow / IROAST Visiting Professor
Viren Ivor MENEZES	Department of Aerospace Engineering, Indian Institute of Technology Bombay, India Professor/ IROAST Visiting Professor
Hamid GHANDEHARI	Director of Utah Center for Nanomedicine/ Chair of Department of Pharmaceutics and Pharmaceutical Chemistry and Bioengineering, University of Utah, USA Professor/ IROAST Visiting Professor
Amir A. FARAJIAN	Department of Mechanical and Materials Engineering, Wright State University, USA Professor/ IROAST Visiting Professor

Details of activities

We have been studying the use of physical delivery of drug or reprogramming factors into the cells and tissue, as a safe and reliable method. We have also been exploring integrated diagnostic and therapeutic (theranostics) modalities/nanoparticles/agents, as a unique approach in nanomedicine. The research has potential to be used in a wide range of medical applications.
Our physical delivery approaches are based on applying electrical/mechanical stresses to the cells. In this respect, attention has been made to understand biophysical reactions to reversibly manipulate the cells by the external stress. We have been investigating promising physical delivery methods including: electroporation with nanosecond pulsed electric fields, needle-free painless microinjection, micro/nano-particle carrier laser-biolistic delivery, sonoporation with microfluidics, and shock waves; which are shown to be appropriate for clinical applications.

During year 2021, due to travel and other restrictions brought by the COVID-19 pandemic, we could not have presence of our Visiting Professors in Kumamoto University.
The Research Unit has welcomed two distinguished scientists as IROAST Visiting Professors, Prof. Stelios Rigopoulos, from Department of Mechanical Engineering, Imperial College London, UK; and Prof. Pouyan Boukany, from Delft University of Technology, Netherlands. Their presence will promote our projects and will help the Research Unit to further achieve its goals. We had fruitful discussions and collaboration with Prof. Kontis for a joint project and budget application. We are working with Prof. Farajian with monthly seminars for a National Science project application. Our nanoparticle delivery work with Prof. Ghandehari is well progressing. We also started closer collaboration with Prof. M.-Nejad for new generation of nanoparticles.

Joint publication with Internship student from Alzahra University (Prof. M.-Nejad's group):

Mona Pakdel, Zahra Moosavi-Nejad, Rouha Kasra Kermanshahi, Hamid Hosano,
Self-assembled uniform keratin nanoparticles as building blocks for nanofibrils and nanolayers derived from industrial feather waste,
Journal of Cleaner Production, 335 130331-130331, Feb, 2022
DOI: 10.1016/j.jclepro.2021.130331

Joint publication with Internship student from the University of Queensland (Prof. Zare's group):

F. Zare, N. Ghasemi, N. Bansal, G. Abhishek, H. Hosano, Increasing the production yield of white oyster mushrooms with pulsed electric fields, IEEE Trans. Plasma Science, 49(2), 805-812, 2021
DOI: 10.1109/TPS.2021.3053071

Joint International publication with Prof. M.-Nejad:

Nushin Hosano, Zahra Moosavi-Nejad, Makoto Satoh, Hamid Hosano,
Shock Waves Enhance Expression of Glycosphingolipid Tumor Antigen on Renal Cell Carcinoma: Dynamics of Physically Unmasking Hidden Intracellular Markers Independent of Gene-Signaling Pathways,
Biomedicines, 10(3) 545-545, Feb, 2022
DOI: 10.3390/biomedicines10030545

Other publications:

Md. Mijanur Rahman, Nushin Hosano, Hamid Hosano,
Recovering Microalgal Bioresources: A Review of Cell Disruption Methods and Extraction Technologies, Molecules, 27(9) 2786-2817, 2022
DOI: 10.3390/molecules27092786

Tomohiko Yamashita, Reon Yamashita, Hamid Hosano, Takashi Sakugawa,
Effects of Voltage and Current Influence of electrode arrangement on recycling metal-coated plastic (DVD-R) using pulsed electric discharge, Journal of Electrostatics, 110 103557-103557, 2021
DOI: 10.1016/j.elstat.2021.103557

Grant: Grants-in-Aid for Scientific Research, Kakenhi (B), 2021-2025

No.4-6	Nano-medicine and Theranostics		
Research Field	Nano Material Science		
Unit Coordinator			
Name	Takuro NIIDOME		
Affiliation	Faculty of Advanced Science and Technology Email: niidome@gpo.kumamoto-u.ac.jp	Title	Professor
Unit Members			

Name	Affiliation/Title
Ick Chan KWON	Biomedical Research Institute, Korea Institute of Science and Technology (KIST), Korea Principal Research Scientist
Ruda LEE	Institute of Industrial Nanomaterials Associate Professor
Keiichi MOTOYAMA	Faculty of Life Sciences Professor
Taishi HIGASHI	Priority Organization for Innovation and Excellence Associate Professor

1) Overview of achievements

Theranostics is a rapidly developing field that combines the unique opportunities offered by nanotechnology with personalized medicine to provide significantly improved treatment efficacy with reduced off-target effects through the specific delivery of therapy to targeted tissues. These approaches combine imaging that uses one of the non-invasive imaging modalities, with specific delivery of therapeutic components, which can be based on different biophysical and biological principles. Theranostics can be synthesized to have optimal delivery properties, low renal clearance, reduced immunogenicity, and antigenicity (for example by PEGylating the surface of theranostic nanoparticles), and high capacity for therapeutic agents, which is required given the limited concentrations of specific molecular markers expressed on cancer cells.

This research unit focus on the development of diagnosis and drug delivery system for biomedical application. The research unit's interdisciplinary research collaboration with engineers, pharmacists, and clinicians can improve a deeper knowledge and understanding of the real interactions involved in the diseased tissues is fundamental for the development of novel therapeutic approaches. In this fiscal year, we suggest new paradigm for cardiac reprogramming, multi-targeting gene delivery system, and other many theranostics nanomedicine platform.

2) Presentations & Publications published between April 2021 and March 2022

Takuro NIIDOME

[Presentations]

1. Wei Xu, Anna Kawano, Tatsuya Baba, **Takuro Niidome**, Antibacterial and Antiviral Activity of Graphene Quantum Dots, 8th Asian Biomaterial Conference, 2021/11/28, Nagoya, Japan

2. **Takuro Niidome**, Emi Takeda, Mitsuhiro Terakawa, Control of Antibacterial Activity of Silica-Coated Silver Nanoplates by Light, 8th Asian Biomaterial Conference, 2021/11/28, Nagoya, Japan
3. **Takuro Niidome**, Gold nanorods for DDS, silver nanoplates as an antimicrobial agent, and magnesium alloy for bioresorbable medical devices, Special Seminar in Department of Chemical Engineering, Kyrgyz-Turkish Manas University, 2021/11/18, web
4. **Takuro Niidome**, Gold, Silver, and Magnesium as Medical Materials, BK21 seminar in Department of Biomedical Engineering in Yonsei University, 2021/10/8, web

[Publications]
1. Wei Xu, Makoto Sasaki, **Takuro Niidome**, Sirolimus release from biodegradable polymers for coronary stent, *Pharmaceutics*, in press
2. Emi Takeda, Wei Xu, Mitsuhiro Terakawa, **Takuro Niidome**, Tailored structure and antibacterial properties of silica-coated silver nanoplates by pulsed laser irradiation, *ACS Omega*, in press
3. Mai Shinohara, Yuya Ashikaga, Wei Xu, Sunnam Kim, Tuyoshi Fukaminato, **Takuro Niidome**, Seiji Kurihara, Photochemical OFF/ON cytotoxicity switching by using a photochromic surfactant with visible light irradiation, *ACS Omega*, in press
4. Waliul Islam, Shintaro Kimura, Rayhanul Islam, Ayaka Harada, Katsuhiko Ono, Jun Fang, **Takuro Niidome**, Tomohiro Sawa, Hiroshi Maeda, EPR effect enhancers strongly potentiate tumor-targeted delivery of nanomedicines to advanced cancers: Further extension to enhancement of the therapeutic effect, *J. Pers. Med.*, 11, 487 (2021)
5. Mio Tameike, **Takuro Niidome**, Yasuro Niidome, Junichi Kurawaki, Novel photoluminescent gold complexes prepared at octanethiol–water interfaces: Control of optical properties by addition of silver ions, *Bull. Chem. Soc. Jpn.*, 94, 1875-1881 (2021)
6. Waliul Islam, Yoshitaka Matsumoto, Jun Fang, Ayaka Harada, **Takuro Niidome**, Katsuhiko Ono, Hiroyasu Tsutsuki, Tomohiro Sawa, Takahisa Imamura, Kazuo Sakurai, Nobuyoshi Fukumitsu, Hirofumi Yamamoto, Hiroshi Maeda, Polymer-conjugated glucosamine complexed with boric acid shows tumor-selective accumulation and simultaneous inhibition of glycolysis, *Biomaterials*, 269, 120631 (2021)
7. Yong Il Park, Seung-Hae Kwon, Gibok Lee, Keiichi Motoyama, Min Woo Kim, Min Lin, **Takuro Niidome**, Jung Hoon Choi, Ruda Lee, pH-sensitive multi-drug liposomes targeting folate receptor β for efficient treatment of non-small cell lung cancer, *J. Controlled Release*, 330, 1-14 (2021)

Ruda LEE
[Presentations]
N/A
[Publications]
1. Chinmaya Mahapatra, **Ruda Lee**, Manash K. Paul. Emerging role and promise of nanomaterials in organoid research. *Drug discovery today*, 27, 890-899, March 2022.
2. Kang Pa Lee, Suji Baek, Myeong Sik Yoon, Ji Soo Park, Bok Sil Hong, Sang Ju Lee, Seung Jun Oh, Seung Hae Kwon, **Ruda Lee**, Dae Ho Lee, Kang-Seo Park, Byung Seok Moon. Potential anticancer effect of aspirin and 2'-hydroxy-2,3,5'-trimethoxychalcone-linked polymeric micelles against cervical cancer through apoptosis. Oncology Letters, 23, 31, November 2021.
3. Sajid Fazal, **Ruda Lee***. Biomimetic Bacterial Membrane Vesicles for Drug Delivery Applications. Pharmaceutics, 13, 1430, September 2021.

Ick Chan KWON
[Presentations]

N/A

[Publications]

1. PDL1-binding peptide/anti-miRNA21 conjugate as a therapeutic modality for PD-L1high tumors and TAMs. Eun Hye Kim, Jongwon Lee, Gijung Kwak, Hochung Jang, Hyosuk Kim, Haeun Cho, Yeongji Jang, Jiwoong Choi, Sung-Gil Chi, Kwangmeyung Kim, **Ick Chan Kwon**, Yoosoo Yang, Sun Hwa Kim. *Journal of Controlled Release* 2022, 345, 62-74.
2. Ultraefficient extracellular vesicle–guided direct reprogramming of fibroblasts into functional cardiomyocytes. Hyosuk Kim, Byeong-Wook Song, Soon-Jung Park, Seong Woo Choi, Hanbyeol Moon, Ki-Chul Hwang, Sun-Woong Kang, Sung-Hwan Moon, Yoosoo Yang, **Ick Chan Kwon***, Sun Hwa Kim. *Science advances* 2022, 8, eabj6621.
3. Multi-targeting siRNA nanoparticles for simultaneous inhibition of PI3K and Rac1 in PTEN-deficient prostate cancer. Min Ju Kim, Hyosuk Kim, Xueliang Gao, Ju Hee Ryu, Yoosoo Yang, **Ick Chan Kwon**, Thomas M Roberts, Sun Hwa Kim. *Journal of Industrial and Engineering Chemistry* 2021, 99, 196-203.
4. Bioorthogonally surface-edited extracellular vesicles based on metabolic glycoengineering for CD44-mediated targeting of inflammatory diseases. Gyeong Taek Lim, Dong Gil You, Hwa Seung Han, Hansang Lee, Sol Shin, Byeong Hoon Oh, EK Pramod Kumar, Wooram Um, Chan Ho Kim, Seungsu Han, Sangho Lee, Seungho Lim, Hong Yeol Yoon, Kwangmeyung Kim, **Ick Chan Kwon**, Dong-Gyu Jo, Yong Woo Cho, Jae Hyung Park. *Journal of extracellular vesicles* 2021, 10, e12077
5. Short-term cessation of dabigatran causes a paradoxical prothrombotic state. Jiwon Kim, Hee Jeong Jang, Dawid Schellingerhout, Su-Kyoung Lee, Ha Kim, Young Dae Kim, Kyung-Yul Lee, Hye-Yeon Choi, Han-Jin Cho, Seong-Soo Jang, Sangmin Jeon, Ick Chan Kwon, Kwangmeyung Kim, Wi-Sun Ryu, Matthias Nahrendorf, Seungbum Choi, Dong-Eog Kim. *Annals of Neurology* 2021, 89, 444-458
6. In vivo tracking of bioorthogonally labeled T-cells for predicting therapeutic efficacy of adoptive T-cell therapy. Woojun Kim, Hong Yeol Yoon, Seungho Lim, Patrick S Stayton, In-San Kim, Kwangmeyung Kim, **Ick Chan Kwon***. *Journal of Controlled Release* 2021, 329, 223-236.
7. Intracellular uptake mechanism of bioorthogonally conjugated nanoparticles on metabolically engineered mesenchymal stem cells. Seungho Lim, Woojun Kim, Sukyung Song, Man Kyu Shim, Hong Yeol Yoon, Byung-Soo Kim, **Ick Chan Kwon***, Kwangmeyung Kim. *Bioconjugate Chemistry* 2021, 32, 199-214.

Keiichi MOTOYAMA & Taishi HIGASHI

[Presentations]

1. Masamichi Inoue, Hirofumi Jono, Takashi Saito, Risako Onodera, **Taishi Higashi**, **Keiichi Motoyama**, Feasibility Study of shRNA Polyplex as a Multi-functional Drug for Alzheimer's Disease, JSB/SFB Joint Symposium (online), Hawaii, USA, January 8-10 (2022).
2. Kosei Utatsu, Tetsuya Kogo, Toru Taharabaru, Risako Onodera, **Keiichi Motoyama**, **Taishi Higashi**, Transformable Supramolecular Materials for Reversible PEGylation of Protein Drugs, JSB/SFB Joint Symposium (online), Hawaii, USA, January 8-10 (2022).
3. Takaya Ariyoshi, Masamichi Inoue, Risako Onodera, **Taishi Higashi**, **Keiichi Motoyama**. Cationic Dendrimer as a Novel Melanogenesis Inhibitor, JSB/SFB Joint Symposium (online), Hawaii, USA, January 8-10 (2022).

[Publications]

1. M. Goto, Y. Kobira, S. Kaneko, H. Arima, A. Michihara, K. Azuma, **T. Higashi**, **K. Motoyama**, H. Watanabe, T. Maruyama, D. Kadowaki, M. Otagiri, D. Iohara, F.

Hirayama, M. Anraku, The effects of sacran, a sulfated polysaccharide, on the gut microbiota using chronic kidney disease model rats. *Biol. Pharm. Bull.*, in press (2022).

2. T. Kogo, K. Utatsu, T. Taharabaru, R. Onodera, **K. Motoyama**, **T. Higashi**, Polyrotaxane-based supramolecular material for improvement of pharmaceutical properties of protein drugs. *J. Pharm. Sci.*, in press (2022).
3. R. Onodera, S. Morioka, S. Unida, **K. Motoyama**, K. Tahara, H. Takeuchi, Design and evaluation of folate-modified liposomes for pulmonary administration in lung cancer therapy. *Eur. J. Pharm. Sci.*, 168, 106081 (2022).
4. R. Onodera, A. Sakai, A. Tokuda, **T. Higashi**, **K. Motoyama**, The effect of folate-appended methyl-β-cyclodextrin increases on survival rates in a peritoneal dissemination mouse models of human ovarian cancer. *J. Incl. Phenom. Macrocycl. Chem.*, 102, 143-149 (2022).
5. K. Utatsu, T. Kogo, T. Taharabaru, R. Onodera, **K. Motoyama**, **T. Higashi**, Supramolecular polymer-based transformable material for reversible PEGylation of protein drugs. *Mater. Today Bio*, 12, 100160 (2021).
6. T. Hoshiko, Y. Kubota, R. Onodera, **T. Higashi**, M. Yokoo, **K. Motoyama**, S. Kimura, Folic acid-appended hydroxypropyl-β-cyclodextrin exhibits potent antitumor activity in chronic myeloid leukemia cells via autophagic cell death. *Cancers*, 13, 5413 (2021).
7. Y. Suzuki, T. Hayashi, R. Yokoyama, F. Nakagawa, J. Inoue, **T. Higashi**, R. Onodera, **K. Motoyama**, Fasting as a potential preventive for eosinophilic asthma through impaired type 2 helper T cell infiltration in the lung, *FEBS Open Bio*, 11, 2619-2630 (2021).
8. K. Morita, **K. Motoyama**, A. Kuramoto, R. Onodera, **T. Higashi**, Synthesis of cyclodextrin-based radial polycatenane cyclized by amide bond and subsequent fabrication of water-soluble derivatives. *J. Incl. Phenom. Macrocycl. Chem.*, 100, 169-175 (2021).
9. Y.I. Park, S-H. Kwon S, G. Lee, **K. Motoyama**, M.W. Kim, M. Lin, T. Niidome, J.H. Choi, pH-sensitive multi-drug liposomes targeting folate receptor β for efficient treatment of non-small cell lung cancer. *J. Control. Release*, 330, 1-14 (2021).
10. N. Wathoni, L. Meylina L, A. Rusdin, A.F.A. Mohammed, D. Tirtamie, Y. Herdiana, **K. Motoyama**, C. Panatarani, I.M. Joni, R. Lesmana, M. Muchtaridi. The Potential Cytotoxic Activity Enhancement of α-Mangostin in Chitosan-Kappa Carrageenan-Loaded Nanoparticle against MCF-7 Cell Line. *Polymers*, 13, 1681 (2021).
11. Y. Suzuki, H. Sugiyama, M. Kano, R. Shimono, G. Shimada, R. Furukawa, E. Mano, **K. Motoyama**, T. Koide, Y. Matsui, K. Kurasaki, I. Takayama, S. Hikage, N. Katori, M. Kikuchi, H. Sakai, Y. Matsuda, Control strategy and methods for continuous direct compression processes. *Asian J Pharm Sci.*, 16, 253-262 (2021).
12. Y. Yamada, Y. Ishitsuka, Y. Kondo, S. Nakahara, A. Nishiyama, T. Takeo, N. Nakagata, **K. Motoyama**, **T. Higashi**, H. Arima, S. Kamei, T. Shuto, Tsuyoshi, H. Kai, Y. Hayashino, M. Sugita, T. Kikuchi, F. Hirata, T. Miwa, H. Takeda, Y. Orita, T. Seki, T. Ohta, Y. Kurauchi, H. Katsuki, M. Matsuo, K. Higaki, K. Ohno, S. Matsumoto, T. Era, T. Irie, Differential mode of cholesterol inclusion with 2-hydroxypropyl-cyclodextrins impacts safety margin in treating Niemann-Pick disease type C. *Br. J. Pharmacol.*, 178, 2727–2746 (2021).
13. M. Sugita, I. Kuwano, **T. Higashi**, **K. Motoyama**, H. Arima, F. Hirata, Computational screening of a functional cyclodextrin derivative for suppressing a side-effect of doxorubicin. *J. Phys. Chem. B*, 125, 2308-2316 (2021).
14. N. Ohshita, **K. Motoyama**, D. Iohara, F. Hirayama, T. Taharabaru, N. Watabe, Y. Kawabata, R. Onodera, **T. Higashi**, Polypseudorotaxane-based supramolecular hydrogels consisting of cyclodextrins and Pluronics as stabilizing agents for antibody drugs. *Carbohydr. Polym.*, 256, 117419 (2021).
15. M. Goto, K. Azuma, H. Arima, S. Kaneko, **T. Higashi**, **K. Motoyama**, A. Michihara, T. Shimizu, T. Maruyama, M. Otagiri, D. Iohara, F. Hirayama, M. Anraku, Sacran, a sulfated polysaccharide, adsorbs triglyceride and modulates the intestinal flora in the gut in non-alcoholic steatohepatitis model rats. *Life Sci.*, 268, 118991 (2021).

16. M. Fukaura, Y. Ishitsuka, S. Shirakawa, N. Ushihama, Y. Yamada, Y. Kondo, T. Takeo, N. Nakagata, **K. Motoyama**, **T. Higashi**, H. Arima, Y. Kurauchi, T. Seki, H. Katsuki, K. Higaki, M. Matsuo, T. Irie, Intracerebroventricular treatment with 2-hydroxypropyl-β-cyclodextrin decreased cerebellar and hepatic glycoprotein nonmetastatic melanoma protein B (GPNMB) expression in Niemann–Pick disease type C model mice. *Int. J. Mol. Sci.*, 22, 452 (2021).

3) Application & acquisition status of KAKENHI and other external grants

Takuro NIIDOME

1. FY2021 JSPS, Grant-in-Aid for Challenging Research (Exploratory)
2. FY2022 Grant-in-Aid for Scientific Research (B)
3. FY2018 JST, CREST
4. FY2018 AMED

Ruda LEE

1. FY2022 JSPS, Grant-in-Aid for Scientific Research (C)
2. FY2021 AMED, Infectious Diseases and Immunology Research: U.S.-Japan Cooperative Medical Sciences Program Collaborative Awards

Ick Chan KWON

: N/A

Keiichi MOTOYAMA & Taishi HIGASHI

1. FY2021 JSPS Grant-in-Aid for Scientific Research (C) (K. Motoyama)
2. A-step tryout (T. Higashi)
3. The Leading Initiative for Excellent Young Researchers (T. Higashi)

4) Application & acquisition status of industrial property rights

Takuro NIIDOME

1. **Takuro Niidome**, Wei Xu, Preparation of carbon nanoparticles and the carbon nanoparticles, and their antibacterial and antiviral activities, patent application 2021-128289

Ruda Lee

: N/A

Ick Chan KWON

1. Immunoregulatory protein-siRNA complex having anticancer activity, SH Kim, **IC Kwon**, IS Kim, KIM Kwangmeyung, Y Yoosoo, Y Ko, US Patent 11,246,939 (2022).
2. Therapeutic agent for treating cancer comprising anti-miRNA-albumin composite, SH Kim, **IC Kwon**, KIM Kwangmeyung, HY Yoon, K Gi-Jung, J Park, US Patent 11,015,197 (2021).

Keiichi MOTOYAMA & Taishi HIGASHI

1. **Keiichi Motoyama**, **Taishi Higashi**, Hidetoshi Arima, Shinya Kimura, Yasushi Kubota, Antitumor agents, patent application 2021-126032.

No. 4-7	Multiscale Modeling of Soil and Rock Materials Using X-ray CT		
Research Field	Advanced Green Bio		
Unit Coordinator			
Name	Jun OTANI		
Affiliation	Faculty of Advanced Science and Technology, Kumamoto University Email: junotani@kumamoto-u.ac.jp	Title	Professor
Unit Members			
Name	Affiliation/Title		
Gioacchino VIGGIANI	Université Grenoble Alpes, France Professor, IROAST Visiting Professor		
José E. ANDRADE	California Institute of Technology , USA Professor, IROAST Visiting Professor		

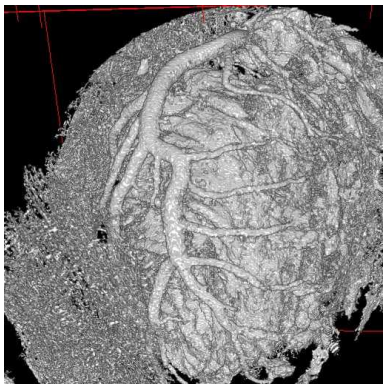
1. Overview of achievements

The topic of this research unit is the application of x-ray imaging to engineering, especially for geomaterials (soils, rock, and concrete). X-ray imaging plays a key role for the experimental multi-scale analysis of geomechanics, in that it helps linking the mechanisms occurring at the micro scale to the mechanical behavior observed at the macro scale.

In this year, we had a series of discussions about the progress on this collaboration using e-mail, especially the submission of collaborative technical paper and we have set a kick-off meeting on this issue at Kumamoto University in April of 2020. However, because of the CORONA Virus, we could not have this meeting. Anyway, our discussion of publishing papers is continued. The possible technical paper will be soon and the title will be “Micro-Macro behavior of geomaterials using X-ray CT and Distinct Element Method ((DEM)” [Tentative]. And of course, when it is ready, we will have a meeting at either Caltech, Grenoble or Kumamoto.

No.4-8-1	Quantification of Three Dimensional Vascular Network		
Research Field	Next-generation Technology (nano X-ray CT)		
Unit Coordinator			
Name	Toshifumi MUKUNOKI		
Affiliation	Faculty of Advanced Science and Technology Email: mukunoki@kumamoto-u.ac.jp	Title	Professor
Unit Members			
Name	Affiliation/Title		
Yuichiro ARIMA Jun OTANI Patrice DELMAS	IRCMS, Developmental Cardiology, Associate Professor (PI) Faculty of Advanced Science and Technology (FAST), Kumamoto University Professor The University of Auckland, New Zealand Associate Professor		

1. Overview of achievements



Using nano-X-ray CT, we try to detect gold-conjugated antibodies. Endothelial cells are labeled with gold-colloid conjugated antibody, and visualized by nano-X-ray CT machine. As a first step, optimal concentration of metal and size of metal-colloid is determined by nano focus X-ray CT scanner (SkyScan 2214, Bruker Co. Ltd.). Then isolectin B4, which specifically reacts to endothelial cells, are labeled with optimized gold colloid. Mouse heart will react with labeled isolectin B4 and visualized by CT scanner.

We established the image shooting method by using nano X-ray CT. Using postnatal day 7 hearts, we enabled to visualize whole vascular architecture. Compared to the previous image using micro-X-ray CT, resolution improved dramatically by using nano-X ray CT (Figure). Conventional contrast has high viscosity, so it was difficult perfuse all vessels, including microcirculation. We have also tested the visualization of gold nano particles. We continue protocol modification using these repeated trials.

2. Presentations & Publications published between April 2021 and March 2022

Presentation

Yuichiro Arima, “Visualization of blood vessel microstructure by CT ~Efforts of medical-engineering collaboration~”, The 8th International Workshop on X-Ray CT Visualization for Socio-Cultural Engineering and Environmental Materials, 2021.

Publication

Arima Y, Mukunoki T, et. al., Sample Preparation for Computed Tomography-based Three-dimensional Visualization of Murine Hind-limb Vessels. **J Vis Exp. 2021**

3. Application & acquisition status of KAKENHI and other external grants

(Application)Grants-in-Aid for Scientific Research-KAKENHI- Challenging research 2022, “CT-based immunostaining”

4. Application & acquisition status of industrial property rights

None

No.4-8-2	MicroCT-based quantification of fibrosis and vascularization in pancreatic tumor		
Research Field	Nano Material Science/ Green Energy/ Environmental Science/ Advanced Green Bio/ Next-generation Technology		
Unit Coordinator			
Name	Toshifumi MUKUNOKI		
Affiliation	Faculty of Advanced Science and Technology, Kumamoto University Email: mukunoki@kumamoto-u.ac.jp	Title	Professor
Unit Members			
Name	Affiliation/Title		
Jun OTANI	Faculty of Advanced Science and Technology (FAST), Kumamoto University Professor		
Takatsugu ISHIMOTO	IRCMS Associate Professor		
Patrice DELMAS	The University of Auckland, New Zealand Associate Professor		

Overview of activities

Inflammation and cancer are closely related and favor each other mutually. We are aiming to find the connection between pancreatic cancer and arachidonic cascade, in which we knocked out the key enzyme 15pgdh in mice and established an inflammatory syngeneic mouse model. Arachidonate cascade is a major inflammatory pathway that produces prostaglandin E2 (PGE2). We have reported that accumulation of PGE2 in 15pgdh KO mouse promoted cancer stem cell fraction and tumor formation (Arima et al. *Oncogene*). In current project we found out that angiogenesis level is promoted by depletion of 15pgdh in tumor microenvironment, and have already confirmed enhancement of vascular structure in 15pgdh+/- mouse comparing to wildtype mouse by NanoCT (Figure 1).

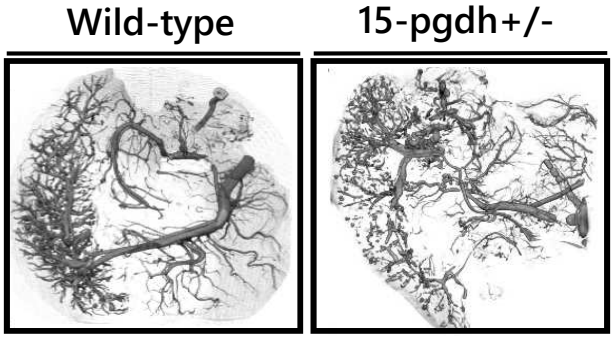


Figure 1

No.4-9	Advanced Structural Materials		
Research Field	Nano Material Science		
Unit Coordinator			
Name	Yoji MINE		
Affiliation	Faculty of Advanced Science and Technology Email: mine@msre.kumamoto-u.ac.jp	Title	Professor
Unit Members			
Name	Affiliation/Title		
Yufeng ZHENG	Department of Materials Science and Engineering, College of Engineering, Peking University, China & International Research Organization for Advanced Science and Technology (IROAST), Kumamoto University, Japan / Professor & IROAST Distinguished Professor		
Paul BOWEN	School of Metallurgy and Materials, University of Birmingham, UK / Professor & IROAST Visiting Professor		
Yu-Lung CHIU	School of Metallurgy and Materials, University of Birmingham, UK / Senior Lecturer		
Hiroto KITAGUCHI	School of Metallurgy and Materials, University of Birmingham, UK / Senior Research Fellow		
Martin DIENWIEBEL	Applied Nanotribology, Karlsruhe Institute for Technology (KIT), Germany / Heisenberg-Professor & IROAST Visiting Professor		
Shirley SHEN	CSIRO, Australia / Principal Research Scientist & IROAST Visiting Professor		
Kazuki TAKASHIMA	IROAST, Kumamoto University, Japan / Distinguished Professor		
Kwangsik KWAK	Faculty of Advanced Science and Technology, Kumamoto University, Japan / Assistant Professor		

1. Overview of achievements

The mechanical properties of materials are dominated by their microstructures such as grain size, precipitates, phase boundary, grain boundary, etc. In our research group, we aim to clarify the mechanical properties at microscopic level, including tensile properties, fracture and fatigue properties, using the micromechanical testing technology that we have developed. Furthermore, in conjunction with crystal plasticity finite element simulation, we aim to predict the mechanical properties of bulk materials based on those at microscopic scale. The results obtained in this research will contribute for developing toughening design of advanced materials. Unfortunately, due to the pandemic of COVIC-19, mutual exchanges were not possible in FY2021, and outcomes were limited. In spite of this situation, some new and valuable results were obtained.

We have collaborated with Professor Bowen and researchers (Dr. Chiu and Dr. Kitaguchi) at the University of Birmingham to elucidate the mechanisms of fatigue crack propagation in martensitic steel, titanium alloy and nickel superalloy using the micro-fatigue testing technique developed by KU. Until 2019, researchers and graduate students had been exchanging their research, but due to

COVID-19, we were not able to do so this year. Therefore, we held web meetings and wrote an international joint paper on the fatigue crack growth mechanism of a carbon steel with lath martensite microstructure (Publication list #5).

We have collaborated with Professor Dienwiebel at KIT to elucidate the mechanisms of micro-tribology in magnesium alloys, stainless steels and alloy steels. Although we did not exchange the researchers in this year, we held web meetings and wrote an international joint paper on the correlation between the microstructure and tribological properties of magnesium alloys (Publication list #4).

2. Presentations & Publications published between April 2021 and March 2022

1) **K. Kwak**, T. Mayama, **Y. Mine**, K. Ohishi, T. Ueno, **K. Takashima**, Multiscale mechanical characterization of 601 nickel-based superalloy fabricated using wire-arc additive manufacturing, Mater. Sci. Eng. A 836 (2022) 142734.
2) D. Bayoumy, **K. Kwak**, T. Boll, S. Dietrich, D. Schliephake, J. Huang, J. Yi, **K. Takashima**, X. Wu, Y. Zhu, A. Huang, Origin of non-uniform plasticity in a high-strength Al-Mn-Sc based alloy produced by laser powder bed fusion, J. Mater. Sci. Technol. 103 (2022) 121–133.
3) S. Ueki, K. Koga, **Y. Mine**, **K. Takashima**, Crystallographic characterisation of hydrogen-induced twin boundary separation in type 304 stainless steel using micro-tensile testing, Tetsu-to-Hagané 108 (2022) 97−106 (in Japanese).
4) K. Takagi, E. Hashamova, **M. Dienwiebel**, **Y. Mine**, **K. Takashima**, Correlation of wear behaviour and microstructural evolution in Mg-Zn-Y alloys with long-period stacking ordered phase, Wear 482–483 (2021) 203983.
5) S. Ueki, **Y. Mine**, X. Lu, **Y.L. Chiu**, **P. Bowen**, **K. Takashima**, Effect of geometric lath orientation on fatigue crack propagation via out-of-plane dislocation glide in martensitic steel, Scr. Mater. 203 (2021) 114045.
6) A. Matsushita, **Y. Mine**, **K. Takashima**, Enhanced resistance to fatigue crack propagation in metastable austenitic stainless steel by nanotwin bundles, Scr. Mater. 201 (2021) 113976.
7) A. Matsushita, S. Ueki, **Y. Mine**, **K. Takashima**, Comparative study of microstructure-sensitive fatigue crack propagation in coarse- and fine-grained microstructures between stable and metastable austenitic stainless steels using miniature specimen, ISIJ Int. 61 (2021) 1688–1697.
8) Y. Shimada, K. Harada, **Y. Mine**, M. Yoshimura, **K. Takashima**, Low-temperature micro-fracture toughness testing of grain boundaries in steel, Mater. Trans. 62 (2021) 570–573.

3. Application & acquisition status of KAKENHI and other external grants

1) Elucidation of plastic deformation mechanism of additively manufactured Ti-6Al-4V alloys using trans-length scale mechanical characterization, KAKENHI Grant-in-Aid for Early-Career Scientists 2021-2024 (New).
2) Development of local strengthening of micro-mechanical components using martensitic transformation induced by focused ion beam irradiation, KAKENHI Grant-in-Aid for Challenging Exploratory Research 2021-2022 (New).
3) Elucidation of fatigue crack growth mechanism of martensite steels using micro-mechanical testing technique and application to fatigue strengthening design, KAKENHI Grant-in-Aid for Scientific Research (A) 2020-2024 (Continuing).
4) Exploration of guiding principles for toughening design of hydrogen-resistant materials using multi-scale mechanical testing, KAKENHI Grant-in-Aid for Scientific Research (B) 2019-2021 (Continuing).

4. Application & acquisition status of industrial property rights

N/A

No.4-10	Microstructure Analysis and Grain Boundary Engineering		
Research Field	Nano Material Science		
Unit Coordinator			
Name	Sadahiro TSUREKAWA		
Affiliation	Faculty of Advanced Science and Technology Email: turekawa@kumamoto-u.ac.jp	Title	Professor
Unit Members			
Name	Affiliation/Title		
Dmitri Aleks MOLODOV	Institute of Physical Metallurgy and Metal Physics, RWTH Aachen University, Germany Professor, IROAST Distinguished Professor		
Pavel LEJČEK	Institute of Physics, Academy of Sciences of the Czech Republic / University of Chemistry and Technology, Prague, Czech Republic Professor, IROAST Visiting Professor		
Mitsuhiro MATSUDA	Faculty of Advanced Science and Technology (FAST) Associate Professor		
Thomas WAITZ	Faculty of Physics, University of Vienna, Austria Associate Professor, IROAST Visiting Professor		
Christian RENTENBERGER	Faculty of Physics, University of Vienna, Austria Associate Professor, IROAST Visiting Professor		
Yoshitaka MATSUKAWA	Faculty of Advanced Science and Technology (FAST) Associate Professor		

Overview of achievements

S. Tsurekawa's (ST) group: Tsurekawa's group has collaborated with Prof. Dmitri A. Molodov (RWTH Aachen University) and Prof. Pavel Lejček (Institute of Physics, Czech Academy of Sciences), who are vising professors of IROAST, in the research field of grain boundary engineering over many years. Prof. D. A. Molodov was appointed distinguished professor by the IROAST in recognition of his contribution to research and education of Kumamoto University. ST expected Profs. D. A. Molodov and P. Lejček to stay at Kumamoto University in FY2021, but unfortunately due to the covid19 pandemic, their stay at Kumamoto University in FY2021 was also cancelled following FY2020. Instead, ST and Prof. D. A. Molodov discussed online the results of their previous collaborations and submitted the papers entitled as "Influence of symmetrical $<10\bar{1}0>$ high-angle tilt grain boundaries on the local mechanical properties of magnesium bicrystals [1]" and "On incipient plasticity in the vicinity of grain boundaries in aluminum bicrystals: Experimental and simulation nanoindentation study [2]", and they were published in Materials Science and Engineering A in 2021.

M. Matsuda's (MM) group:

Many of functional materials, such as semiconductor, super conductor, solar cell, magnetic materials and shape memory alloys, contains numerous interfaces and domains. Functional properties are greatly affected by the interfaces and boundaries between domains. The structural and mechanical properties of nanocrystalline materials was discussed in detail with Vienna's Group (Prof. T. Waitz and Prof. C. Rentenberger) by e-mail and web meeting at twice a month. At this time, we are preparing to submit these research papers. Also, our research team acquired "Promotion of Joint International Research (Fostering Joint International Research(B)) of KAKENHI", and the "Scientific Research B" to collaborate the research more strongly. Mitsuhiro Matsuda has a plan for visiting in University of Vienna as soon as the coronavirus is over.

Publications collaborated with unit members

[1] L.A. Barrales-Mora, Y. Tokuda, D.A. Molodov, S. Tsurekawa, On incipient plasticity in the vicinity of grain boundaries in aluminum bicrystals: Experimental and simulation nanoindentation study, Materials Science and Engineering: A 828 (2021), 142100 (14 pages).

[2] J.E. Brandenburg, J. Seo, K. Eto, D.A. Molodov, S. Tsurekawa, Influence of symmetrical <10$\bar{1}$0> high-angle tilt grain boundaries on the local mechanical properties of magnesium bicrystals, Materials Science and Engineering: A 826 (2021), 141913 (10 pages).

Acquisition status of KAKENHI and other external grants

[1] M. Matsuda: Promotion of Joint International Research (Fostering Joint International Research(B)) of KAKENHI, "*Development of innovative functional materials based on the evaluation and control for interface dynamics*", Grant Number JP19KK0125 (from FY2019 to FY2022),
[2] M. Matsuda: Grant-in-Aid for Scientific Research (B), "*Development of high temperature shape memory alloy based on the atomic shuffling mechanism in martensitic transformation*", Grant Number JP20H02427 (from FY2020 to FY2023).
[3] S. Tsurekawa: Grant-in-Aid for Scientific Research (B), "*Grain boundary – dislocation interactions under chemical and physical reaction fields associated with grain boundary segregation*", Grant Number 20H001760 (from FY2022 to FY2025).
[4] S. Tsurekawa: The Iron and Steel Institute of Japan Research Promotion Grant, "*Impact of grain boundary character and structure on hydrogen embrittlement of grain boundary in α-iron*" (from FY2022 to FY2023).

No.4-11	Structure and Dynamics of Materials Using Quantum Beams and Data-Driven Sciences		
Research Field	Nano Material Science		
Unit Coordinator			
Name	Ichiro AKAI		
Affiliation	Institute of Industrial Nanomaterials Email: iakai@kumamoto-u.ac.jp	Title	Professor
Unit Members			

Name	Affiliation/Title
March de BOISSIEU	SIMaP, CNRS, Université Grenoble Alpes, France Director, IROAST Visiting Professor
Matthieu MICOULAUT	Sorbonne Université, France Professor, IROAST Visiting Professor
Anita ZEITLER	Department of Physics, University of Bath, UK Lecturer
László PUSZTAI	Wigner Research Centre for Physics, Hungarian Academy of Sciences, Hungary/ IROAST Scientific Advisor, IROAST Distinguished Professor
Alexei KUZMIN	Laboratory of Materials Morphology and Structure Investigations, Institute of Solid State Physics, University of Latvia, Riga, Latvia Head of Laboratory, IROAST Visiting Professor
Masaru ANIYA	Faculty of Advanced Science and Technology (FAST), Kumamoto University Professor
Masahiro HARA	Faculty of Advanced Science and Technology (FAST), Kumamoto University Associate Professor
Yoichi NAKAJIMA	Faculty of Advanced Science and Technology (FAST), Kumamoto University Assistant Professor
Shinya HOSOKAWA	Institute of Industrial Nanomaterials (IINa), Kumamoto University Project Professor

1. Overview of achievements

The aim of this research group is to investigate structure and dynamics of materials using quantum beam facilities in combination with data-driven sciences and computer simulations. Recent developments of quantum beam facilities, such as synchrotron radiation, x-ray free electron laser, and intense neutron sources, lead remarkable progresses in the quality of experimental data.

In conjunction with them, new varieties of the data sets appear, such as two-dimensional images etc. and the corresponding data volumes explosively increase. The present task for researchers is how to extract scientifically valuable information from the experimental data of huge size in quantity but of still insufficient in quality. In this research unit, thus, we carry out state-of-art experiments such as scattering and imaging using quantum beam facilities, and analyze the data using, e.g., Inverse problem, Bayesian inference with Metropolis' algorithm (reverse Monte Carlo modeling) and some others. Furthermore, the data-driven science such as Sparse modeling is a very promising tool for handling the data. To support the experimental results, first principles computer simulations are also indispensable.

Concerning the above aim of this unit, 26 papers are published in referred journals and 4 projects are supported by JST and JSPS for this research unit members in this fiscal year.

2. Presentations & Publications published between April 2021 and March 2022

1) H. Kumazoe, Y. Igarashi, F. Iesari, R. Shimizu, Y. Komatsu, T. Hitosugi, D. Matsumura, H. Saitoh, K. Iwamitsu, T. Okajima, Y. Seno, M. Okada, I. Akai, Bayesian sparse modeling of extended x-ray absorption fine structure to determine interstitial oxygen positions in yttrium oxyhydride epitaxial thin film, AIP Advances **11**, 125013-1-5 (2021).
2) I. Sakata, T. Sakata, K. Mizoguchi, S. Tanaka, G. Oohata, I. Akai, Y. Igarashi, Y. Nagano, M. Okada, Complex energies of the coherent longitudinal optical phonon-plasmon coupled mode according to dynamic mode decomposition analysis. Scientific Reports volume **11**, 23169-1-10 (2021).
3) H. Tanimoto, X. Hongkun, M. Mizumaki, Y. Seno, J. Uchiwada, R. Yamagami, H. Kumazoe, K. Iwamitsu, Y. Kimura, K. Amezawa, I. Akai, Non-negative matrix factorization for 2D-XAS images of lithium ion batteries, Journal of Physics Communications **5**, 115005-1-16 (2021).
4) K. Iwamitsu, Y. Nishi, T. Yamasaki, M. Kamezaki, K. Higashiyama, S. Yakura, H. Kumazoe, S. Aihara, K. Nagata, M. Okada, I. Akai, Replica exchange Monte Carlo method incorporating auto-tuning algorithm based on acceptance ratios for effective Bayesian spectroscopy, Journal of the Physical Society of Japan **90**, 104004-1-13 (2021).
5) Y. Yokoyama, N. Tsuji, I. Akai, K. Nagata, M. Okada, M. Mizumaki, Bayesian Orbital Decomposition and Determination of End Condition for Magnetic Compton Scattering, Journal of the Physical Society of Japan **90**, 094802-1-6 (2021).
6) T. Yamasaki, K. Iwamitsu, H. Kumazoe, M. Okada, M. Mizumaki, I. Akai, Bayesian spectroscopy of synthesized soft X-ray absorption spectra showing magnetic circular dichroism at the Ni-L3, -L2 edges, Science and Technology of Advanced Materials: Method **1**, 75-86 (2021).
7) LVD Gammond, H Auer, R Mendes Da Silva, A Zeidler, JF Ortiz-Mosquera, AM Nieto-Muñoz, ACM Rodrigues, IAA Silva, H Eckert, CJ Benmore, and PS Salmon, Structure of crystalline and amorphous materials in the NASICON system Na1+xAlxGe2−x(PO4)3, The Journal of Chemical Physics 155 (7), 074501 (2021).
8) A Polidori, RF Rowlands, A Zeidler, M Salanne, HE Fischer, B Annighöfer, S Klotz, and PS Salmon, Structure and dynamics of aqueous NaCl solutions at high temperatures and pressures, The Journal of Chemical Physics 155 (19), 194506 (2021).
9) LVD Gammond, RE Youngman, A Zeidler, BG Aitken, PS Salmon, Structural model for amorphous aluminosilicates, The Journal of Chemical Physics 156 (6), 064503 (2022).
10) S. Pothoczki, I. Pethes, L. Pusztai, L. Temleitner, K. Ohara, and I Bakó, Properties of

Hydrogen-Bonded Networks in Ethanol–Water Liquid Mixtures as a Function of Temperature: Diffraction Experiments and Computer Simulations; *The Journal of Physical Chemistry B*; **125,** 6272-6279 (2021).

11) I. Pethes, L. Pusztai, K. Ohara, and L. Temleitner, Temperature-dependent structure of 1-propanol/water mixtures: X-ray diffraction experiments and computer simulations at low and high alcohol contents, *Journal of Molecular Liquids* **340**, 117188 (2021).

12) I. Bakó, D. Csókás, I. Mayer, S. Pothoczki, and L. Pusztai, The influence of cations on the dipole moments of neighboring polar molecules; *International Journal of Quantum Chemistry* **122**, e26758-1-12 (2021).

13) L. Temleitner, L. Pusztai, G. Cuello, and A. Stunault, Structural studies of ^{1}H-containing liquids by polarized neutrons: Chemical environment and wavelength dependence of the incoherent background, *Journal of Molecular Liquids* **350**, 118535 (2022).

14) Masaru Aniya, Haruhito Sadakuni, and Eita Hirano, Ionic Conductors: Effect of Temperature on Conductivity and Mechanical Properties and Their Interrelations, *Crystals* **11**, 1008-1022 (2021).

15) Masahiro Ikeda and Masaru Aniya, Predicting the Temperature Range of Arrhenius Crossover of Structural Relaxation in Fragile Glass-forming Liquids, Glass Physics and Chemistry 47, 427-430 (2021).

16) Kazuma Hagihara and Masaru Aniya, A Model for the Particle Size Dependence of the Ionic Conductivity, AIP Conference Proceedings **2440**, 030002-1-6 (2022).

17) Kazuho Murata and Masaru Aniya, Particle Size and Dimensionality Dependence of the Grüneisen Parameter, AIP Conference Proceedings **2440**, 030004-1-5 (2022).

18) Masaru Aniya and Takesi Usuki, Ion Conducting Chalcogenide Glasses, *Solid State Physics* **57**, 21-33 (2022). (in Japanese).

19) K. Oka, S. Tateno, Y. Kuwayama, K. Hirose, Y. Nakajima, K. Umemoto, N. Tsujino, and S. I. Kawaguchi, A cotunnite-type new high-pressure phase of Fe_2S, *American Mineralogists*, (in press)

20) L. Temleitner, T. Hattori, J. Abe, Y. Nakajima, and L. Pusztai, Pressure-Dependent Structure of Methanol-Water Mixtures up to 1.2 GPa: Neutron Diffraction Experiments and Molecular Dynamics Simulations, *Molecules*, **26**, 1218 (2021).

21) E. S. Jennings, S. A. Jacobson, D. C. Rubie, Y. Nakajima, A. K. Vogel, L. A. Rose-Weston, and D. J. Frost, Metal–silicate partitioning of W and Mo and the role of carbon in controlling their abundances in the bulk silicate earth, *Geochimica et Cosmochimica Acta* **293**, 40-69 (2021).

22) B. Paulus, J. R. Stellhorn, S. Hosokawa, B. D. Klee, Y. Sutou, and W.-C. Pilgrim, Short-Range Order Investigation of $Cu_xGe_{50-x}Te_{50}$ Phase-Change Materials, *Physica Status Solidi B* 2100619 (2022). (in press)

23) M. Inui, Y. Kajihara, S. Hosokawa, A. Chiba, Y. Nakajima, K. Matsuda, J. R. Stellhorn, T. Hagiya, D. Ishikawa, H. Uchiyama, S. Tsutsui, and A. Q. R. Baron, Low energy excitation in liquid Sb and liquid Bi observed in inelastic x-ray scattering spectra, *Journal of Physics: Condensed Matter* **33**, 475101-1-8 (2021).

24) K. Hayashi, N. Happo, and S. Hosokawa, A cryostat designed for x-ray fluorescence holography experiments down to 4 K, *Review of Scientific Instruments* **92**, 083703-1-7 (2021).

25) M. Inui, Y. Kajihara, S. Hosokawa, A. Chiba, Y. Nakajima, K. Matsuda, Y. Tsuchiya, J. R. Stellhorn, T. Hagiya, H. Uchiyama, S. Tsutsui, and A. Q. R. Baron, Longitudinal acoustic and higher energy excitations in liquid phase change material $Ge_2Sb_2Te_5$, *Physical Review B* **104**, 064202-1-8 (2021).

26) F. Demmel. S. Hosokawa, and W.-C. Pilgrim, Collective particle dynamics of molten NaCl by inelastic x-ray scattering, *Journal of Physics: Condensed Matter* **33**, 375103-1-12 (2021).

27) N. Happo, K. Hayashi, T. Matsushita, and S. Hosokawa, Local structure analysis on yttria-stabilized zirconia by x-ray fluorescence holography, *e-Journal of Surface Science and Nanotechnology* **20**, 51-57 (2022).
28) S. Hosokawa, N. Happo, K. Hayashi, T. Matsushita, and A. Yamashita, Three-dimensional atomic image of FeSe high-temperature superconductor by x-ray fluorescence holography, *e-Journal of Surface Science and Nanotechnology* **20**, 36-41 (2022).
29) S. Hosokawa, Progress of structural analysis on amorphous materials by quantum beams, *Solid State Physics* **57**, 35-44 (2022). (in Japanese)

3. Application & acquisition status of KAKENHI and other external grants

1) JST CREST (Continued), Main Proposer: I. Akai, 10,950,000 JPY
2) JSPS Grant-in-Aid for Scientific Research (C): M. Aniya, 1,000,000 JPY
3) JSPS Grant-in-Aid for Scientific Research (C): Y. Nakajima, 600,000 JPY
4) JSPS Grant-in-Aid for Transformative Research Areas (A): S. Hosokawa, 3,000,000 JPY

4. Application & acquisition status of industrial property rights

None.

No.4-12	Hydrological Environments		
Research Field	Environmental Science		
Unit Coordinator			
Name	Takahiro HOSONO		
Affiliation	Faculty of Advanced Science and Technology Email: hosono@kumamoto-u.ac.jp	Title	Professor
Unit Members			
Name	Affiliation/Title		
Kimpei ICHIYANAGI	Associate Professor, Faculty of Advanced Science and Technology, Kumamoto University, Japan		
Jens HARTMANN	Professor, Institute for Geology, University of Hamburg, Germany		
Rusmawan SUWARMAN	Assistant Professor, Faculty of Earth Science and Technology, Bandung Institute of Technology (ITB), Indonesia		
Pascale LOUVAT	CNRS research engineer, Institut de Physique du Globe de Paris, France		

1. Overview of achievements

1.1. Publishing joint research work

While the weathering of silicate rocks on the Earth's surface consumes atmospheric CO_2 and regulates climate over geological timescales, other sources of acids, including sulphuric acid, nitric acid, halogens acids and organic acids also contribute to weathering fluxes. Several studies highlight that active volcanic areas with a hydrothermal system produce high riverine cation fluxes, although a significant part does not relate to atmospheric CO_2 consumption. Volcanic hydrothermal waters display highly diverse chemical compositions as they result from admixing of magmatic fluids with meteoric waters. The dissolution of magmatic gases, like sulphur dioxide, carbon dioxide, and halogen compounds, in meteoric waters produce strong and weak acids that act as proton sources, thereby enhancing water-rock interaction. Thus, the correct assessment on the hydrothermal contribution to weathering fluxes requires to estimate relationship between weathering and atmospheric CO_2 withdrawal in volcanic terranes. To be able to understand the regional controls on these fluxes, a research area like the Aso caldera or Kirishima represent unique opportunities due the given infrastructure. Unit members Drs. J. Hartmann, T. Hosono and P. Louvat have conducted surveys for the past seven years due this infrastructure and performed geochemical analysis, which allows us to analyses in depth the diverse processes controlling the water quality. As a results, our analyses show that hydrothermal waters strongly influence the sulphur budget in Aso caldera watershed, accounting for 67 to 91% of the total sulphate flux at the caldera outlet. The dissolution of magmatic CO_2 and SO_2 contribute with more than 60% to the observed weathering fluxes in this volcanic area. Our study demonstrated that magmatic gases and hydrothermal fluids should be considered for the estimation of biogeochemical budgets at the regional and global scale using and their products must be parameterized. We have successfully

published this new finding in international journal *Chemical Geology* (Romero-Mujalli et al., 2022).

1.2. Discussing on a global water quality database, considering a long-term plan and strategy building on the previous GLORICH database.

Dr. J. Hartmann is trying to develop a global water quality database, GLORICH database, https://www.geo.uni-hamburg.de/geologie/forschung/geochemie/glowachem.html, with several key scientists over the world. Dr. T. Hosono is in charge of data collection from southeast Asian division. In 2020, Dr. T. Hosono has collected database from whole Japanese islands and some southeastern countries that were added in the database. In 2021, Dr. T. Hosono has started analyzing hydrochemical database for stream waters that covers whole Japanese islands and it will be continued next year to try to generalize water chemistry feature whole Japan by applying data processing approaches such as artificial intelligence.

1.3. Financial supports

Dr. T. Hosono was financially supported by IROAST for paying article processing charges on publishing paper in Earth, Planets and Space ($1622.50 ≒ 183,015 JPY). The study was also supported by IROAST Research Award (500,000 JPY). T.H. wishes to thank all these supports.

2. Presentations & Publications published between April 2021 and March 2022

2.1. Presentations (international congress)

Hermawan, O.R., **Hosono, T.**, Yasumoto, J., Sawada, K., Song, K.-H., Shinjo, R. Nitrate contamination source identification by using multiple isotopes ratios in Ryukyu limestone aquifer, southern Okinawa island, Japan. JpGU-AGU joint session, Japan Geoscience Union Meeting 2021, online, 30 May-6 June 2021 (presentation on 4th June).

Irfan Tsany Rahmawan, Haruchika Hamatake, **Kimpei Ichiyanagi**, Jun Shimada and Tsutomu Ichikawa, Seasonal variation of the groundwater spring discharge around Lake Ezu, Kumamoto City. The 16th International Student Conference on Advanced Science and Technology (ICAST2021), Kumamoto University, online, 2-3 December 2021 (presentation on 3rd December).

Jeerapong Laonamsai, **Kimpei Ichiyanagi**, Stable Isotope Dynamics of Hydrological Interactions in The Chao Phraya River System in Thailand. Japan Geoscience Union Meeting 2021, online, 30 May-6 June 2021 (presentation on 6th June).

Kimpei Ichiyanagi, Global water cycle and virtual water. Guest Lecture on Institut Teknologi Sepuluh Nopember (ITS), online, 14 June 2021.

Rahman, A.T.M.S., **Hosono, T.**, Tawara, Y., Fukuoka, Y., Hazart, A., Shimada, J. Physically Based Groundwater Flow Simulation using Tracer-aided model in Kumamoto Region, Japan. JpGU-AGU joint session, Japan Geoscience Union Meeting 2021, online, 30 May-6 June 2021 (presentation on 4th June).

Romero-Mujalli, G.**, Hartmann, J., Hosono, T.**, Ide, K., Amann, T., **Louvat, P.** Hydrothermal influence on rock weathering in the Kirishima volcanic complex. Goldschmidt 2021, 4-9 July 2021, online conference, Lyon, France (presentation on 6th July).

Yasumoto, J. Shinjo, R., Razafindrabe, B., Toki, T., Sawada, K., **Hosono, T.**, Hermawan, O.R., Nakaya, S., Takada, R., Nakagawa, K., Kagabu, M., Tawara, Y., Murai, A., Yasumoto, K., Mizusawa, N., Hirose, M., Maruyama, R., Iijima, M., Iguchi, A. Watershed Governance Based on Participation and Consensus for Sustainable Water Resource Use in Subtropical Islands. JpGU-AGU joint session, Japan Geoscience Union Meeting 2021, online, 30 May-6 June 2021 (presentation on 4th June).

2.2. Presentations (domestic congress)

Oktanius Richard Hermawan, **Takahiro Hosono**, Yasumoto Jun, Ryuichi Shinjo, Chitoshi Mizota, Toshiro Yamanaka: Cause of elevated sulfate concentrations in limestone aquifers in southern Okinawa Island, Japan. 日本地下水学会, 2021 年 12 月 2-4 日（発表日 2 日）.

Rahman, A.T.M.S., **Hosono, T.**, Quilty, J.M., Das, J., Basak, A. Automated Hybrid Machine Learning Approaches for Groundwater Level Forecasting in Kumamoto area, Japan. 日本地球惑星科学連合 2021 年大会, オンライン, 2021 年 5 月 30 日-6 月 6 日（発表日 6 月 3 日）

丸山莉織, 安元 剛, 水澤奈々美, 天野春菜, 神保 充, 渡部終五, 高田遼吾, 廣瀬(安元)美奈, 新城竜一, **細野高啓**, 飯島真理子, 井口 亮, 安元 純: 琉球石灰岩地域における陸水のメタゲノム解. 日本地下水学会, 2021 年 12 月 2-4 日（発表日 3 日）.

丸山莉織, 飯島真理子, 水澤奈々美, 安元 剛, 安元 純, 井口 亮, 廣瀬美奈, 新城竜一, **細野高啓**, 天野春菜,神保 充, 渡部終五: 琉球石灰岩地域における水循環中のメタゲノム解析. 第 21 回マリンバイオテクノロジー学会学術大会, オンライン, 2021 年 5 月 15-16 日（発表日 16 日）.

山本祐生, **細野高啓**, Oktanius Richard Hermawan, 新城竜一, 伊藤湧人, 宋科翰, 安元純, 宮城もね, 松岡走, 高田遼吾, 安元剛, 丸山莉緒, 三雲さき, 飯島真理子: 沖縄県多良間島の淡水レンズにおける硝酸性窒素の起源と挙動に関する 2021 年調査報告. 日本地下水学会, 2021 年 12 月 2-4 日（発表日 2 日）.

赤田尚史，柿内秀樹，**一柳錦平**，岡田一沙，桑田遥，太田代楠生，田中将裕， 市販の固体高分子膜電解濃縮装置の高濃縮効率化に向けた改良．日本地球化学会第 68 回年会，弘前大学，2021 年 9 月 9 日～10 日（発表日 10 日）.

壁谷直記、清水晃、黒川潮、酒井佳美、鳥山順平、釣田竜也、小林政広、清水貴範、**一柳錦平**，自動採水器を用いた時間別降雨採水装置の開発．第 77 回九州森林学会，オンライン，2021 年 10 月 29 日～11 月 5 日（発表日 11 月 1 日）.

2.4. Publications

Aizawa, M., Mizota, C., **Hosono, T.**, Shinjo, R., Furukawa, Y., Nobori, Y., 2022. Lead isotopic characteristics of gun bullets prevailed during the 19th century in Japan: Constraints on the provenance of lead source from the United Kingdom and Japan. Journal of Archaeological Science: Reports, 41, 103268. https://doi.org/10.1016/j.jasrep.2021.103268

Hosono, T., Yamanaka, C., 2021. Origins and pathways of deeply derived carbon and fluids observed in hot spring waters from non-active volcanic fields, western Kumamoto, Japan. Earth, Planets and Space, 155, 73. https://doi.org/10.1186/s40623-021-01478-1

Jeerapong Laonamsai, **Kimpei Ichiyanagi**, Supapap Patsinghasanee (2021), Isotopic temporal and spatial variations of tropical rivers in Thailand reflect monsoon precipitation signals. Hydrological Processes, 2021;35:e14068, https://doi.org/10.1002/hyp.14068.

Jeerapong Laonamsai, **Kimpei Ichiyanagi**, Supapap Patsinghasanee, and Kiattipong Kamdee (2021), Controls on stable isotopic characteristics of water vapour over Thailand. Hydrological Processes, 35(7), e14202. https://doi.org/10.1002/hyp.14202.

Mizota, C., Hansen, R., **Hosono, T.**, Okumura, A., 2022. Museum-archived and recent acquisition nitrates from the Atacama Desert, Chile, South America: refinement of the dual isotopic compositions ($\delta^{15}N$ vs. $\delta^{18}O$). Isotopes in Environmental and Health Studies, 58, 1-17. https://doi.org/10.1080/10256016.2021.1990913

Mojtaba Heydarizad, Masoud Minaei, **Kimpei Ichiyanagi**, Rogert Sori (2021), The effects of local and regional parameters on the $\delta^{18}O$ and $\delta^{2}H$ values of precipitation and surface water resources in the Middle East. Journal of Hydrology, 600, 126485. https://doi.org/10.1016/j.jhydrol.2021.126485.

Rahman, A.T.M.S., **Hosono, T.**, Tawara, Y., Fukuoka, U., Hazart, A., Shimada, J., 2021. Multiple-

tracers-aided surface-subsurface hydrological modeling for detailed characterization of regional catchment water dynamics in Kumamoto area, southern Japan. Hydrogeology Journal, 29, 1885-1904. https://doi.org/10.1007/s10040-021-02354-8

Romero-Mujalli, G., Hartmann, J., **Hosono, T.**, Louvat, P., Okamura, K., Delmelle, P., Amann, T., Böttcher, M.E., 2022. Hydrothermal and magmatic contributions to surface waters in the Aso caldera, southern Japan: Implications for weathering processes in volcanic areas. Chemical Geology, 588, 120612. https://doi.org/10.1016/j.chemgeo.2021.120612

Tanimizu, M., Sugimoto, N., **Hosono, T.**, Kuribayashi, C., Morimoto, T., Ito, A., Umam, R., Nishio, Y., Nagaishi, K., Ishikawa, T., 2021. Application of B and Li isotope systematics for detecting chemical disturbance in groundwater associated with large shallow inland earthquakes in Kumamoto, Japan. Geochemical Journal, 55, 241-250. https://doi.org/10.2343/geochemj.2.0633

3. Application & acquisition status of KAKENHI and other external grants

T. Hosono, JSPS Grant-in-Aid for Scientific Research (A), 2022-2026
T. Hosono, JSPS Fostering Joint International Research (A), 2020-2023, 19KK0291

4. Application & acquisition status of industrial property rights

non

No.4-13	Nano-materials for Energy Applications and Environmental Protection		
Research Field	Nano Material Science		
Unit Coordinator			
Name	Tetsuya KIDA		
Affiliation	Faculty of Advanced Science and Technology Email: tetsuya@kumamoto-u.ac.jp	Title	Professor
Unit Members			
Name	Affiliation/Title		
Armando T. QUITAIN	Center for International Education, Kumamoto University/ Professor		
Maria Jose COCERO	Chemical Engineering & Environmental Technology, Universidad de Valladolid Spain/ Professor		
Yusuke INOMATA	Department of Applied Chemistry & Biochemistry, Faculty of Advanced Science and Technology, Kumamoto University/ Assistant Professor		

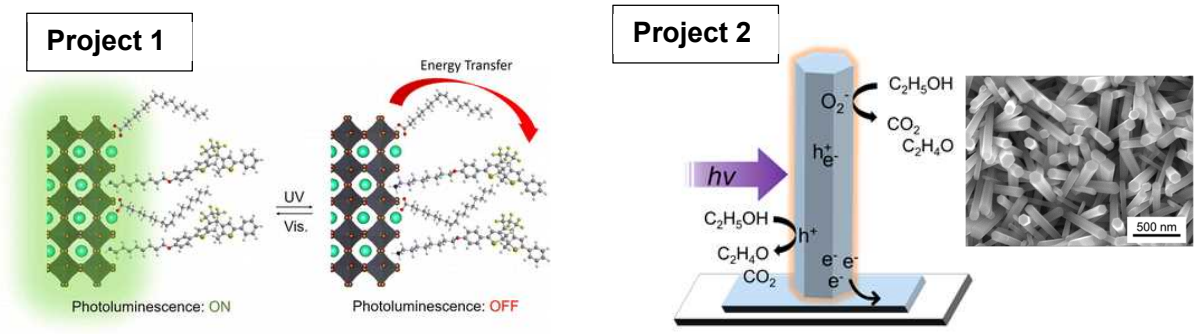
1. Overview of achievements

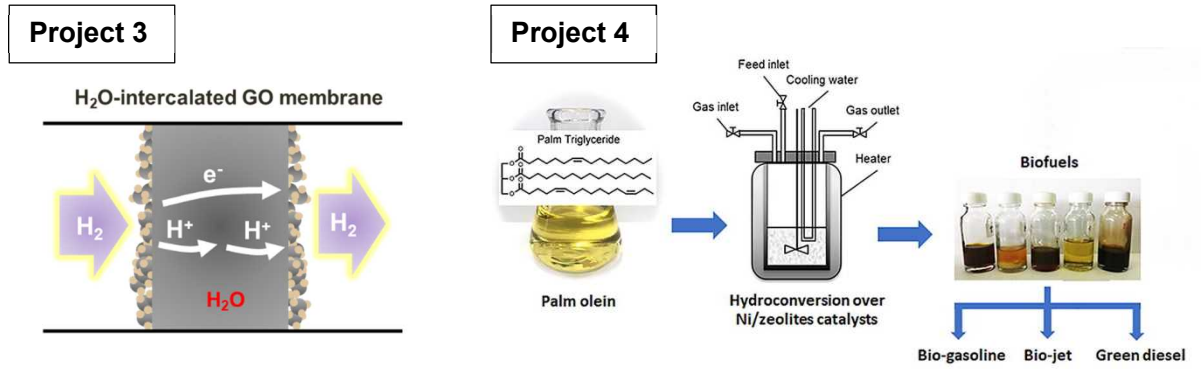
Our research projects are divided into four categories:

1) Synthesis of colloidal quantum dots for optical applications.
2) Synthesis of oxide nanomaterials for gas sensing.
3) Electrochemical applications of proton/electron conducting graphene oxide membranes.
4) Catalytic conversion of biomass into valuable compounds.

The key achievements include:

A) On/Off switching of photoemission from perovskite quantum dots, $CsPbX_3$ (X = Cl, Br, I) by coupling with photochromic diarylethene molecules.
B) Development of highly-sensitive gas sensor for volatile organic compounds (VOCs) using vertically-aligned ZnO nanorods under visible light irradiation.
C) Succuss of super selective hydrogen separation at room temperature using mixed conducting graphene oxide nanosheet membranes.
D) Efficient conversion of palm olein biomass into bio-jet fuel by Ni/zeolite catalysts.





2. Presentations & Publications published between April 2021 and March 2022

[Journal publications]

1. M.C.A. Macawile, A. Durian, R.V. Rubi, A. Quitain, T. Kida, R. Tan, L. Razon, J. Auresenia, Green Synthesis, Characterization, and Catalytic Activity of Amine-multiwalled Carbon Nanotube for Biodiesel Production, ***Bulletin of Chemical Reaction Engineering & Catalysis***, 5 (2022).
2. P. Nuket, Y. Akaishi, G. Yoshimura, P. Vas-Umnuay, T. Kida, Enhanced Interfacial Charge Transfer Between $CsPbBr_3$ Quantum Dots and Surface-Modified TiO_2/FTO Photoanodes for Photocurrent Generation, ***Materials Today Nano***, 100174 (2022).
3. T. Tsukahara, S. An, S. Otsuru, Y. Tezuka, S. Nozawa, J. Adachi, K. Akashi, Y. Inagaki, T. Kawae, H. Ishii, Y.-F. Liao, T. Kida, S. Suehiro, M. Nantoh, K. Ishibashi, Y. Ishiwata, Correlation between ferromagnetism and dopant 3d metal-oxygen hybridized state lying at the bottom of conduction band in ZnO-based diluted magnetic semiconductor system, ***Journal of Applied Physics***, 130, 243904 (2021).
4. C.S.C. Issasi, K. Mori, R.M. Ibarra, M. Sasaki, A.T. Quitain, T. Kida, S. Okubayashi, T. Furusato, One-Pot Synthesis of Thermoresponsive Poly(N-Isopropylacrylamide) Assisted by Pulsed Arc Discharge in Contact with the Water Interface for Wound Dressing Purposes, ***ACS Applied Polymer Materials***, 4, 74-83 (2021).
5. A. Hardiansyah, W.J. Budiman, N. Yudasari, Isnaeni, T. Kida, A. Wibowo, Facile and Green Fabrication of Microwave-Assisted Reduced Graphene Oxide/Titanium Dioxide Nanocomposites as Photocatalysts for Rhodamine 6G Degradation, ***ACS omega***, 6, 32166-32177 (2021).
6. A. Mokhtar, R. Morinaga, Y. Akaishi, M. Koinuma, S. Kim, S. Kurihara, T. Kida, T. Fukaminato, Luminescence Photoswitching of Colloidal $CsPbBr_3$ Nanocrystals by Photochromic Diarylethene Ligands, ***Chemistry Letters***, 50, 1534-1538 (2021).
7. P. Siabbamrung, A.T. Quitain, T. Kida, N. Laosiripojana, P. Boonnoun, A. Shotipruk, Solid acid catalyst prepared via one-step microwave-assisted hydrothermal carbonization: Enhanced stability towards intensified production of 5-hydroxymethylfurfural in water/γ-valerolactone/NaCl, ***Molecular Catalysis***, 512, 111772 (2021).
8. P. Chintakanan, T. Vitidsant, P. Reubroycharoen, P. Kuchonthara, T. Kida, N. Hinchiranan, Bio-jet fuel range in biofuels derived from hydroconversion of palm olein over Ni/zeolite catalysts and freezing point of biofuels/Jet A-1 blends, ***Fuel***, 293, 120472 (2021).
9. H.K.G Singh, S. Yusup, A.T. Quitain, B. Abdullah, A. Inayat, M. Ameen, K.W. Cheah, M. Sasaki, T. Kida, Y. H. Chai, Five-lump kinetic approach on biofuel production from refined rubber seed oil over Cu/ZSM-5 catalyst via catalytic cracking reaction, ***Renewable Energy***, 171, 1445-1453 (2021).
10. S. Balasubramaniam, S. Ninomiya, M. Sasaki, A.T. Quitain, T. Kida, M.D.A. Saldaña, Carbon-based solid acid catalyst derived from Undaria pinnatifida and its application in

esterification, ***Algal Research***, 55, 102272 (2021).

11. A. D. Pramata, Y. Akaishi, K. N. Kodama, Y. Mokuge, S. Kawashima, M. Shimoyoshi, C. Sairot, P. Nuket, P. Vas-Umnuay, T. Kida, TiO_2-Coated $CsPbI_3$ Quantum Dots Coupled with Polyoxometalates for On/Off Fluorescent Photoswitches, ***ACS Applied Nano Materials***, 4, 4103-4113 (2021).
12. N.L. Hamidah, M. Shintani, A.S.A. Fauzi, S. Kitamura, E.G. Mission, M. Sasaki, A.T. Quitain, T. Kida, Electrochemical hydrogen production from humid air using cation-modified graphene oxide membranes, ***Pure and Applied Chemistry***, 93, 1-11 (2021).
13. M. Tao, S. Ishikawa, Z. Zhang, T. Murayama, Y. Inomata, A. Kamiyama, I. Nakaima, Y. Jing, S. Mine, K. Shimoda, T. Toyao, K.-i. Shimizu, W. Ueda, Synthesis of Zeolitic Ti, Zr-Substituted Vanadotungstates and Investigation of Their Catalytic Activities for Low Temperature NH_3-SCR, ***ACS Catalysis***, 11, 14016–14025 (2021).
14. Y. Inomata, S. Hata, E. Kiyonaga, K. Morita, K. Yoshida, M. Haruta, T. Murayama, Synthesis of bulk vanadium oxide with a large surface area using organic acids and its low-temperature NH_3-SCR activity, ***Catalysis Today***, 376, 188-196 (2021).
15. H. Kubota, T. Toyao, Z. Maeno, Y. Inomata, T. Murayama, N. Nakazawa, S. Inagaki, Y. Kubota, and K.-i. Shimizu, Analogous Mechanistic Features of NH3-SCR over Vanadium Oxide and Copper Zeolite Catalysts, ***ACS Catalysis,*** 11, 11180–11192 (2021).

[Book Chapters]

1. T. Quitain, E.G. Mission, J.K.C.N. Agutaya, M. Sasaki, T. Kida, Thermal, hydrothermal liquefaction, and electromagnetic processes for biomass conversion. In ***AZ of Biorefinery***, 1st ed.; N. Thongchul, A. Kokossis, S. Assabumrungrat Eds.; Elsevier: Amsterdam, Netherlands, 2021; pp. 421-446.
2. J.K.C.N. Agutaya, A.T. Quitain, Y.L. Kam, S. Zullaikah, J. Auresenia, R.R. Tan, S. Assabumrungrat, T. Kida, Hydrothermal liquefaction of algal biomass to bio-oil. In ***Value-Chain of Biofuels***, 1st ed.; S. Yusup, N.A. Rashidi Eds.; Elsevier: Amsterdam, Netherlands, 2021; Volume 3, pp. 159-180.

3. Application & acquisition status of KAKENHI and other external grants

- MEXT/JSPS KAKENHI Grant-in-Aid for Scientific Research（B）, “ON/OFF Emission Switching of Perovskite Quantum Dots”, 2020.4~2023.3, 17,680,000-yen, PI: Tetsuya KIDA
- MEXT/JSPS KAKENHI Fund for the Promotion of Joint International Research (Fostering Joint International Research (B)), “Design of highly sensitive gas recognition interfaces using 1D/2D nanomaterials”, 2020.11~2025.3, 18,720,000-yen, PI: Tetsuya KIDA
- JSPS Bilateral joint research project, “Biomass conversion into value-added compounds using nanocarbon-based catalysts”, 2021.4~2023.3, 3,900,000-yen, PI: Tetsuya KIDA
- JST A-STEP Tryout, “Development of highly emissive quantum dot films having remote control function”, 2020.12~2022.3, 3,000,000-yen, PI: Tetsuya KIDA
- The ENEOS Hydrogen Trust Fund, “Super selective hydrogen separation using graphene oxide membrane”, 2020.11~2021.10, 10,000,000-yen, PI: Tetsuya KIDA
- MEXT/JSPS KAKENHI Grant-in-Aid for Scientific Research (Fostering Joint International Research (A)), “Analyses of the Synergy of Sub/Supercritical H_2O-CO_2 System for Synthesis of Green Platform Chemicals”, 2018.4~2023.3, 15,210,000-yen, PI: Armando T. QUITAIN
- JST e-ASIA Joint Research Program, “Development of Algal Bioenergy Systems for Green and Sustainable ASEAN Region”, 2019.4~2023.3, 35,100,000-yen, PI: Armando T. QUITAIN
- JASTIP-Net Japan-ASEAN Science, Technology and Innovation Platform (JASTIP),

"Development of Green Technologies for Biomass Conversion into Chemicals and Fuels Adaptable to the ASEAN Region", 2020.4~2025.3, 2,500,000-yen, PI: Armando T. QUITAIN

- MEXT/JSPS KAKENHI Grant-in-Aid for Early-Career Scientists, "Synthesis of W-V complex oxides for deNOx catalysts", 2020.4~2022.3, 4,160,000-yen, PI: Yusuke INOMATA

4. Application & acquisition status of industrial property rights

N/A

No.4-14	Quantitative Bioimaging		
Research Field	Advanced Green Bio		
Unit Coordinator			
Name	Takumi HIGAKI		
Affiliation	IROAST/ Faculty of Advanced Science and Technology	Title	Professor
Unit Members			
Name	Affiliation/Title		
Fei DU Masaki SHIMONO Kae AKITA	Chinese Academy of Sciences, China Postdoctoral Fellow Michigan State University, USA Research Associate Japan Women's University, Japan Assistant Professor		

Details of activities

Recent advances in bioimaging equipment have enabled scientists to acquire large amounts of bioimage data within a short period of time. Following this influx of bioimage information, biologists are now engaging in bioimage informatics, an emerging area of bioinformatics. In this Quantitative Bioimaging Unit, we focus on microscopic image analysis on cytoskeleton. Cytoskeleton relates cell dynamics including cell division, growth, and differentiation. Its higher-order structures (e.g. bundles or meshworks) dynamically change in response to developmental or environmental cues. We are working on the development of a bioimage analysis framework to quantitatively evaluate multi-dimensional cytoskeletal organizations based on tight collaboration among experts in cell biology and bioimage informatics. Specifically, we are now trying to make a new image analysis system that (1) does not need manual segmentation, (2) provides multi-dimensional features without laborious pre-processing, and (3) makes results visualization based on multi-dimensional features by multivariate analysis and image clustering method. In FY2021, we worked on a collection of various types of cytoskeletal images and the development of the image analysis framework to quantitatively evaluate multidimensional cytoskeletal organizations, and refined the analysis techniques developed over the last fiscal year. Specifically, we developed a method for segmentation of the cytoskeleton with the aid of deep learning. Previously, microscopic images were mainly judged based solely on the visual inspection of the researcher, but this method lacked objectivity and had poor reproducibility, which has been pointed out as a problem. With the recent digitization of microscopic images and improvements in computer performance, quantitative evaluation methods for cytoskeletal structure have been developed using image analysis. Nowadays, quantitative evaluation of cytoskeletal structure is widely used to describe novel cytoskeletal dynamics and to analyze phenotypes of mutants, and is becoming a common method. For quantitative analysis of cytoskeletal structure, image processing called segmentation is important to determine cytoskeletal regions from microscopic images. Two main methods have been commonly used for cytoskeletal segmentation. One is the manual thresholding method, in which an expert visually checks the image and manually sets the threshold values. While this method can accurately extract cytoskeletal regions, it is not reproducible and is time

and labor intensive because it is based on the expert's manual effort. The other method uses an automatic thresholding algorithm. This method is more reproducible and faster, but depending on the image quality, it may not be as accurate as the former method. We examined the usefulness of a new segmentation method, deep learning, for quantitative evaluation of cytoskeletal structure. First, using plant cultured cells in which microtubules were fluorescently labeled, we acquired many confocal microscopic images of microtubules. Then we performed manual thresholding segmentation based on visual observation of the acquired images and trained a deep learning model using the ground truth as the correct data. To verify the accuracy of the model trained in this study, a comparison was made with segmentation based on Otsu's method, which is a typical automatic thresholding algorithm. The results showed that there was no significant difference between this method and the existing method in measuring the average angle and parallelness of microtubules, but this method was more accurate than the existing method in measuring density. Our method with the help of deep learning can estimate the density of the cytoskeleton with high accuracy and high speed, which has been difficult to achieve with conventional methods.

Publications

Sakai Y, Higaki T, Ishizaki K, Nishihama R, Kohchi T, Hasezawa S (2022) Migration of prospindle before the first asymmetric division in germinating spore of Marchantia polymorpha. Plant Biotech 39: 5-12. (Published: 25 Mar 2022)

Okubo-Kurihara E, Ali A, Hiramoto M, Kurihara Y, Abouleila Y, Abdelazem EM, Kawai T, Makita Y, Kawashima M, Esaki T, Shimada H, Mori T, Hirai MY, Higaki T, Hasezawa S, Shimizu Y, Masujima T, Matsui M (2022) Tracking metabolites at single-cell resolution reveals metabolic dynamics during plant mitosis. Plant Physiol in press. (Published: 18 Mar 2022)

Suzuki R, Yamada M, Higaki T, Aida M, Kubo M, Tsai AY, Sawa S (2021) PUCHI regulates giant cell morphology during root-knot nematode infection in Arabidopsis thaliana. Front Plant Sci 12: 755610. (Published: 06 Oct 2021)

Kikukawa K, Sato R, Iwamoto M, Higaki T, "Wide-range segmentation of cotyledon epidermal cells for morphometrical analysis and mechanical simulation," Cytologia, 86: 189-194. 2021. (Published: 25 Sep 2021)

Kikukawa K, Yoshimura K, Watanabe A, Higaki T (2021) Metal-nano-ink coating for monitoring and quantification of cotyledon epidermal cell morphogenesis. Front Plant Sci 12: 745980. (Published: 21 Sep 2021)

Kamon E, Noda C, Higaki T, Demura T, Ohtani M (2021) Calcium signaling contributes to xylem vessel cell differentiation via post-transcriptional regulation of VND7 downstream events. Plant Biotech 38: 331-337 (Published: 18 Sep 2021)

Fujihara R, Uchida N, Tameshige T, Kawamoto N, Hotokezaka Y, Higaki T, Simon R, Torii KU, Tasaka M, Aida M (2021) The boundary-expressed EPIDERMAL PATTERNING FACTOR-LIKE2 gene encoding a signaling peptide promotes cotyledon growth during Arabidopsis thaliana embryogenesis. Plant Biotech 38: 317-322. (Published: 18 Sep 2021)

Sato F, Iba K, Higaki T (2021) Involvement of the membrane trafficking factor PATROL1 in the salinity stress tolerance of Arabidopsis thaliana. Cytologia 86: 119-126. (Published: 25 June 2021)

Higaki T, Sato F, Iba K (2021) Environmental responses of the membrane trafficking factor PATROL1 in the Arabidopsis stomatal complex. Cytologia 86: 101-102. (Published: 25 June 2021)

Kimura T, Haga K, Nomura Y, Higaki T, Nakagami H, Sakai T (2021) Phosphorylation of NONPHOTOTROPIC HYPOCOTYL3 affects photosensory adaptation during the phototropic response. Plant Physiol 187: 981–995. (Published: 17 June 2021)

Matsumoto H, Kimata Y, Higaki T, Higashiyama T, Ueda M (2021) Dynamic rearrangement and directional migration of tubular vacuoles are required for the asymmetric division of the Arabidopsis zygote. Plant Cell Physiol 62: 1280–1289. (Published: 02 Jun 2021)

Kunita I, Morita MT, Toda M, Higaki T (2021) A three-dimensional scanning system for digital archiving and quantitative evaluation of Arabidopsis plant architectures. Plant Cell Physiol 62: 1975-1982. (Published: 22 May 2021)

No.4-15	Development of novel therapeutic strategy using iron targeted upconversion nanoparticles for Parkinson's disease		
Research Field	Advanced Green Bio		
Unit Coordinator			
Name	Ruda LEE		
Affiliation	IROAST/ Institute of Industrial Nanomaterials Email: aeju-lee@kumamoto-u.ac.jp	Title	Associate Professor
Unit Members			
Name	Affiliation/Title		
Yong Il PARK	Chonnam National University, Republic of Korea/ Associate Professor		
Jung Hoon CHOI	Kangwon National University, Republic of Korea/ Professor		
Xiaoxue(Helen) XU	University of Technology Sydney, Australia/ Lecturer		

1. Overview of achievements

FY 2021, we focused on the animal experiment. Approximately, 10-12 upconversion nanoparticles (UCNPs) were loaded on the hybrid nanoconstructs. The cellular behaviors were confirmed using substantia nigra (SN) cell line. Various gene and protein expressions were evaluated and confirmed the iron-chelating effects of the nanoconstructs. Different severity of Parkinson's disease model was prepared to show severity dependent iron expression. Based on these achievements, we will prepare paper publication in FY2022.

2. Presentations & Publications published between April 2021 and March 2022

Ruda Lee

[Presentation]

N/A

[Publications]

① Chinmaya Mahapatra, **Ruda Lee**, Manash K. Paul. Emerging role and promise of nanomaterials in organoid research. Drug Discovery Today, 27, 890-899. March 2022.

② Kang Pa Lee, Suji Baek, Myeong Sik Yoon, Ji Soo Park, Bok Sil Hong, Sang Ju Lee, Seung Jun Oh, Seung Hae Kwon, **Ruda Lee**, Dae Ho Lee, Kang-Seo Park, Byung Seok Moon. Potential anticancer effect of aspirin and 2'-hydroxy-2,3,5'-trimethoxychalcone-linked polymeric micelles against cervical cancer through apoptosis. Oncology Letters, 23, 31, November 2021.

③ Sajid Fazal, **Ruda Lee***. Biomimetic Bacterial Membrane Vesicles for Drug Delivery Applications. Pharmaceutics, 13, 1430. September 2021.

Yong Il PARK

[Presentation]

N/A

[Publications]

① Song Yeul Lee, Joo-Yeon Park, Hyun-Jae Kim, Yun-Sung Lee, **Yong Il Park***. Prussian Blue-Graphene Oxide Composite Cathode for a Sodium-Ion Capacitor with Improved Cyclic Stability and Energy Density. Journal of Alloys and Compounds, 898, 162952, March 2022.

② Song Yeul Lee, Dasom Park, Byung Sun Yoon, Yun-Sung Lee,* **Yong Il Park**,* Chang Hyun Ko*. Atomic Layer Deposition-Based Synthesis of TiO_2 and Al_2O_3 Thin-Film Coatings on Nanoparticle Powders for Sodium-Ion Batteries with Enhanced Cyclic Stability. Journal of Alloys and Compounds, 897, 163113, March 2022.

③ V. Naresh, Venkata N. K. B. Adusumalli, **Yong Il Park**, Nohyun Lee. NIR Triggered $NaYF_4$:Yb,Tm@$NaYF_4$/$CsPb(Br_{1-x}/I_x)_3$ Composite for Up-converted White Light Emission and Dual-Model Anti-counterfeiting Applications. Materials Today Chemistry, 23, 100752, March 2022.

④ Ranjith Thangavel, Daseul Han, Brindha Moorthy, Bala Krishnan Ganesan, Megala Moorthy, **Yong Il Park**, Kyung-Wan Nam, Yun-Sung Lee. Understanding the Structural Phase Transitions in $Na_3V_2(PO_4)_3$ Symmetrical Sodium-Ion Batteries Using Synchrotron-Based X-Ray Techniques. Small Methods, 6, 2100888, February 2022.

⑤ Ramesh Poonchi Sivasankaran, Pran Krisna Das, Maheswari Arunachalam, Rohini Subhash Kanase, **Yong Il Park**, Jeongsuk Seo, Soon Hyung Kang. TiO_2 Nanotube Arrays Decorated with Reduced Graphene Oxide and Cu-Tetracyanoquinodimethane as Anode Materials for Photoelectrochemical Water Oxidation. ACS Applied Nano Materials, 4, 13218-13233, December 2021.

Jung Hoon CHOI

[Presentation]

N/A

[Publications]

① Jung HY, Kim W, Hahn KR, Kang MS, Kwon HJ, **Choi JH**, Yoon YS, Kim DW, Yoo DY, Won MH, Hwang IK. Changes in the expression of the B subunit of vacuolar H+-ATPase, in the hippocampus, following transient forebrain ischemia in gerbils. Iran J Basic Med Sci. 2021 Nov;24(11):1482-1487.

② Jung HY, Kim W, Hahn KR, Nam SM, Yi SS, Kwon HJ, Kang MS, **Choi JH**, Kim DW, Yoon YS, Hwang IK. Spatial and temporal changes in the PGE2 EP2 receptor in mice hippocampi during postnatal development and its relationship with cyclooxygenase-2. Iran J Basic Med Sci. 2021 Jul;24(7):908-913. doi: 10.22038/ijbms.2021.56286.12556.

Helen XU

[Presentation]

N/A

[Publications]

① B Hu, G Bao, **X Xu**, K Yang, The Topical Hemostatic Materials for Coagulopathy, Journal of Materials Chemistry B, 2022, 10, 1946-1959

② Z Deng, L Zhao, H Zhou, **X Xu**, W Zheng, Recent advances in electrochemical analysis of hydrogen peroxide towards in vivo detection, **Process Biochem.**, 2022, 115, 57-69

③ G Bao, K Wang, L Yang, J He, B He*, **X Xu***, Y Zheng*, Feasibility evaluation of a Zn-Cu alloy for intrauterine devices: in vitro and in vivo studies, ***Acta Biomater.***, 2022, https://doi.org/10.1016/j.actbio.2022.01

④ L. Gao, S. Li, X. Xu, C. Zou, G. Zhang, Highly Sensitive H2 Sensors Based on Co3O4/PEI-CNTs at Room Temperature, ***J. Nanomater.***, 2022, https://doi.org/10.1155/2022/4743040

⑤ F. Zhang, X. Zhang, Z. Li, R. Yi, Z. Li, N. Wang, **X. Xu**, Z. Azimi, L. Li, M. Lysevych, X. Gan, Y. Lu, H. Tan, C. Jagadish, L. Fu, A New Strategy for Selective Area Growth of

Highly Uniform InGaAs/InP Multiple Quantum Well Nanowire Arrays for Optoelectronic Device Applications, ***Adv. Funct. Mater.***, 2021, 32 (3), 2103057

⑥ N. Holmes, S. Chambon, A. Holmes, **X. Xu**, K. Hirakawa, E. Deniau, C. Lartigau-Dagron, A. Bousquet, Organic semiconductor colloids: From the knowledge acquired in photovoltaics to the generation of solar hydrogen fuel, ***Curr. Opin. Colloid Interface Sci.***, 2021, 56, 101511

⑦ K. Wang, G. Bao, Q. Fan, L. Zhu, L. Yang, T. Liu, Z. Zhang, G. Li, X. Chen, **X. Xu***, B. He*, Y. Zheng*, In vitro and in vivo studies of Cu-38Zn alloy to evaluate its the feasibility as a material for intrauterine devices, ***Acta Biomater.***, 2021, 138, 561-575

⑧ **X. Xu**, Z. Jia, Y. Zheng, Y., Wang, Bioadaptability of biomaterials: Aiming at precision medicine, ***Matter***, 2021, 4, 2648-2650

⑨ Y. Liu, H. Li, Y. Li, **X. Xu**, Z. Yang, G. Ding, Optimization of the Discrete Structure in a Pressure Sensor Based on a Multiple-Contact Mechanism to Improve Sensitivity and Nonlinearity, ***IEEE Sens. J.***, 2021, 21, 21259 - 21267

⑩ Q. Fan, G. Bao, D. Ge, K. Wang, M. Sun, T. Liu, J. Liu, Z. Zhang, X. Xu, **X. Xu***, B. He*, J. Rao, Y. Zheng*, Effective Easing of the Side Effects of Copper Intrauterine Devices using Ultra-fine-grained Cu-0.4Mg Alloy, ***Acta Biomater.***, 2021,128, 523-539

⑪ H. Wen, **X. Xu**, S. Cheong, S. Lo, J. Chen, S. Chang, C. Dwyer, Metrology of convex-shaped nanoparticles via soft classification machine learning of TEM images, Nanoscale Adv., 2021, 3, 6956-6964

3. Application & acquisition status of KAKENHI and other external grants

Ruda LEE

① CRDF Global female young researcher grant, Granted (Principal Investigator)

② FY2022 JSPS, Grant-in-Aid for Scientific Research (C), Applied/Granted (Principal Investigator)

Yong Il PARK

① Korea Basic Science Institute, 2021 Research Facility Council Development Support Project, 2021.04.01~2021.11.30 (Principal Investigator)

② National Research Foundation of Korea (NRF), Basic Science Research Program, Applied 2021.06.01~2026.05.31 (Principal Investigator)

Jung Hoon CHOI

① National Research Foundation of Korea funded by the Ministry of Education (NRF-2019R1I1A3A01061857) (Principal Investigator)

Helen XU

① Innovative Grant funded by Juvenile Diabetes Research Foundation (USA) (1-INO-2020-914-A) (Principal Investigator)

4. Application & acquisition status of industrial property rights

Ruda LEE

N/A

Yong Il PARK

N/A

Jung Hoon CHOI

N/A

Helen XU

N/A

No.4-16	Deep Learning for Hydrology		
Research Field	Environmental Science		
Unit Coordinator			
Name	Kei ISHIDA		
Affiliation	Center for Water Cycle, Marine Environment and Disaster Management Email: keiishida@kumamoto-u.ac.jp	Title	Associate Professor
Unit Members			
Name	Affiliation/Title		
Motoki AMAGASAKI	FAST Associate Professor		
Masato KIYAMA	FAST Assistant Professor		
Ali ERCAN	University of California, USA Assistant Professor		
Tonbi TU	Sun Yat-Sen University Associate Professor		

1. Overview of achievements

The objectives of this study are to apply new machine learning techniques to hydrological issues, and meanwhile develop new machine learning techniques with hydrological data. In this fiscal year (second year), because of the situation of COVID-19, we could not go abroad, and then we could not have a meeting in person. However, we had online meetings. In addition, we had discussions on phone several times.

Figure 1. Online meeting in July, 2021

We have worked on several topics. For example, we developed a new architecture using recurrent neural networks for hourly-scale rainfall-runoff modeling. This result was published in an international journal, Journal of Hydroinformatics. We conducted a hybrid downscaling that

consists of the dynamical downscaling and the statistical downscaling using convolutional neural network (CNN), which successfully improve the accuracy of estimated precipitation depths at the target area. This results was published in an international journal, Journal of Hydrology: Regional Studies. We used Generative Adversarial Network (GAN) to increase the resolution of sea surface temperature data. An academic paper was published in an international journal, Journal of Water and Climate Change. In addition, we conducted sensitive analyses of recurrent neural networks and ensemble learning for rainfall-runoff modeling. These results were published in a domestic journal, Intelligence, Informatics and Infrastructure. One of them obtained an award, Intelligence, Informatics and Infrastructure Outstanding Potential Paper Award.

2. Presentations & Publications published between April 2021 and March 2022

International Academic Papers:

1. Ishida, K., Kiyama, M., Ercan, A., Amagasaki, M., Tu, T., 2021."Multi-time-scale input approaches for hourly-scale rainfall–runoff modeling based on recurrent neural networks," Journal of Hydroinformatics, 23(6), 1312–1324, 2021.
2. Tongbi Tu, Kei Ishida, Ali Ercan, Masato Kiyama, Motoki Amagasaki, Tongtiegang Zhao, “Hybrid precipitation downscaling over coastal watersheds in Japan using WRF and CNN,” Journal of Hydrology: Regional Studies, Vol37, 100921, 2021.
3. Yokoo, K., Ishida, K., Ercan, A., Tu, T., Nagasato, T., Kiyama, M., Amagasaki, M., “Capabilities of deep learning models on learning physical relationships: Case of rainfall-runoff modeling with LSTM” Sci. Total Environ. 802, 149876, 2021

Domestic Academica Papers:

1. Kazuki YOKOO, Kei ISHIDA, Takeyoshi NAGASATO, Daiju SAKAGUCHI, Masato KIYAMA, Motoki AMAGASAKI SENSITIVITY ANALYSIS OF LSTM TO INPUT VARIABLES FOR RAINFALL-RUNOFF MODELING Intelligence, Informatics and Infrastructure, 2021, Volume 2, Issue J2, Pages 883-892
2. Daiju SAKAGUCHI, Kei ISHIDA, Kazuki YOKOO, Takeyoshi NAGASATO, Masato KIYAMA, Motoki AMAGASAKI A STUDY ON WEAK LEARNERS IN RIVER FLOW ESTIMATION BY ENSEMBLE LEARNING Intelligence, Informatics and Infrastructure, 2021, Volume 2, Issue J2, Pages 872-882.

International Conference Oral Presentations:

1. Kazuki Yokoo, Kei Ishida, Takeyoshi Nagasato, Masato Kiyama, and Motoki Amagasaki: Investigation of Learning Process of Deep Learning Method for Rainfall-Runoff Modeling, ASCE 2021 World Environmental & Water Resources Congress, Online Meeting, June, 2021.
2. Takeyoshi Nagasato, Kei Ishida, Kazuki Yokoo, Masato Kiyama, and Motoki Amagasaki: Effects of Input Variables Selection on Accuracy of Watershed-scale Precipitation Downscaling by Means of Convolutional Neural Network, ASCE 2021 World Environmental & Water Resources Congress, Online Meeting, June, 2021.

International Conference Poster Presentations:

1. Takeyoshi Nagasato, Kei Ishida, and Kazuki Yokoo: Reconstruction of Severe Flood at Kuma River Basin during 2020 July Storm by Means of Deep Learning Method, ASCE 2021 World Environmental & Water Resources Congress, Online Meeting, June, 2021.
2. Kazuki Yokoo, Kei Ishida, Takeyoshi Nagasato, Masato Kiyama, and Motoki Amagasaki: Sensitivity Analysis of Hyper Parameters of Long Short-Term Memory Networks for Rainfall-Runoff Modeling at Snow-Dominated Watersheds, ASCE 2021 World Environmental & Water Resources Congress, Online Meeting, June, 2021.
3. Takeyoshi Nagasato, Kei Ishida, Kazuki Yokoo, Masato Kiyama and Motoki Amagasaki: Sensitivity Analysis of the Hyperparameters of CNN for Precipitation Downscaling, EGU

General Assembly 2021, online, 19–30 Apr 2021, EGU21-4400, 2021.

4. Kazuki Yokoo, Kei Ishida, Takeyoshi Nagasato, and Ali Ercan: Effect of input variables on rainfall-runoff modeling using a deep learning method, EGU 2021 European Geosciences Union, Online Meeting, April 2021.
5. Kazuki Yokoo, Kei Ishida, Takeyoshi Nagasato, Daiju Sakaguchi, Ali Ercan, Masato Kiyama and Motoki Amagasaki: Applicability of precipitation data from reanalysis as input to rainfall-runoff model using LSTM, 2021 AGU Fall Meeting, Online Meeting, Dec. 2021.
6. Takeyoshi Nagasato, Kei Ishida, Kazuki Yokoo, Daiju sakaguchi, Masato Kiyama, and Motoki Amagasaki: Complement method of missing streamow time-series data by means of Long and Short-TermMemory network, 2021 AGU Fall Meeting, Online Meeting, Dec. 2021.
7. Daiju Sakaguchi, Kei Ishida, Kazuki Yokoo, Takeyoshi Nagasato, Yasunori Kawagoshi, and Hiroaki Ito: Improving the accuracy of Kumamoto's groundwater level modeling using deep learning LSTM, 2021 AGU Fall Meeting, Online Meeting, Dec. 2021.

3. Application & acquisition status of KAKENHI and other external grants
None

4. Application & acquisition status of industrial property rights
None

No.4-17	Environmental Impacts of Ionic Solutes		
Research Field	Environmental Science		
Unit Coordinator			
Name	Shin-Ichi OHIRA		
Affiliation	Faculty of Advanced Science and Technology Email: ohira@kumamoto-u.ac.jp	Title	Professor
Unit Members			
Name	Affiliation/Title		
C. Phillip SHELOR	Department of Chemistry, University of Texas at Arlington, USA Assistant Research Professor		
Jian MA	College of the Environment and Ecology, Xiamen University, CHINA Professor		
Yuta NAKASHIMA	FAST Associate Professor		

1. Overview of achievements

This research unit is targeted “ion” especially in environment. Ions plays an important role in the environment. Ions are one of the key chemical forms of the global cycles and observed in marine, soil, river/lake, atmosphere, and living cells. In the research unit, the specialists of analytical chemistry, marine chemistry, and cell science are gathered worldwide. In 2021, we could not meet face to face, even though we had several on-line meetings. However, we strongly continued collaborative studies as follows:

Drs. Shelor and Ohira successfully developed universal detection method of organic acids with pH detection. The method can detect any kinds of acids after chromatographic separation. The results are summarized and published in *Analytical Chemistry* (Nature indexed journal, IF 6.785).

Drs. Ma and Ohira developed analytical method for Fe(II) in marine and river waters. The targeted Fe(II) is playing a key role of livings in aqueous environment. The developed portable system can detect ~ 10 ngFe(II)/L which is similar sensitivity to inductively coupled plasma – mass spectrometry (ICP-MS). The chemical forms of Fe(II) is easy to change even by dissolved oxygen. Thus, it is important to measure on the site. The presently developed method can be recognize the concentration distribution accurately. The parts of the results are presented at the conference and young poster award was obtained. Next, we are planning to determine Fe(II) in marine and on-ship analysis at Xiameng, China.

Dr. Nakashima developed the method to determine the cancer cell in whole blood.

One of the core technologies in our research unit, ion transfer device (ITD), is introduced at Japan Analytical & Scientific Instruments Show (JASIS) on Nov., 2021. More than 100 of the customers are visited booth for 3 days. Also, some companies offered collaborative study to develop and/or improve the present analytical method for ionic solutes. The method, which we developed, are widely applying not only for environment, but also for industrial and medical chemistries.

2. Presentations & Publications published between April 2021 and March 2022

Manuscripts

- Y. Sugo, R. Miyachi, S. Obata, Y. Maruyama, H. Manabe, M. Mori*, N.S. Ishioka, K. Toda, **S. Ohira***, Rapid Flow-Based System for Separation of Radioactive Metals by Selective Complex Formation, *Analytical Chemistry* (IF 6.785), **93**, 17069-17075 (2021).
- **S. Ohira***, Y. Sato, K. Horiuchi, **C.P. Shelor**, and K. Toda, Indirect Potentiometric pH Detection of Weak Acids with Absolute Quantitation by a Theoretical Approach, *Analytical Chemistry* (IF 6.785), **93**, 12305-12311 (2021).
- K. Owen, K. Saeki, J.D. Warren, A. Bocconcelli, D.N. Wiley, **S. Ohira**, A. Bombosch, K. Toda, D.P. Zitterbart, Natural Dimethyl Sulfide Gradients would Lead Marine Predators to Higher Prey Biomass, *Communications Biology* (IF 5.489), **4**, 149 (2021).
- K. Saeki, K. Ikari, Y. Kazuya, H. Yokoi, **S. Ohira**, H. Okochi, K. Toda, Biogenic Diamines and Their Amide Derivatives Are Present in the Forest Atmosphere and May Play a Role in Particle Formation, *ACS Earth and Space Chemistry* (IF 3.475), **6**, 421–430 (2022).
- **Y. Nakashima***, M. Akaike, M. Kounoura, K. Hayashi, K. Morita, Y. Oki, Y. Nakanishi, Evaluation of Osteoblastic Cell Behavior upon Culture on Titanium Substrates Photo-functionalized by Vacuum Ultra-Violet Treatment, *Experimental Cell Research* (IF 3.905), **410**, 112944, (2022).
- S. Fukuyama, S. Kumamoto, S. Nagano, S. Hitotsuya, K. Yasuda, Y. Kitamura, M. Iwatsuki, H. Baba, T. Ihara, Y. Nakanishi, and **Y. Nakashima***, Detection of cancer cells in whole blood using a dynamic deformable microfilter and a nucleic acid aptamer, *Talanta* (IF 6.057), **228**, 122239 (2021).

Presentations

- S. Obata, M. Fujiwara, K. Toda, **S. Ohira**, "Flow analysis by electrodialytic pretreatment and enrichment for Fe(II) in environment", 57th FIA symposium (On-line), 2021/10/6. [Young poster award]
- **S. Ohira**, Electrodialytic Ion Handling for Chromium Speciation Analysis, 4th International Seminar on Chemical Education, 2021/9/15. [Invited lecture]
- **S. Ohira**, R. Miyachi, S. Obata, Y. Maruyama, H. Manabe, M. Mori, Y. Sugo, N. Ishioka, "Flow devices for simultaneous separation, enrichment and probe synthesis with radio isotopes", QST scientific festa 2021, 2021/12/8. [Invited lecture]
- **S. Ohira**, W.C. Nugraha, K. Toda, Electrodialytic Speciation Analysis for Chromium Species, Pacifichem 2021, on-line, 2021/12/17.
- **S. Ohira**, Y. Sato, K. Kaneda, K. Toda, Universal Detection HPLC for Sugars and Organic acids, Pacifichem 2021, on-line, 2021/12/17.

3. Application & acquisition status of KAKENHI and other external grants

- **S. Ohira**, KAKENHI, Grant-in-Aid for Scientific Research (B) as representative, 2021–2023FY 4,550 kJPY for 2021
- **S. Ohira**, KAKENHI, Grant-in-Aid for Scientific Research (B) as collaborator, 2020 – 2023FY 780k JPY for 2021
- **S. Ohira**, Adaptable and Seamless Technology transfer Program through targetdriven R&D (A-STEP), 2021FY 3,000 kJPY.
- **S. Ohira**, Collaborative study with four companies, total 3,800 kJPY for 2021.
- **S. Ohira**, New Energy and Industrial Technology Development Organization (NEDO) JPNP20004 as representative, 2021-2022FY 0 JPY for 2021 (10,000 kJPY for 2022).
- **Y. Nakashima**, KAKENHI, Grant-in-Aid for Scientific Research (B) as representative, 2019–2022FY, 3,120 kJPY for 2021
- **Y. Nakashima**, KAKENHI, Grant-in-Aid for Challenging Exploratory Research as representative, 2020–2021FY, 3,185 kJPY for 2021
- **Y. Nakashima**, Collaborative study with three companies, total 3,885 kJPY for 2021.

4. Application & acquisition status of industrial property rights

- **S. Ohira**, K. Toda, “Methods and instruments for ionic liquid synthesis”, patent application 2021-186459 (Japan), 2021/11/16.
- S. Hoshim T. Kato, T. Hukui, **S. Ohira**, K. Toda, “Analysis method and instruments for ionic solutes in ultra-pure water”, patent application 2021-158070 (Japan), 2021/9/28.
- **S. Ohira**, K. Toda, Y. Sugo, M. Mori, “Separation and purification of radio isotope metals”, patent application 2021-128299 (Japan), 2021/8/4.

No.4-18	Radio Astronomy		
Research Field	Next-generation Technology		
Unit Coordinator			
Name	Keitaro TAKAHASHI		
Affiliation	Faculty of Advanced Science and Technology Email: keitaro@kumamoto-u.ac.jp	Title	Professor
Unit Members			
Name	Affiliation/Title		
Rachel WEBSTER	Melbourne University Professor		
Bart PINDOR	Melbourne University Professor		
Takuya AKAHORI	National Astronomical Observatory of Japan Researcher		
Shintaro YOSHIURA	National Astronomical Observatory of Japan JSPS Fellow		
Takeshi FUKUSAKO	Kumamoto University Professor		
Ryo KATO	Kumamoto University Researcher		

1. Overview of achievements

Continuing from last year, we conducted observation with a radio telescope in Australia, MWA (Murchison Widefield Array), attempting to detect 21cm-line signal from the Epoch of Reionization. We put a constraint on the power spectrum of the 21cm-line signal with a careful calibration of ionosphere effect and foreground contamination. Further, in order to reduce the contamination from the foreground emission, we developed a methodology to produce expected signal images from observational data of galaxies called LAE, by utilizing Generative Adversarial Network, which is one of a powerful method of deep learning.

As another application of radio astronomy, we conducted precise observations of pulsars, in order to study the emission mechanism and detect gravitational waves from super-massive black holes. We have found a change in the pulse profile of PSR J1713+0747 using the uGMRT, a radio telescope in India. Further, from archived data of Parkes radio telescope, we discovered single pulse signals from the Large Magellanic Could. We are now attempting to confirm if the signals

are emitted from pulsars and have just obtained observation time at Parkes radio telescope for the coming year.

2. Presentations & Publications published between April 2021 and March 2022

[1] “Low-frequency wideband timing of InPTA pulsars observed with the uGMRT”
K Nobleson, Nikita Agarwal, Raghav Girgaonkar, Arul Pandian, Bhal Chandra Joshi, M A Krishnakumar, Abhimanyu Susobhanan, Shantanu Desai, T Prabu, Adarsh Bathula, Timothy T Pennucci, Sarmistha Banik, Manjari Bagchi, Neelam Dhanda Batra, Arpita Choudhary, Subhajit Dandapat, Lankeswar Dey, Yashwant Gupta, Shinnosuke Hisano, Ryo Kato, Divyansh Kharbanda, Tomonosuke Kikunaga, Neel Kolhe, Yogesh Maan, Piyush Marmat, P Arumugam, P K Manoharan, Dhruv Pathak, Jaikhomba Singha, Mayuresh P Surnis, Sai Chaitanya Susarla, Keitaro Takahashi,
to be published in Monthly Notices of the Royal Astronomical Society (2022)

[2] “A Parkes "Murriyang" Search for Pulsars and Transients in the Large Magellanic Cloud”
Shinnosuke Hisano, Fronefield Crawford, Victoria Bonidie, Md F. Alam, Keitaro Takahashi, Duncan R. Lorimer, Josh P. Ridley, Maura M. McLaughlin, Benetge B. P. Perera,
to be published in Astrophysical Journal (2022)

[3] “Testing the non-circularity of the spacetime around Sagittarius A* with orbiting pulsars”
Yohsuke TAKAMORI, Atsushi NARUKO, Yusuke SAKURAI, Keitaro TAKAHASHI, Daisuke YAMAUCHI, and Chul-Moon Yoo,
to be published in Publications of the Astronomical Society of Japan (2022)

[4] “Constraints on ultra-low-frequency gravitational waves from an eccentric supermassive black hole binary”
Tomonosuke Kikunaga, Shinnosuke Hisano, Hiroki Kumamoto, and Keitaro Takahashi,
Monthly Notices of the Royal Astronomical Society, Volume 509, Issue 4, pp.5188-5196, 02/2022

[5] “Axion Cloud Decay due to the Axion-photon Conversion with Background Magnetic Fields”
Yoo, Chul-Moon; Naruko, Atsushi; Sakurai, Yusuke; Takahashi, Keitaro; Takamori, Yohsuke; Yamauchi, Daisuke,
Publications of the Astronomical Society of Japan, Volume 74, Issue 1, pp.64-72, 02/2022

[6] “Epoch of Reionization Power Spectrum Limits from Murchison Widefield Array Data Targeted at EoR1 Field”
M. Rahimi, B. Pindor, J. L. B. Line, N. Barry, C. M. Trott, R. L. Webster, C. H. Jordan, M. Wilensky, S. Yoshiura, A. Beardsley, J. Bowman, R. Byrne, A. Chokshi, B. J. Hazelton, K. Hasegawa, E. Howard, B. Greig, D. Jacobs, R. Joseph, M. Kolopanis, C. Lynch, B. McKinley, D. A. Mitchell, S. Murray, M. F. Morales, J. C. Pober, K. Takahashi, S. J. Tingay, R. B. Wayth, J. S. B. Wyithe, Q. Zheng,
Monthly Notices of the Royal Astronomical Society, Volume 508, Issue 4, pp.5954-5971, 12/2021

[7] “Constraining the 21cm brightness temperature of the IGM at z=6.6 around LAEs with the Murchison Widefield Array”
Cathryn M. Trott, C.H. Jordan, J.L.B. Line, C.R. Lynch, S. Yoshiura, B. McKinley, P. Dayal, B. Pindor, A. Hutter, K. Takahashi, R.B. Wayth, N. Barry, A. Beardsley, J. Bowman, R. Byrne, A. Chokshi, B. Greig, K. Hasegawa, B.J. Hazelton, E. Howard, D. Jacobs, M. Kolopanis, D.A. Mitchell, M.F. Morales, S. Murray, J.C. Pober, M. Rahimi, S.J. Tingay, R.L. Webster, M. Wilensky, J.S.B. Wyithe, Q. Zheng,
Monthly Notices of the Royal Astronomical Society Letters 507 (2021) 772-780, 10/2021

[8] “Evidence for profile changes in PSR J1713+0747 using the uGMRT”
Jaikhomba Singha, Mayuresh P Surnis, Bhal Chandra Joshi, Pratik Tarafdar, Prerna Rana, Abhimanyu Susobhanan, Raghav Girgaonkar, Neel Kolhe, Nikita Agarwal, Shantanu Desai, T Prabu, Adarsh Bathula, Subhajit Dandapat, Lankeswar Dey, Shinnosuke Hisano, Ryo Kato, Divyansh Kharbanda, Tomonosuke Kikunaga, Piyush Marmat, Sai Chaitanya Susarla, Manjari Bagchi, Neelam Dhanda Batra, Arpita Choudhury, A Gopakumar, Yashwant Gupta, M A Krishnakumar, Yogesh Maan, P K Manoharan, K Nobleson, Arul Pandian, Dhruv Pathak, Keitaro Takahashi,
Monthly Notices of the Royal Astronomical Society Letters 507 (2021) L57-L61, 10/2021

[9] “Predicting 21cm-line map from Lyman α emitter distribution with Generative Adversarial Networks”
Shintaro Yoshiura, Hayato Shimabukuro, Kenji Hasegawa, Keitaro Takahashi,
Monthly Notices of the Royal Astronomical Society 506 (2021) 357-371, 09/2021

[10] “A new MWA limit on the 21 cm Power Spectrum at Redshifts ~ 13 – 17”
S. Yoshiura, B. Pindor, J.L.B. Line, N. Barry, C. M. Trott, A. Beardsley, J. Bowman, R. Byrne, A. Chokshi, B. J. Hazelton, K. Hasegawa, E. Howard, B. Greig, D. Jacobs, C. H. Jordan, R. Joseph, M. Kolopanis, C. Lynch, B. McKinley, D. A. Mitchell, M. F. Morales, S. Murray, J. C. Pober, M. Rahimi, K. Takahashi, S. J. Tingay, R. B. Wayth, R. L. Webster, M. Wilensky, J. S. B. Wyithe, Z. Zhang, Q. Zheng,
Monthly Notices of the Royal Astronomical Society 505 (2021) 4775-4790, 08/2021

[11] “Constraints on ultra-low-frequency gravitational waves with statistics of pulsar spin-down rates II: Mann-Whitney U test”
Kumamoto, H.; Hisano, S.; Takahashi, K.,
PASJ 73 (2021) 1001, 08/2021

3. Application & acquisition status of KAKENHI and other external grants

Transformative Research Areas (A) (rep: Keitaro Takahashi), rejected

4. Application & acquisition status of industrial property rights

N/A

No.4-19	Plant Stem Cells and Regeneration		
Research Field	Advanced Green Bio		
Unit Coordinator			
Name	Mitsuhiro AIDA		
Affiliation	IROAST Email: m-aida@kumamoto-u.ac.jp	Title	Professor
Unit Members			
Name	Affiliation/Title		
Yoshihisa IKEDA	Centre of the Region Haná for Biotechnological and Agricultural Research, Czech Advanced Technology and Research Institute (CATRIN), Palacký University/Junior Researcher		
Stefan DE FOSTER	Unidad de Genómica Avanzada (LANGEBIO), Centro de Investigación y de Estudios Avanzados del Instituto Politécnico Nacional (CINVESTAV-IPN), Guanajuato, México		
Jose Irepan REYES-OLALDE	Universidad Estatal del Valle de Toluca, Ocoyoacac Edo. Mex. Mexico		

1. Overview of achievements

We analyzed the functions of two AP2/ERF transcription factor encoding genes, *ESR1* and *ESR2*, in postembryonic shoot development and examined genetic interactions of these factors with *WUS*, *STM*, and *REV*, which are central regulators of stem cell activity in the shoot. The results indicate that each mutation of the *ESR* genes interacted differently with the shoot stem cell mutants and this difference likely attributed to the expression patterns rather than protein functions of ESRs.

We also focused on the function of the *CUC1* and *CUC2* genes, which encode NAC transcription factors, in the development of the gynoecium, and analyzed their interactions with cytokinin signaling, a major phytohormone signaling pathway regulating meristematic activities in various developmental contexts. The results suggested that mutual interactions between the CUC genes and cytokinin signaling play pivotal roles in the development of carpel margins, which is an important site for production of internal gynoecium organs.

2. Presentations & Publications published between April 2021 and March 2022

Ikeda Y, Králová M, Zalabák D, Kubalová I, Aida M (2021). Post-embryonic lateral organ development and adaxial–abaxial polarity are regulated by the combined effect of *ENHANCER OF SHOOT REGENERATION 1* and *WUSCHEL* in Arabidopsis shoots. **Int. J. Mol Sci** 22, 10621. doi: 10.3390/ijms221910621

Reyes-Olalde, Jose Irepan, De Folter Stefan and Mitsuhiro Aida "A C*UP-SHAPED COTYLEDON*-cytokinin regulatory module in the carpel margin meristem". The 63rd annual meeting of the Japanese Society of Plant Physiologists, March 22, 2022 (oral presentation).

3. Application & acquisition status of KAKENHI and other external grants

Mitsuhiro Aida, Grant-in-Aid for Scientific Research on Innovative Areas (The Japan Society for the Promotion of Science) (applied)

Mitsuhiro Aida, Grant-in-Aid for Scientific Research on Innovative Areas (The Japan Society for the Promotion of Science), Principles of pluripotent stem cells underlying plant vitality, "Establishment of plant hormone microenvironment during shoot stem cell formation," April 2020-March 2022.

4. Application & acquisition status of industrial property rights
Not applicable.

No.4-20	Development of Microbially-Aided Carbon Sequestration Technology		
Research Field	Green Energy		
Unit Coordinator			
Name	Atsushi SAINOKI		
Affiliation	Faculty of Advanced Science and Technology Email: atsushi_sainoki@kumamoto-u.ac.jp	Title	Associate Professor
Unit Members			
Name	Affiliation/Title		
Murat KARAKUS	Adelaide University, Australia Associate Prof.		
Akira SATO	Faculty of Advanced Science and Technology (FAST), Kumamoto University Associate Prof.		
Kazunori NAKASHIMA	Hokkaido University, Japan Associate Prof.		
Hiroaki ITO	Faculty of Advanced Science and Technology (FAST), Kumamoto University Assistant Prof.		

1. Overview of achievements

There is still a significant demand for fossil fuel power generation around the world since it is difficult to replace all the fossil fuel power plants to renewable energy power generation, such as wind and solar power. Therefore, there is an urgent need for large-scale CO_2 reduction worldwide in order to satisfy the Paris Agreement, of which goal is to limit global warming to below 2 degrees Celsius, compared to pre-industry levels. Carbon dioxide capture and storage (CCS) is expected as one of the key technologies that can quickly address this problem. CCS can reduce a large amount of carbon dioxide emission into the atmosphere by storing carbon dioxide separated and recovered from large-scale power plants, such as natural gas processing and power plants, in aquifers in the ground. However, CCS has some challenges to overcome. Among them, the leakage of CO_2 from the underground is a life-threatening phenomenon that directly affects our lives, so that we have to consider measures to prevent the occurrence of the leakage.

For the purpose, during the fiscal year of 2021, our research group investigated the types of anaerobic microorganisms screened from a rock specimen obtained from various locations in Japan and qualitatively examined CO_2 immobilization ability of the microorganisms. The experimental procedure is described as follows. First, several types of rocks to be used for microorganisms screening were collected from a tunnel in Hokkaido, a limestone quarry in Saitama prefecture, and an underground coal mine in Hokkaido. Andesite, limestone, and coal were eventually selected for the rocks to be investigated (Figure 1), considering the geological condition, mineral composition, and organic substances. In the field, the rock cores were put into an anaerobic jar, as soon as cores or rock fragments were obtained. Next, various types of aqueous media were prepared for cultivating anaerobic microorganisms, and the microorganisms were cultivated in an anaerobic state. In addition to the agueous medium, an agar medium is also prepared for the purpose of screening a single type of microorganism. Finally, qualitative

evaluations were performed on the types of anaerobic microorganisms cultivated (DNA analysis) and CO_2 immobilization ability (elemental analysis).
As a result of DNA analysis (Table 1), specific microorganisms, which are supposed to be cultivated in DSMZ media, were not found. However, Desulfitobacterium was cultivated, which is very close to Desulfotomaculum targeted by DSMZ63 and is classified in the same family. In addition, other DSMZ microorganisms screened are also consistent at the phylum and levels. It was also clarified that even when the same type of rock is used, the type of microorganisms cultivated changes if the medium changes. This result indicates that it is possible to identify metal elements necessary for carbon dioxide mineralization in the medium by comparing the rock-only cultivation with that in the DSMZ or other types of original medium created for this experiment.

In conclusion, the study conducted during the fiscal year of 2021 infers that CO_2 mineralization may be enhanced by the presence of anaerobic microorganisms (Figure 2) in the form of organic matters, although the precipitation of $CaCO_3$ is still low. Furthermore, the metal elements required for the successful cultivation of the microorganisms that contribute to CO_2 mineralization can be identified by conducting screening with different types of media.

Figure 1: rock specimens: andesite (left), limestone (middle), coal (right)

Table1: Types of anaerobic microbes screened from andesite, limestone, and coal cores

門	綱	目	科	屬	A1	A2	C1	C2	C3	C4	L1	L2
Proteobacteria					***	***	***	**	***	**	***	***
	Gammaproteobacteria				***	***	***	**	***	**	***	***
		Enterobacteriales			***					***		
			Enterobacteriaceae		***	**					*	
				not assigned	***	**					*	
		Pseudomonadales			**	**	***	**	***	**	**	***
			Moraxellaceae		**	**	***	**			**	***
				Acinetobacter			***	*				***
			Pseudomonadaceae		*	**	**	**	***	**	**	**
				Pseudomonas			**	**	***	**	**	**
		Betaproteobacteriales			*	**	**				***	**
			Burkholderiaceae		*	**	**				***	**
				not assigned			**				***	
Firmicutes					**	***	*	***	**	***	**	
	Bacilli				**	***		*	**	***	**	
		Bacillales			**	***		*	**	***	**	
			Staphylococcaceae		**	***		*	**		**	
				Staphylococcus	**	***		*	**		**	
			Bacillaceae			*				***		
				Bacillus		*				***		
	Clostridia					**		***		**	*	
		Clostridiales				**		***		**	*	
			Peptococcaceae					***				
				Desulfitobacterium				***				
			Clostridiaceae 1					***				
				Clostridium sensu stricto 1				***				
Actinobacteria					***	**	**	**	***		***	*
	Actinobacteria				***	**	**	**	***		***	*
		Corynebacteriales			**	**	*	**	***		*	
Chloroflexi									***		*	
	Anaerolineae								***			
		SBR1031							***			

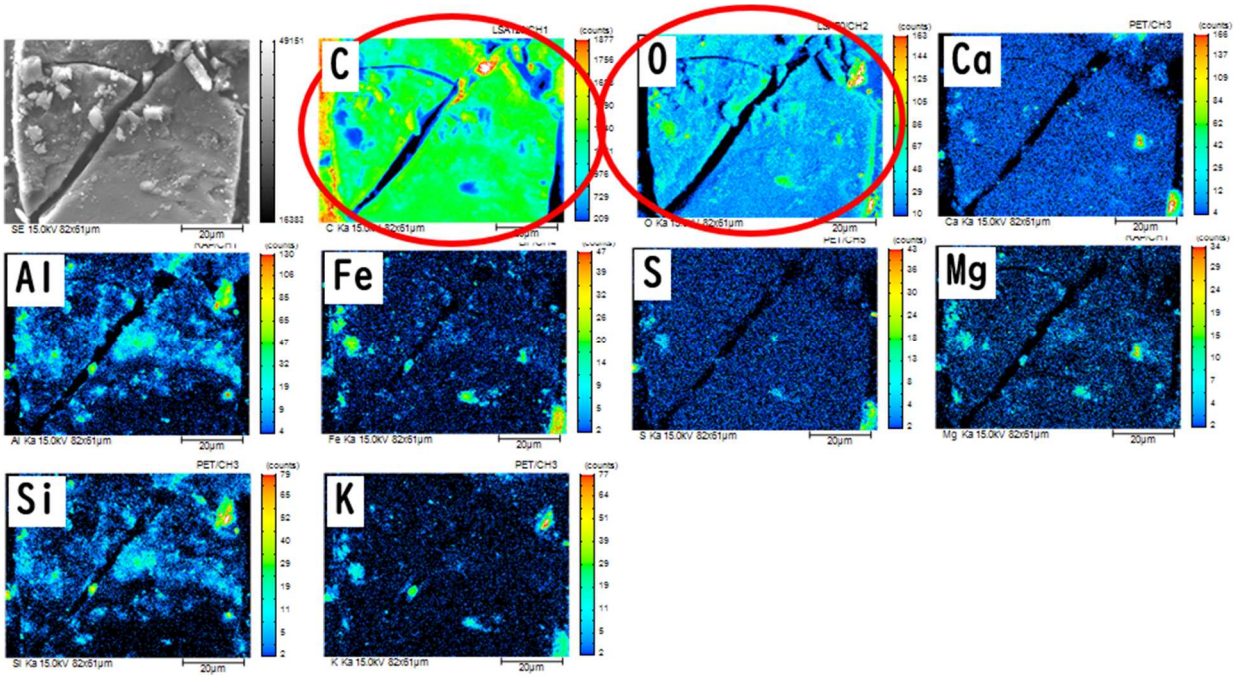


Figure 2: Carbon fixation as organic matters, but low precipitation as $CaCO_3$

2. Presentations & Publications published between April 2021 and March 2022
N/A

3. Application & acquisition status of KAKENHI and other external grants
We have applied research grant provided by The Fukuda Geological Institute. The result will be announced by the end of April, 2022.

4. Application & acquisition status of industrial property rights
N/A

No.4-21	Advanced Biomedical Evaluation System		
Research Field	Nano Material Science/ Advanced Green Bio		
Unit Coordinator			
Name	Makiko KOBAYASHI		
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Unit Members			
Name	Affiliation/Title		
Makiko KOBAYASHI	FAST, Kumamoto University/ Professor		
Toshitaka YAMAKAWA	FAST, Kumamoto University/ Associate Professor		
Masayuki TANABE	FAST, Kumamoto University/ Assistant Professor		
Rajendra Udyavara ACHARYA	Ngee Ann Polytechnic/ Senior Faculty Member		
Shu Lih OH	Ngee Ann Polytechnic/ R&D Project Engineer		
Ru san TAN	National Heart Centre/Doctor		

1. Overview of achievements
   Prototype 8 channel flexible ultrasonic sensors with rubber molding were successfully developed as shown in Fig. 1. Prototype 8 channel portable pulser/receiver (P/R) machines were also successfully developed as shown in Fig. 2. The machine size became smaller, and it became more suitable for real application. By developed sensor and measurement system, M mode image was taken as shown in Fig. 3 from the chest.

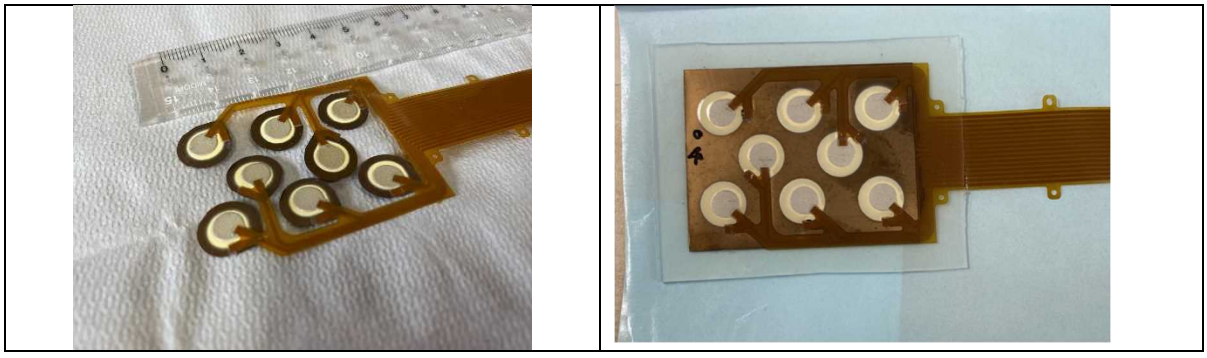

Fig. 1 Prototype 8 channel flexible ultrasonic sensors.

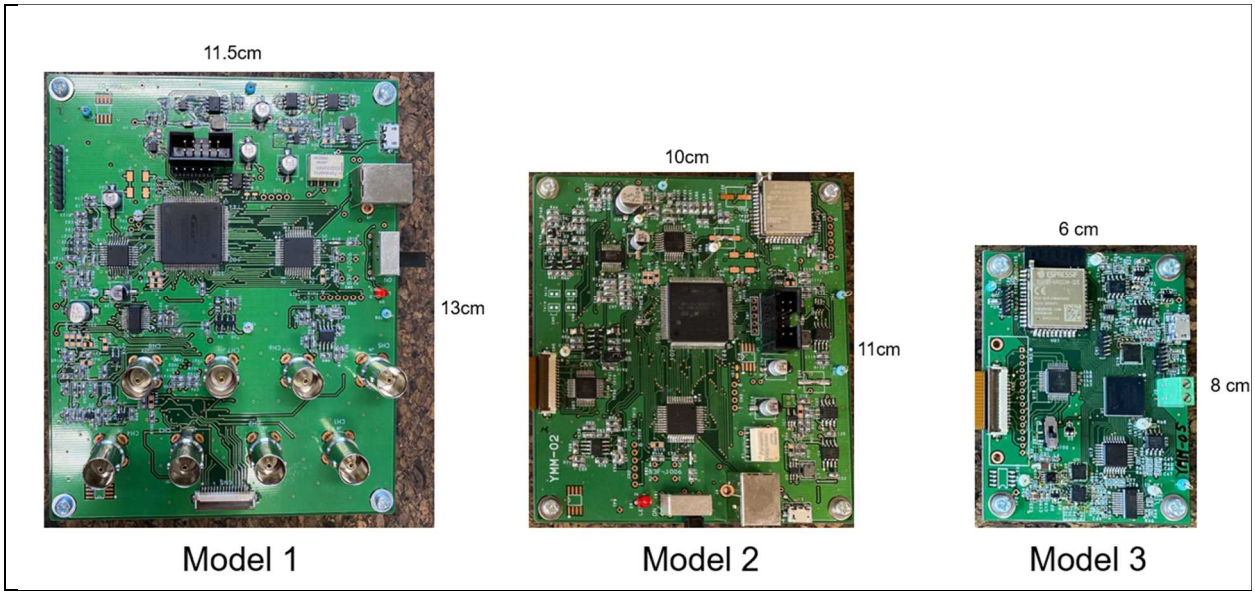

Fig. 2 Prototype 8 channel portable P/R machines.

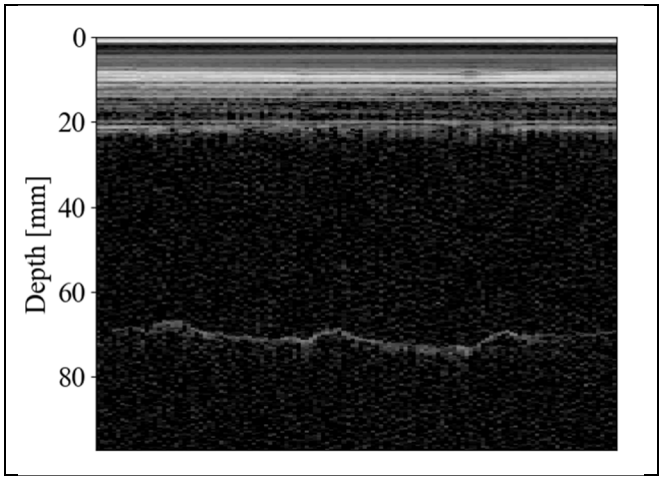

Fig. 3 M mode image by prototype sensors and P/R

2. Presentations & Publications published between April 2021 and March 2022

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Heart Rate Variability Indices May Change Accompanying Cognitive Skills Improvement in eSports Tasks
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Journal of Digital Life 1(4), Feb. 2022.

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Moloud Abdar, Maryam Samami, Sajjad Dehghani Mahmoodabad, Thang Doan, Bogdan Mazoure, Reza Hashemifesharaki, Li Liu, Abbas Khosravi, U Rajendra Acharya, Vladimir Makarenkov, Saeid Nahavandi
Computers in biology and medicine 135, 104418, Aug. 2021.

Automated detection of schizophrenia using optimal wavelet-based l 1 norm features extracted from single-channel EEG
M Sharma, UR Acharya
Cognitive Neurodynamics 15 (4), 661-674, Aug. 2021.

Automated identification of insomnia using optimal bi-orthogonal wavelet transform technique with single-channel EEG signals
M Sharma, V Patel, UR Acharya
Knowledge-Based Systems 224, 107078, Jul. 2021.

An automated skin melanoma detection system with melanoma-index based on entropy features
Kang Hao Cheong, Kenneth Jian Wei Tang, Xinxing Zhao, Joel En Wei Koh, Oliver Faust, Raj Gururajan, Edward J Ciaccio, V Rajinikanth, U Rajendra Acharya
Biocybernetics and Biomedical Engineering 41 (3), 997-1012, Jul. 2021.

Automated ASD detection using hybrid deep lightweight features extracted from EEG signals
Mehmet Baygin, Sengul Dogan, Turker Tuncer, Prabal Datta Barua, Oliver Faust, N Arunkumar, Enas W Abdulhay, Elizabeth Emma Palmer, U Rajendra Acharya
Computers in Biology and Medicine 134, 104548, Jul. 2021.

Automated detection of chronic kidney disease using image fusion and graph embedding techniques with ultrasound images
Anjan Gudigar, U Raghavendra, Jyothi Samanth, Mokshagna Rohit Gangavarapu, Abhilash Kudva, Ganesh Paramasivam, Krishnananda Nayak, Ru-San Tan, Filippo Molinari, Edward J Ciaccio, U Rajendra Acharya
Biomedical Signal Processing and Control 68, 102733, Jul. 2021.

Automated accurate emotion recognition system using rhythm-specific deep convolutional neural network technique with multi-channel EEG signals
D Maheshwari, SK Ghosh, RK Tripathy, M Sharma, UR Acharya
Computers in Biology and Medicine 134, 104428, Jul. 2021.

Automated detection of coronary artery disease, myocardial infarction and congestive heart failure using GaborCNN model with ECG signals
V Jahmunah, EYK Ng, TR San, UR Acharya
Computers in biology and medicine 134, 104457, Jul. 2021.

Application of substitution box of present cipher for automated detection of snoring sounds
S Dogan, E Akbal, T Tuncer, UR Acharya
Artificial Intelligence in Medicine 117, 102085, Jul. 2021.

Fusion of convolution neural network, support vector machine and Sobel filter for accurate

detection of COVID-19 patients using X-ray images
Danial Sharifrazi, Roohallah Alizadehsani, Mohamad Roshanzamir, Javad Hassannataj Joloudari, Afshin Shoeibi, Mahboobeh Jafari, Sadiq Hussain, Zahra Alizadeh Sani, Fereshteh Hasanzadeh, Fahime Khozeimeh, Abbas Khosravi, Saeid Nahavandi, Maryam Panahiazar, Assef Zare, Sheikh Mohammed Shariful Islam, U Rajendra Acharya
Biomedical Signal Processing and Control 68, 102622, Jul. 2021.

Application of Petersen graph pattern technique for automated detection of heart valve diseases with PCG signals
T Tuncer, S Dogan, RS Tan, UR Acharya
Information Sciences 565, 91-104, Jul. 2021.

Corrigendum to'An Introduction to the Cyrcadia Breast Monitor: A Wearable Breast Health Monitoring Device'[Computer Methods and Programs in Biomedicine 197: 105758]
Rob Royea, Kevin J Buckman, Matt Benardis, Jim Holmes, Ronald L Fletcher, Ng Eyk, U Rajendra Acharya, Joshua DI Ellenhorn
Computer methods and programs in biomedicine 205, 106118, Jun., 2021.

Future IoT tools for COVID-19 contact tracing and prediction: A review of the state-of-the-science
Vicnesh Jahmunah, Vidya K Sudarshan, Shu Lih Oh, Raj Gururajan, Rashmi Gururajan, Xujuan Zhou, Xiaohui Tao, Oliver Faust, Edward J Ciaccio, Kwan Hoong Ng, U Rajendra Acharya
International journal of imaging systems and technology 31 (2), 455-471, Jun. 2021.

UncertaintyFuseNet: Robust uncertainty-aware hierarchical feature fusion with ensemble Monte Carlo dropout for COVID-19 detection
Moloud Abdar, Soorena Salari, Sina Qahremani, Hak-Keung Lam, Fakhri Karray, Sadiq Hussain, Abbas Khosravi, U Rajendra Acharya, Saeid Nahavandi
arXiv preprint arXiv:2105.08590, May 2021.

PDCNNet: An automatic framework for the detection of Parkinson’s disease using EEG signals
SK Khare, V Bajaj, UR Acharya
IEEE Sensors Journal 21 (15), 17017-17024, May 2021.

Efficient deep neural network model for classification of grasp types using sEMG signals
M Coskun, O Yildirim, Y Demir, UR Acharya
Journal of Ambient Intelligence and Humanized Computing, 1-14, May 2021.

A hybrid deep learning approach for gland segmentation in prostate histopathological images
Massimo Salvi, Martino Bosco, Luca Molinaro, Alessandro Gambella, Mauro Papotti, U Rajendra Acharya, Filippo Molinari
Artificial Intelligence in Medicine 115, 102076, May 2021.

Development of accurate classification of heavenly bodies using novel machine learning techniques
M Wierzbiński, P Pławiak, M Hammad, UR Acharya
Soft Computing 25 (10), 7213-7228, May 2021.

ECNet: An evolutionary convolutional network for automated glaucoma detection using fundus images
DR Nayak, D Das, B Majhi, SV Bhandary, UR Acharya

Biomedical Signal Processing and Control 67, 102559, May 2021.

Automated interpretation of biopsy images for the detection of celiac disease using a machine learning approach
Joel En Wei Koh, Simona De Michele, Vidya K Sudarshan, V Jahmunah, Edward J Ciaccio, Chui Ping Ooi, Raj Gururajan, Rashmi Gururajan, Shu Lih Oh, Suzanne K Lewis, Peter H Green, Govind Bhagat, U Rajendra Acharya
Computer Methods and Programs in Biomedicine 203, 106010, May 2021.

Spwvd-cnn for automated detection of schizophrenia patients using eeg signals
SK Khare, V Bajaj, UR Acharya
IEEE Transactions on Instrumentation and Measurement 70, 1-9, Apr. 2021.

Detection of Parkinson's disease using automated tunable Q wavelet transform technique with EEG signals
SK Khare, V Bajaj, UR Acharya
Biocybernetics and Biomedical Engineering 41 (2), 679-689, Apr. 2021.

Application of Artificial Intelligence techniques for the detection of Alzheimer's disease using structural MRI images
X Zhao, CKE Ang, UR Acharya, KH Cheong
Biocybernetics and Biomedical Engineering 41 (2), 456-473, Apr. 2021.

Automatic identification of insomnia using optimal antisymmetric biorthogonal wavelet filter bank with ECG signals
M Sharma, HS Dhiman, UR Acharya
Computers in Biology and Medicine 131, 104246, Apr. 2021.

Novel and accurate non-linear index for the automated detection of haemorrhagic brain stroke using CT images
U Raghavendra, Anjan Gudigar, V Vidhya, B Nageswara Rao, Sukanta Sabut, Joel Koh En Wei, Edward J Ciaccio, U Rajendra Acharya
Complex & Intelligent Systems 7 (2), 929-940, Apr. 2021.

Risk factors prediction, clinical outcomes, and mortality in COVID-19 patients
Roohallah Alizadehsani, Zahra Alizadeh Sani, Mohaddeseh Behjati, Zahra Roshanzamir, Sadiq Hussain, Niloofar Abedini, Fereshteh Hasanzadeh, Abbas Khosravi, Afshin Shoeibi, Mohamad Roshanzamir, Pardis Moradnejad, Saeid Nahavandi, Fahime Khozeimeh, Assef Zare, Maryam Panahiazar, U Rajendra Acharya, Sheikh Mohammed Shariful Islam
Journal of medical virology 93 (4), 2307-2320, Apr. 2021.

ECG Language processing (ELP): A new technique to analyze ECG signals
S Mousavi, F Afghah, F Khadem, UR Acharya
Computer Methods and Programs in Biomedicine 202, 105959, Apr. 2021.

3. Application & acquisition status of KAKENHI and other external grants

Optimization of poling condition for porous piezoelectric material made by sol-gel composite technique
19K04493, Makiko Kobayashi (Principal Investigator), Grant-in-Aid for Scientific Research (C)

Fundamental development of physiological measurement and analysis platform toward 2nd-generation healthcare IoT technology
21H03855, Toshitaka Yamakawa (Principal Investigator), Grant-in-Aid for Scientific Research (B)

Identification of personalized chronobiological and psychological factor which induce epileptic seizure
21K07540, Toshitaka Yamakawa (Co-Investigator), Grant-in-Aid for Scientific Research (C)

Development of Heat Stroke Alert System by Wearable Device
19H04501, Toshitaka Yamakawa (Co-Investigator), Grant-in-Aid for Scientific Research (B)

4. Application & acquisition status of industrial property rights
PCT application (PCT/SG2020/050538) on this topic in 2020 and entered national phase to Singapore, Japan, and USA in 2022.

No.4-22	Bio-inspired Functional Molecular System		
Research Field	Nano Material Science		
Unit Coordinator			
Name	Yutaka KUWAHARA		
Affiliation	Faculty of Advanced Science and Technology Email: kuwahara@kumamoto-u.ac.jp	Title	Assistant Professor
Unit Members			
Name	Affiliation/Title		
Tomoyasu MANI	University of Connecticut, USA / Assistant Professor		
Yann FERRAND	University of Bordeaux, France / Research Director, Group Leader		
Céline OLIVIER	University of Bordeaux, CNRS, France / Research Associate		
Etsuko FUJITA	Brookhaven National Laboratory, USA / Senior Scientist Emeritus		

1. Overview of achievements

In this unit, we have developed bio-inspired functional molecular systems with chirality for controlling of their function. Three projects for applications of photonic (P1), electronic and magnetic (P2), catalytic reaction in artificial photosynthesis (P3) are conducted by the members from Kumamoto University (KU), Brookhaven National Laboratory (BNL), USA, University of Connecticut (UC), USA, and University of Bordeaux (UB), France.

1-1. Collaboration with the BNL, USA, related with the project P3

The unit members of the BNL and the KU could not alternately visit this year due to the COVID-19 crisis. We communicated with Dr. Fujita, Visiting Professor of IROAST, and other collaborators to submit a paper including research results to an international journal.

1-2. Collaboration with the UC, USA, related with the projects P1 and P2

The KU and UC members could not alternately visit this year. Dr. Kuwahara had several discussions about recent research results with Prof. Mani, Visiting Associate Professor of IROAST, online. We submitted a paper including the results to an international journal.

1-3. Collaboration with the UB, France, related with the project P1

The KU members could not visit and invite French collaborators, Dr. Ferrand and Dr. Olivier, of the UB this year.

2. Presentations & Publications published between April 2021 and March 2022

Presentations

(i) M. Matsunaga, Y. Kuwahara, M. Ito, T. Iwamoto, M. Takafuji, H. Ihara, Chiroptical properties for chiral assembling systems of metal complexes induced by glutamide derivatives as supramolecular templates, Materials Research Meeting 2021 (MRM2021), *Hybrid* (onsite at Yokohama and online), Dec. 14, 2021.

(ii) Y. Kuwahara, N. Nagatomo, M. Takafuji, K. Yoshida, S. Nagaoka, R. Oda, T. Hamada, H. Ihara, Enantioselective chiroptical response with glutamide-based supramolecular organogels, The International Chemical Congress of Pacific Basin Societies (Pacifichem 2020), *Hybrid* (online and onsite at Hawaii, USA), Dec. 21, 2021.
(iii) M. Ito, Y. Kuwahara, N. Ryu, T. Mani, H. Ihara, M. Takafuji, Chiroptical properties and their stability for supramolecular assemblies of viologen-modified glutamide derivatives and their reduced derivatives, The International Chemical Congress of Pacific Basin Societies (Pacifichem 2020), *Hybrid* (online and onsite at Hawaii, USA), Dec. 21, 2021.
(iv) M. Ito, Y. Kuwahara, T. Iwamoto, N. Ryu, M. Takafuji, H. Ihara, Changes in physicochemical properties for supramolecular nano-assemblies of cationic glutamide derivatives by electron-donating and electron-accepting, The 70th SPSJ Annual Meeting (Japanese), *Online*, May 28, 2020.

Publication with members as coauthors
(v) B. N. DiMarco, D. E. Polyansky, D. C. Grills, P. Wang, Y. Kuwahara, X. Zhao and E. Fujita, Structural and electronic influences on rates of tertpyridine-amine Co^{III}-H formation during catalytic H_2 evolution in an aqueous environment, *ChemPhysChem*, 2021, **22**, 1478-1487. (DOI: 10.1002/cphc.202100295)
(vi) Y. Kuwahara, M. Ito, T. Iwamoto, M. Takafuji, H. Ihara, N. Ryu, T. Mani, Chemical redox-induced chiroptical switching of supramolecular assemblies of viologens, *RSC Advances*, 2022, **12**, 2019-2025. (DOI: 10.1039/D1RA08984F)

3. Application & acquisition status of KAKENHI and other external grants
(i) KAKEN Grant-in-Aid for Scientific Research (C), JSPS, as a PI, Direct cost (total): 3,300,000 yen, FY: 2020 – 2022.
(ii) KAKEN Grant-in-Aid for Challenging Research (Exploratory), JSPS, as a Co-I, Direct cost (total as Co-I): 1,100,000 yen, FY: 2020 – 2022.

No. 4-23	Nanomaterials processing for medical, cosmetic, and environmental applications		
Research Field	Nano Material Science, Green Energy, Environmental Science		
Unit Coordinator			
Name	Mitsuru SASAKI		
Affiliation	Institute of Industrial Nanomaterials (IINa) Kumamoto University Email: msasaki@kumamoto-u.ac.jp	Title	Associate Professor
Unit Members			
Name	Affiliation/Title		
Olivier BOUTIN	Aix Marseille University, France Professor		
Bushra AL-DURI	The University of Birmingham, UK Professor		
Hosano HAMID	Institute of Industrial Nanomaterials (IINa), Kumamoto University Professor		
Marleny D.A. SALDAÑA	University of Alberta, Canada Professor		
M. J. COCERO	Valladolid University, Spain Professor		
Elisabeth BADENS	Aix Marseille University, France Professor		
Rodolfo M. IBARRA	Universidad Autonoma de Nuevo León, Mexico Associate Professor		
Cinthya ISSAI	Graduate School of Science and Technology (GSST), Kumamoto University Ph.D. candidate		

1. Overview of achievements

1.1. Quick degradation of nitrogen- or sulfur-containing organic compounds in water.

Pulsed arc discharge was experimentally investigated as a rapid decomposition method for persistent substances in water. We used the following substances as starting materials in this study: (1) bisphenol-A, (2) dimethyldisulfide (DMDS) and (3) dimethyltrisulfide (DMTS). As a result, it was found that bisphenol A (BPA) was almost decomposed within a couple of minutes to form phenol, hydroquinone,and a small amount of organic acids. It was also found that both DMDS and DMTS almost decomposed by the pulsed arc discharge. This fiscal year we also tried to do additional experiments of the substances to understand possible reaction pathways and to explore optimum operating conditions, and found out suitable operating conditions where DMDS and BPA could be degraded perfectly using pulsed arc discharge technique within several minutes at

ambient temperature and pressure. As for wet air oxidation, we have been trying our best and will last systematic experiments and analyses with partner professors in this group for comparing reaction behavior and decomposition efficiency.

1.2. Efficient biomass liquefaction and value-added component production with subcritical water

We tried to confirm possibility that food processing waste and nutrients in non-edible biomass can convert to value-added chemicals and functional materials using subcritical water. In this study, we aim to liquefy a food processing waste (sake lees) in subcritical water to produce aqueous solution with high contents of amino acids, ammonia, and minerals. As a result, it was found that about 40-50% of sake lees liquefied and relatively high concentration of amino acids and minerals in subcritical water at 120-140ºC for 4 hours by using a batch-type reactor (Yamato *et al.*, *SN Applied Sciences*, 2020). Next, we carried out acetic acid fermentation experiments of the liquefied samples obtained from the above experiments and found that good quality vinegar solution could be produced by the hybrid method of subcritical water solubilization and acetic acid fermentation methods. If we can confirm the reproducibility of the experiments, we will try to do next experiments using a continuous reaction system.

1.3. Nanomaterials production processes for medical and industrial fields.

We aimed to develop and establish an efficient, environmentally-friendly and feasible method for the synthesis of poly-(*N*-isopropylacrylamide) by using the gas-liquid interfacial pulsed arc discharge in water (Unpublished data). Also, we prepared a biomass-based solid acid catalyst using hydrothermal treatment. Next, we tried to produce medically available Metal/silk fibroin hybrid materials with the pulsed arc discharge method. Ag nanoparticles (AgNPs) which had produced by the pulsed arc discharge treatment was mixed with nano fibroin aqueous solution with stirring, and then hybrid materials could be produced from the UV-Vis and TEM analyses.

2. Presentations & Publications (incl. submitted papers)

Publications

Cinthya Soreli Castro Issasi, "In-situ Synthesis of Poly(N-Isopropylacrylamide) Decorated with Silver Nanoparticles Using Pulsed Electrical Discharge in Contact with Water Interface", submitted for publication in *Nanocomposites* (2022).

Mitsuru Sasaki*, Yuji Miyagawa, Kouki Nonaka, Ryota Miyanomae, Armando T. Quitain, Tetsuya Kida, Motonobu Goto, Tetsuo Honma, Tomohiro Furusato, Kunio Kawamura*, "Nano-pulsed discharge plasma-induced abiotic oligopeptide formation from diketopiperazine", submitted for publication in *The Science of Nature* (2022).

Masayo Nishizono, Cinthya Soreli Castro Issasi, Hiroyuki Mizukami, Mitsuru Sasaki*, "Comparison of Quality and Microstructure of Strawberry Powders Prepared by Two Different Drying Methods: Low Temperature Drying with Convection Dryer and Vacuum Freeze Drying", *Journal of Antioxidant Activity*, **2**(3), 10-22 (2022).

Mahmoud A Shouman, Ahmed H El-Shazly, Marwa F Elkady, Mohamed Nabil Sabry, Ramma Kamogawa, Koki Nonaka, Mitsuru Sasaki, Akimaro Kawahara*, "A hepatic sinusoids-based microtube reactor for (Z)-5-(4-hydroxybenzylidene) thiazolidine-2, 4-dione intermediate drug synthesis", *Chemical Engineering Science*, **247**, 116960 (2022).

Armando T Quitain, Elaine G Mission, Jonas Karl Christopher N Agutaya, Mitsuru Sasaki, Tetsuya Kida, "Thermal, hydrothermal liquefaction, and electromagnetic processes for biomass

conversion,", *AZ of Biorefinery*, 421-446 (2022)

Kotchakorn T.sriwong, Ramma Kamogawa, Cinthya Soreli Castro Issasi, Mitsuru Sasaki*, Tomoko Matsuda*, "Geotrichum candidum acetophenone reductase immobilization on reduced graphene oxide: A promising biocatalyst for green asymmetric reduction of ketones", *Biochemical Engineering Journal*, **177**, 108263 (2022).

Tomohiro Furusato, Mitsuru Sasaki, Yoshinobu Matsuda, Takahiko Yamashita, "Underwater shock 0wave induced by pulsed discharge on water", *Journal of Physics D: Applied Physics*, **55**(11), 115203 (2021).

Cinthya Soreli Castro Issasi, Kanae Mori, Rodolfo M. Ibarra, Mitsuru Sasaki*, Armando T. Quitain, Tetsuya Kida, Satoko Okubayashi, and Tomohiro Furusato, "One-Pot Synthesis of Thermoresponsive Poly(N-Isopropylacrylamide) Assisted by Pulsed Arc Discharge in Contact with the Water Interface for Wound Dressing Purposes", *ACS Applied Polymer Materials*, **4**(1), 74-83 (2021).

Kazuharu Yamato, Daigo Murakami, Shoji Hirayama, Yukiko Hoshino, Munehiro Hoshino, Mitsuru Sasaki*, "Food-grade vinegar production from the extract of sake lees obtained by subcritical water treatment," *The Journal of Food and Nutrition*, **7**, 203, 1-2 (2021)

Shamala Balasubramaniam, Shohei Ninomiya, Mitsuru Sasaki*, Armando T. Quitain, Tetsuya Kida, Marleny D. A. Saldana, "Carbon-based solid acid catalyst derived from Undaria pinnatifida and its application in esterification", *Algal Research*, **55**, 102272 (2021)

Presentations

Ramma Kamogawa, Hiras T. Manalu, Mitsuru Sasaki*, Armando T. Quitain, Tetsuya Kida, "Hydrolysis of Rutin Using Solid Acid Catalyst Under Hydrothermal Conditions for High Yield of Quercetin" (ID: 3584338), Pacifichem 2021 Congress (online), Hawaii, US, 2021.

Daigo Murakami, Mitsuru Sasaki*, et al., "Liquefaction of sake lees by subcritical water treatment and application of the liquefied product as an additive for vinegar production" (ID: 3586194), Pacifichem 2021 Congress (online), Hawaii, US, 2021.

Ryohei Mori, Mitsuru Sasaki*, Tetsuo Honma, "Development of Detoxification Technology for Water Pollutants Using Pulse Discharge at the Air-Liquid Interface: Decomposition of Bisphenol A" (ID: 3584330), Pacifichem 2021 Congress (online), Hawaii, US, 2021.

Ippei Yamashina, Mitsuru Sasaki*, et al., "A Study on the Effectiveness of Pulsed Arc Discharge as a New Technology for Char Treatment Process in Whisky Production" (ID: 3588752), Pacifichem 2021 Congress (online), Hawaii, US, 2021.

Masayo Nishizono, Cinthya Soreli Castro Issasi, Hiroyuki Mizukami, Mitsuru Sasaki*, "Comparison of quality and microstructure of strawberry powders prepared by two different drying methods, low temperature drying with convection dryer and vacuum freeze drying", The 16th International Student Conference on Advanced Science and Technology (ICAST2021) (online), Kumamoto 2021.

Cinthya Soreli Castro Issasi, Mitsuru Sasaki*, and Rodolfo Morales Ibarra, "Ex-situ synthesis of AgNps/PNIPAM nanocomposite using pulsed arc discharge method in contact with water

interface", The 16th International Student Conference on Advanced Science and Technology (ICAST2021) (online), Kumamoto, December 2021.

Ippei Yamashina, Tetsuya Kida, Mitsuru Sasaki*, Armando T. Quitain, "Elution Rate Analysis of Oak Surface Treatment and Aromatic Components by Pulsed Arc Discharge", The 16th International Student Conference on Advanced Science and Technology (ICAST2021) (online), Kumamoto, December 2021.

Ryohei Mori, Mitsuru Sasaki*, Tetsuya Kida, Armando T. Quitain, "Decomposition of BPA Using Gas-liquid Interface Pulsed Discharge Plasma", The 16th International Student Conference on Advanced Science and Technology (ICAST2021) (online), Kumamoto, December 2021.

3. Application & acquisition status of KAKENHI and other external grants

Study on chemical evolution by simulation experiments regarding the plasma processes and hydrothermal conditions with minerals under the Hadean Earth environments, KAKENHI Grant-in-Aid for Scientific Research (B) 2019-2022 (Ongoing).

Research on the aging of rice shochu using locally produced wood and its utilization, Project Research at Japan Sake and Syochu Makers Association 2021 (Ongoing).

4-24	Ferroelectric Photovoltaics		
Research Field	Green energy / Next-generation Technology		
Unit Coordinator			
Name	Hiroki MATSUO		
Affiliation	IROAST Email: matsuo_h@cs.kumamoto-u.ac.jp	Title	Associate Professor
Unit Members			
Name	Affiliation/Title		
Yuji NOGUCHI	Kumamoto University / Professor		
Ho-Yong LEE	Ceracomp Co. Ltd. / President		
Moon-Chan KIM	Ceracomp Co. Ltd. / Researcher		

1. Overview of achievements

Ferroelectric materials exhibit a characteristic photovoltaic effect that can generate photovoltage far exceeding their bandgap energy and light polarization-dependent photocurrent. Activation of visible light response is a key issue for the development of the ferroelectric materials with high energy conversion efficiency and a high photocurrent anisotropy. The aim of this research unit is to develop the ferroelectric materials with the high visible-light activity and to reveal basic science in the ferroelectric photovoltaics.

In this term, 1% Mn-doped $BaTiO_3$ (Mn-BT) ferroelectric single crystals were prepared by a solid-state single crystal growth (SSCG) method. X-ray diffraction measurements for the single crystals confirmed that the crystals were successfully grown without formation of secondary phases. Strong visible light absorption was observed for the Mn-BT single crystals in transmittance measurements which suggested that the Mn-doping provided impurity levels inside the bandgap of $BaTiO_3$ acting as a visible-light absorption center. To control a ferroelectric domain structure of the single crystals, conditions of a poling treatment were performed. We confirmed that micrometer-size domains with the ferroelectric polarization parallel to applied electric fields during the poling treatment were constructed by piezoresponse force microscope measurements, which provided non-zero net ferroelectric polarization. Besides, a transient absorption spectroscopy measurement was performed to reveal the photocarrier dynamics. We found increase in light absorption at a specific wavelength suggesting the existence of the impurity levels derived from Mn atoms.

We will perform photovoltaic measurements for the single crystals after the poling treatment. An influence of valence state of Mn atoms on the photovoltaic properties and photocarrier dynamics will also be evaluated.

2. Presentations & Publications published between April 2021 and March 2022

- (**Invited**) Hiroki Matsuo, Yuji Noguchi "Activation of Visible Light Response in Ferroelectric Photovoltaic Effects via Gap-State Engineering"
  The Joint International Conference on Applied Physics and Materials Applications & Applied Magnetism and Ferroelectrics (ICAPMA-JAMG-2021), December 2021, Pattaya (Virtual)

- Hiroki Matsuo, Yuji Noguchi "Gap-State Engineering for Enhanced Ferroelectric Photovoltaic Effect under Visible Light Irradiation"
  2021 MRS Fall Meeting & Exhibit, December 2021, Boston (Virtual)

- Hiroki Matsuo, Yuji Noguchi "Photovoltaic properties of $BiFeO_3$-based ferroelectric thin film via gap-state engineering"
  The 50 th Japan Conference on Crystal Growth, October 2021, Virtual.

No.4-25	Next-Generation Design of Structures		
Research Field	Environmental Science/ Next-generation Technology		
Unit Coordinator			
Name	Gaochuang CAI		
Affiliation	IROAST Email: cai@kumamoto-u.ac.jp	Title	Associate Professor
Unit Members			
Name	Affiliation/Title		
Kazuo DAN	Faculty of Advanced Science and Technology, Kumamoto University (KU) /Full professor		
Amir Si LARBI	University of Lyon, France/ Full professor		
Konstantinos Daniel TSAVDARIDIS	City, University of London, U.K./ Full professor		
Danièle WALDMANN	Insitut für Massivbau (Institute of Concrete and Masonry Structures), Technischen Universität Darmstadt, Germany/ Full professor		

1. Overview of achievements

The research unit aims to the two key research themes, i.e., (1) safety and optimization of structures under extreme loads (e.g. earthquake-fire, LPGM, NFGM) including the application of high-performance materials, and (2) recycling of wastes arising from the extreme loads, in particular the application in the concrete industry, and strengthening the well-designed structures with limited damages subjected to the extreme loads. The two themes also can be shortly called *Design for structural safety and sustainability* (DfS^3), one of the most important parts of Design for X (DfX).

Since December 2021, the research activities will be conducted using advanced numerical methods, algebraic analysis, and experimental verification. As the PI of the unit, the applicant has rich experience in collaboration with international leading academic partners and local industry partners.

Since December 2021, the following core activities have been conducted,

(1) Implementation of international collaboration and research exchanges. Through a series of online activities, including zoom meetings and discussions in email or message apps, regular collaboration activities have been conducted. The collaboration topics are mainly listed here: Fiber-reinforced polymer (FRP)-repaired structures, development of resilient structures such as resilient concrete-filled steel tube (CFT), evaluation and optimization of the structures with Design for deconstruction (DfD) such as bolted concrete structures, high ductile materials (Textile reinforced mortar, structural health monitor cementitious composite), to promote development and application of the next generation structures and materials.

(2) Co-authorship of several journal papers. five journal articles have been submitted with the unit members as co-authors, and the other four journal articles are also under preparation at this moment.

(3) Co-application of international collaboration fundings. The activities include THREE JSPS

postdoctoral fellowships and ONE JSPS invitational fellowship.

(4) Several new collaborations are being developed. New unit members will be added soon.

2. Presentations & Publications published between April 2021 and March 2022

Since the research unit has been built in December 2021, the following publications with the affiliation of IROAST have been submitted to several international journals,

(1). **G.C Cai***, T. Fujinaga, **A. Si Larbi** (2021). Cyclic behavior of CFT columns reinforced with LBHSRs, *Bulletin of Earthquake Eng.* (Under review). ***(* as a corresponding author)***

(2). F. Zhao, F. Xiong, **G.C. Cai***, **A. Si Larbi** (2021). Experimental and numerical study of full-scale PC wall panels with bolted connections subjected to cyclic loads. *Journal of Building Engineering,* (Under review).

(3). Y. Sun, **G.C Cai*** (2021). Lateral capacity and deformation ability of RCCCs under large cyclic loads, *ASCE-J. Struct. Eng.* (Under review).

(4). Y. Wang, G. Chen, **G.C Cai*** et al. (2021) Constitutive models of circular GFRP-steel tube confined concretes under cyclic axial compression, *Engineering Structures*, (Under review).

(5). Q. Su, **G.C Cai***(2021) Damage controlling of infilled RC frames under simulated seismic loads: An experimental study, *Engineering Structures,* (Under review).

(6). Y.L Wang, **G.C Cai*** et al. Seismic performance of square GFRP-steel tube confined concrete columns, *Journal of Building Engineering,* (Under review).

Besides, the following papers are under preparation,

(7). **G.C. Cai***, **A. Si Larbi** (2021). Cyclic behavior of XRCFT columns under simulated seismic loads, Target journal: *Structures.*

(8). **G.C. Cai***, W. Liu, **A. Si Larbi** (2021). Monotonic and cyclic tensile properties and a simplified calculation model of reinforced textile reinforced mortars (RTRM), Target journal: *Buildings*.

(9). H. Zhu, Y. He, **G.C. Cai***, Y. Zhang, L. Chen, Bond performance between CFRP rebars and ultra-high-performance concrete, Target journal: *Construction Buildings Materials*

(10). **G.C. Cai***, Y.J. He (2021). Seismic performance and evaluation of FRP-strengthened RC columns: A critical review, Target journal: *Structures.*

3. Application & acquisition status of KAKENHI and other external grants

Application

Since October 2021, the following JSPS applications have been submitted,

(1). JSPS Invitation Fellowships for research in Japan, AI-based design and optimization of composite structures under strong earthquakes, submitted.

(2). JSPS Postdoctoral fellowships for research in Japan, Resilient RC structures, submitted.

(3). JSPS Postdoctoral fellowships for research in Japan, A smart concrete performance assessment system, submitted.

(4). JSPS Postdoctoral fellowships for research in Japan, AI design and optimization of concrete structures, submitted.

Based on the collaboration activities of the unit, the following applications are under preparation,

(1). JST, Strategic Basic Research Programs, CREST, one proposal (with collaboration outside Kumamoto University), 2022.

(2). Heiwa Nakajima Foundation, International Academic Joint Research Grant, 2022.

(3). The Kajima Foundation, Support Program for International Joint Research Activities

4. Application & acquisition status of industrial property rights

N/A

5. Young Faculty Members Support Program for New IROAST Major Research Area

No.	Name	Project Title
5-1	**Yusuke Inomata**	Development of Alkaline Copper Halide Based Highly Luminescent Circularly Polarized Luminescent Materials
5-2	**Ryo Nozu**	Comparative genomics reveals the mechanism of gonadal sex change in fishes
5-3	**Yoshihiro Sekine**	Development of Diamond Spin-Qubit Based on Graphene Oxide
5-4	**Ahmad Muhammad Sohail**	Selective hydrogen separation membranes based on two-dimensional carbon nanosheets: Toward a stable supply of hydrogen energy
5-5	**Yi-Lun Tsai**	Soil chemotactic signal perception and response of plant-parasitic nematodes
5-6	**Akira Ueda**	Development of novel highly processable super/high conducting materials composed of purely organic small molecules

No.5-1	Development of Alkaline Copper Halide Based Highly Luminescent Circularly Polarized Luminescent Materials		
Name	Yusuke Inomata		
Affiliation Contact	Faculty of Advanced Science and Technology Email: inomata@kumamoto-u.ac.jp	Title	Assistant Professor
Research Field	Novel Functional Materials		

1. Overview and achievements

Materials showing circularly polarized luminescence (CPL) has attracted much attention owning to their application to light source of liquid crystal display, dye materials for 3D display and security painting. Current CPL materials are organic, supramolecules and organic-inorganic hybrid -based materials. The CPL properties can be finely controlled and they show high luminescence. However, the drawbacks are their chemical stability and complicated synthetic process. Alkali copper halides are inorganic luminescent materials with high quantum yield. The salts are soluble to polar solvents and they can be easily crystalized from water or other polar solvents. In addition to the luminescent properties, alkali copper halides tend to possess chiral crystal structure such as $CsCuCl_3$ (Space groups: $P6_122$ or $P6_522$), $CsCuBr_3$ (Space group: $C222_1$), Cs_2CuBr_3 (Space group: $P2_12_12_1$). In this work, we try to enantioselectivity crystalize the alkali copper halides and their luminescent properties are investigated.

Among the alkali copper halides, we synthesized $CsCuCl_3$ that has right-handed ($P6_122$) and left-handed crystal structures. $CsCuCl_3$ was crystalized from water using $CuCl_2$ and CsCl as precursors and chiral organic acids as chiral additives. Red-brown single crystals were obtained and single crystal XRD measurements were conducted to determine the absolute structures. We found that right-handed and left-handed crystals were selectively synthesized depending on the chirality (L or D) of organic acids (***Figure 1***). Cu(I) is known as a luminescent center of alkali copper halides. Therefore, $CsCuCl_3$ was partially reduced by $NaBH_4$ to reduce Cu(II) to Cu(I). The reduced $CsCuCl_3$ powders showed bright green luminescence. We further analyze the CPL properties of the partially reduced $CsCuCl_3$ and increase the stability.

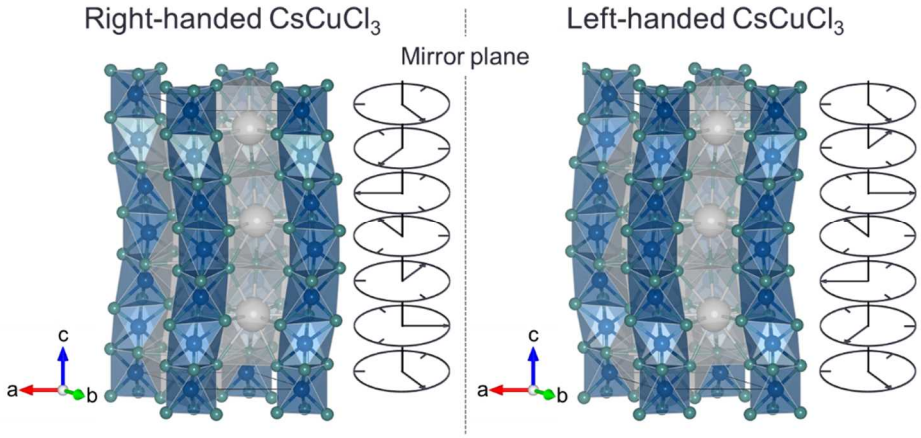


Figure 1. Crystal structures of right-handed ($P6_122$) and left-handed ($P6_522$) $CsCuCl_3$.

2. Prospect for further research collaboration with other university/institution

N/A

3. Application plan of KAKENHI and other external grants

- Grant-in-Aid for Early-Career Scientists
- LOTTE foundation research grant

No.5-2	Comparative genomics reveals the mechanism of gonadal sex change in fishes		
Name	Ryo Nozu		
Affiliation Contact	Faculty of Advanced Sciences and Technology Email: rnozu@kumamoto-u.ac.jp	Title	Project Assistant Professor
Research Field	Fisheries biology		

1. Overview and achievements

It is well known that some teleost fish can functionally change sex (i.e., switch gametogenesis) during their lives. These fish are referred to as sequential hermaphroditic and/or sex-changing fish. Interestingly, recent studies have shown that not only sex-changing fish, but also gonads of gonochoristic fish (i.e., determined sex does not change) are potentially capable of functional sex-change throughout their lifetime. However, in gonochoristic fish, sex-change is considered to never occur under the natural environment (condition). Thus, it is still unknown what is responsible for the expression or not of sex-change ability in fish. Here, I thought that a genome-wide comparison between sex-changing and gonochoristic fish would be a useful approach to reveal this question.

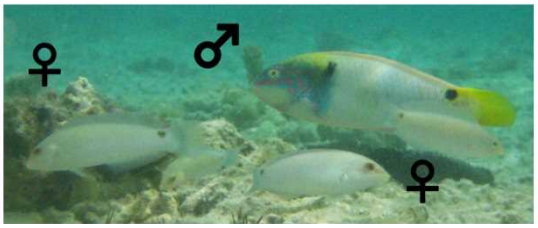


Fig. 1. Three-spot wrasse (*H. trimaculatus*) is a protogynous species. Females change sex to males under certain environmental condition.

The goal of this research is to determine the genome sequence of the protogynous wrasse (three-spot wrasse, *Halichoeres trimaculatus*, (Fig. 1) and compare it to that of a gonochoristic fish in order to understand the mechanism that enable the expression of sex-change ability. I have two specific approaches for genome-wide comparisons. (i) Search for genes specific to sex-changing and/or gonochoristic fish, and (ii) Comprehensive analysis of transcriptional regulatory regions of sex-related genes common to both sex-changing and gonochoristic fish. In this year, I focused on assembling the draft genome of protogynous three-spot wrasse.

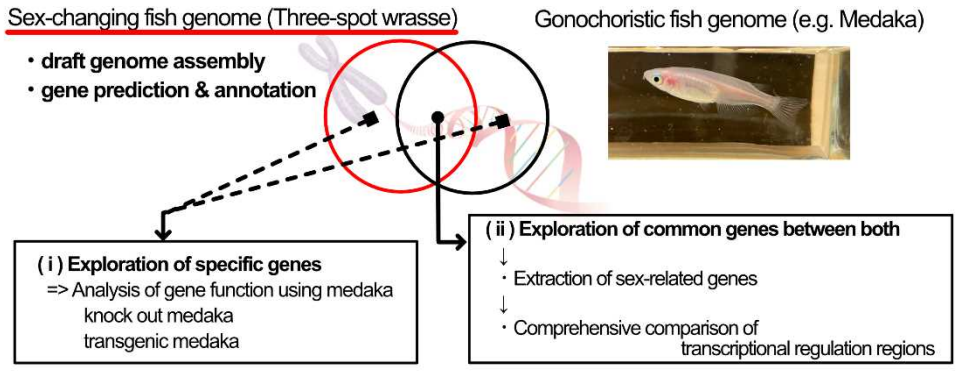


Fig. 2. Schematic of research strategy.

Using a NucleoBond AXG column, long genomic DNA with a peak of >30 Kb was extracted from muscle tissue of an adult female (Fig. 3). This was used to acquire high precision long read

(HiFi) data for one SMRT cell by Sequel II sequencer (PacBio). About 32 Gb of HiFi data consisting of about 1.9 million DNA sequences (average length 17 Kb) were assembled by the hifiasm program, which converged to 108 contigs. These contigs showed a maximum length of 43 Mb, N50 length of 35 Mb and total base length of approximately 850 Mb (Table 1). Evaluation of the completeness of the draft genome assembly using the BUSCO program showed a detection rate of more than 98% for highly conserved orthologs (of 3,354 genes) across vertebrata, resulting in a highly comprehensive and continuous assembly of the whole genome sequence for this species.

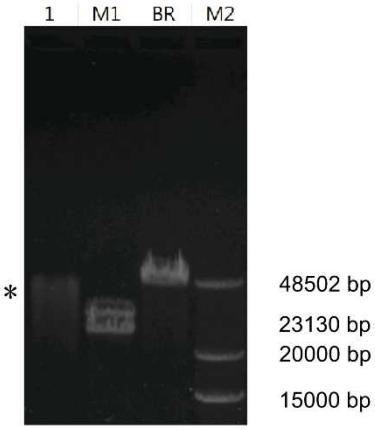


Fig. 3. Quality check of extracted genomic DNA by pulsed-field gel electrophoresis. Lane 1: sample; BR, M1 & M2: DNA markers. * indicates a band of the sample.

Table 1. The stats of draft genome assembly of the three-spot wrasse.

	Stats
Number of contigs	108
Max length (bp)	43,064,949
N50	35,407,678
Total length (bp)	849,850,474

2. Significance of the research and progress status

To investigate the mechanism of gonadal sex change using fish as a model, and the findings will provide new fundamental information on sexual plasticity not only in fish but also in vertebrates. The genome sequence of the protogynous fish will provide important molecular information for the future sex change and sexual plasticity research area.

Using the Hi-C analysis, I plan to perform chromosome-level scaffolding in the future to complete the whole genome information with a high degree of completeness. In addition, gene prediction and annotation will be performed and then, genome-wide comparisons will be conducted with gonochoristic fish.

3. Prospect for further research collaboration with other university/institution

This research is already underway in collaboration with Professor Shigehiro Kuraku (RIKEN BDR, National Institute of Genetics), who has expertise in genomic DNA extraction methods and advanced information analysis techniques. I plan to continue collaboration with RIKEN BDR, which has extensive experience in chromosome-level scaffolding using Hi-C data.

4. Application plan of KAKENHI and other external grants.

I am planning to apply for the FY2023 Grant-in-Aid for Scientific Research (C) on the theme of brushing up the sex-changing fish genome information developed in the present project and elucidating the sex-changing mechanism using a genome-wide approach.

No.5-3	Development of Diamond Spin-Qubit Based on Graphene Oxide		
Name	Yoshihiro Sekine		
Affiliation Contact	Priority Organization for Innovation and Excellence Email: sekine@kumamoto-u.ac.jp	Title	Associate Professor
Research Field	Material Science		

1. Overview and achievements

What brings about the creation of innovation in science and technology is basic and applied research that brings about new scientific and technological concepts. Carbon materials are attracting attention as materials that bring innovation in various fields, and diamond, in particular, is expected to have various functionalities due to the characteristics of doping and surface modification of the sp^3 carbon. These functionalities of diamond can be combined to create even better materials, and thus have great potential as materials that bring about innovation. As innovation in energy devices and catalysts as truly useful materials is eagerly awaited, there is a growing interest in research on the functional exploration of diamond and the development of materials.

The defects (NV centers) in nitrogen-doped diamond, also known as spin-Qubit, have great potential in quantum computation. The key to functional diamond synthesis is how to synthesize carbon materials containing reasonably hetero-doped elements, but the suitably synthetic strategies are not well established.

In this research, I have investigated the preparation of the suitable candidate of the spin-qubit materials based on the doped diamond. The doped diamond could be prepared by following strategies; A) the preparation of the doped graphene oxide and their reduction materials, B) High-temperature and pressure method yielded in the diamond.

A) This study focused on the preparation of the diamond by graphene oxide through high-temperature and high-pressure method.(Fig.1a)[1] In addition, another atom doped reduced-graphene oxide was prepared by graphene oxide through chemical doping and thermal reduction. B) High-temperature and pressure method gave diamond-like materials from doped reduced graphene oxide, which was confirmed by XPS, raman spectra and temperature-dependent magnetic properties measurements. As a result, we have succeeded in synthesizing doped diamond-like materials. Next step is to investigate and characterize their relaxation times for evaluating spin-qubit functionalities.

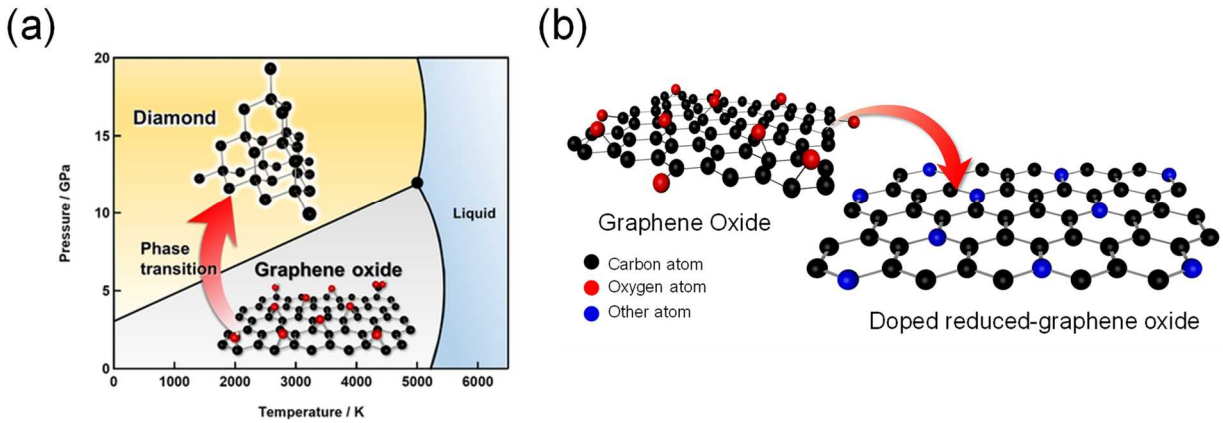


Fig1. (a) Phase diagram of carbon materials. (b) Schematic illustration of transformation from graphene oxide to doped reduced graphene oxide.

[1] M. Fukuda, Md. S. Islam, Y. Sekine, T. Shinmei, L. F. Lindoy, S. Hayami, *ChemistrySelect*, 6(14), 3399-3402 (2021).

2. Significance of the research and progress status

The significance of this research is to systematically prepare doped diamond materials (Fig. 2). The doped diamonds have potential to exhibit spin-qubit, but there is difficulty that how to prepare it and control the number and amount of dopant. This research could provide systematically controlled doping ratio and atoms, through systematic synthesis of doped graphene oxide. This research has potential to investigate the functionality of spin qubit and doping information of doped reduced graphene oxide and doped diamond materials.

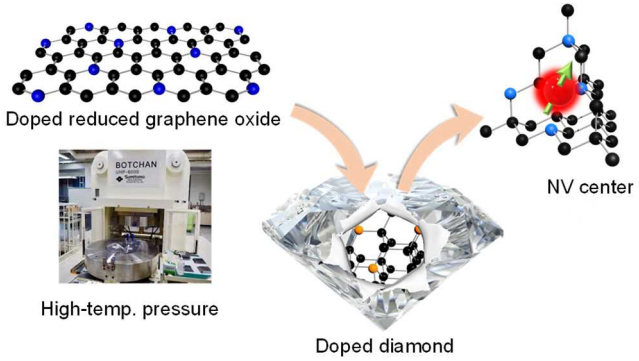


Fig. 2 The preparation scheme of NV center in doped diamond from doped reduced graphene oxide.

3. Prospect for further research collaboration with other university/institution

From this research, I have succeeded in the preparation of the target materials consisting of total isolated spin unit. The preparation of doped diamond materials from reduced graphene oxide were conducted with Dr. T. Shinmei in Ehime university. Now we are collaborating with Prof. Sato in Osaka city university, who is the specialist of the pulse-ESR measurements. The pulse-ESR measurement is one of the strong tools to investigate their relaxation time of spin.

4. Application plan of KAKENHI and other external grants.

My current Kakenhi will end in the end of March, 2023. Therefore, I have plan to apply the Kakenhi in this year.

No.5-4	Selective hydrogen separation membranes based on two-dimensional carbon nanosheets: Toward a stable supply of hydrogen energy		
Name	Ahmad Muhammad Sohail		
Affiliation Contact	Faculty of Advanced Science and Technology Email: sohail@kumamoto-u.ac.jp	Title	Research Assistant Professor
Research Field	Materials Chemistry and Chemical Engineering		

1. Overview and achievements

Membranes are important in gas separation applications due to their high energy efficiency, low operational costs, and durability. However, the traditional systems for the gas generation/separation technology in the industry are energy-intensive and environmentally unfriendly. In contrast, the fast-growing field of membranes technology offers new strategies for sustainable gas separation, providing modularity, scalability, compactness, and high energy efficiency. In this context, graphene membranes have emerged as promising alternatives for gas separation application due to their atomic thickness enabling ultrahigh presence but they suffer from low gas selectivity. In this direction, I aimed to develop such graphene-based membrane that has high permeability and selectivity toward hydrogen separations from mixed gases.

Currently, Hydrogen (H_2) energy is considered one of the preeminent alternatives to fossil fuels due to its natural abundance, zero pollutant transpiration, and high energy capacity. In the H_2 production process, specifically, methane reforming reaction, there are several byproducts e.g., N_2, CO, CO_2, and CH_4 which cause detrimental influences on the energy contents and usage of H_2. However, the tradeoff between permeability and selectivity is a crucial challenge, which is also difficult to adjust during the separation process.

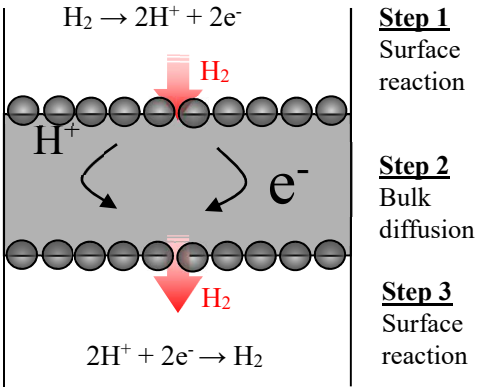


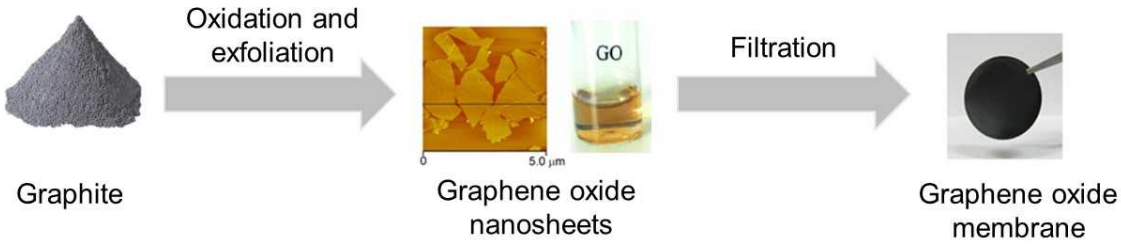
Fig. H_2 permeation mechanism in GO.

In FY2021, I focused on the controlled synthesis of graphene oxide, which should have both electron (sp2 domain of graphene oxide) and proton conductivity (sp3 domain of graphene oxide). The H_2 permeation mechanism in mixed conducting graphene oxide membrane can be seen in the figure right side.

2. Significance of the research and progress status

Production, purification, storage, and transport of hydrogen gas are essential technologies to use H_2 as energy effectively. H_2 permeable membranes are important materials for separating and purifying hydrogen gas from a gas mixture.

In this project, FY 2021, graphene oxide was synthesized by a typical modified Tour's method (oxidation and exfoliation of the graphite). Further, the thin-film membranes have been developed with high electron and proton conductivity by controlling the physical properties such as surface oxygen functional groups. Finally, a free-standing membrane is readily obtained by stacking the nanosheets via filtration (Figure below).



Graphene oxide has the potential to replace conventional technologies for hydrogen separations. The figure on the right side shows the results, indicating that hydrogen selectively permeated via graphene oxide membrane while helium was not permeated. These results encourage us to move forward with this study.

This technology, which can purify the hydrogen selectively using graphene-based membrane will greatly contribute to the realization of a low carbon society.

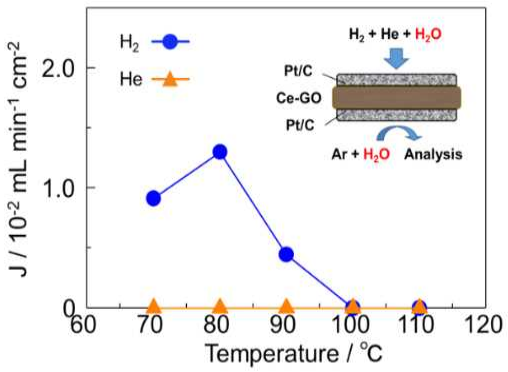


Fig. Preliminary results.

<u>FY2022, the below experiments are planned</u>

- ✓Characterization of the graphene oxide membrane
- ✓Further, enhance the permeability of the hydrogen gas
- ✓Submission of the manuscript.

3. Prospect for further research collaboration with other university/institution

The following Collaborative research is planned in FY2022

- ✓ Graphene oxide for enhanced photoelectrochemcial hydrogen evaluation with King Fahad University of Petroleum and Minerals, Saudi Arabia

4. Application plan of KAKENHI and other external grants.

Kakenhi, Grant-in-Aid for Early-Career Scientists

No.5-5	Soil chemotactic signal perception and response of plant-parasitic nematodes		
Name	Yi-Lun Tsai		
Affiliation Contact	Faculty of Advanced Science & Technology, International Research Center for Agricultural & Environmental Biology Email: tsai-yilun@kumamoto-u.ac.jp	Title	Assistant Professor
Research Field	Plant biology		

1. Overview and achievements

I am interested in exploring the inter-specific interactions between plants and soil organisms, by using the plant-parasitic root-knot nematodes (*Meloidogyne incognita*, RKN) as a model. RKN are soil-borne obligate parasites that infest plant roots and feed on plant cells in order to survive and propagate. During the infestation, RKN converts the plant host's cells into specialized feeding organs known as galls or root knots, by utilizing the host plant's own hormone signaling pathways.

RKN are hatched as free-living juveniles in the soil, and must seek out appropriate host plants to infect as soon as possible. It is now known that RKN juveniles utilize chemotaxis and follow gradients of chemicals secreted by the host plant to find potential hosts to infect. The identities of these RKN chemo-attractants thus play critical roles in regulating RKN infection efficiencies. Despite their importance, currently little is known about the chemical structures of compounds that can act as RKN chemo-attractants.

Previously I have found that RKN juveniles are attracted to seeds of the model plant Arabidopsis (*Arabidopsis thaliana*), in a seed coat mucilage-dependent fashion (Fig. 1)[1]. The seed coat of many flowering plants are known to synthesize a gelatinous substance known as mucilage, which absorbs water and expands when the seeds are wetted. Seed coat mucilage typically consist of cell wall carbohydrates such as hemicellulose and pectin, and this finding suggests that cell wall carbohydrates may be involved in RKN chemotaxis[2]. Indeed, later I discovered that the mucilage from flaxseed (*Linum usitatissimum*) also attracts RKN juveniles. Specifically, the flax mucilage rhamnogalacturonan-I with L-galactose sidechains were found to be essential for RKN attraction[3]. This suggests that RKN juveniles can not only perceive cell wall carbohydrates as chemo-attractants, but can distinguish molecular features such as hydroxyl groups and chiral centers on the attractant molecules as well.

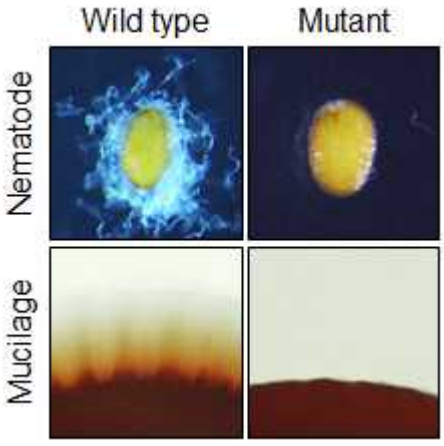


Fig. 1. RKN behavior toward Arabidopsis seeds (top panels), and Ruthenium red-stained mucilage of the corresponding seeds (bottom panels)

2. Significance of the research and progress status

Plant-parasitic nematodes are significant agricultural pests in many parts of the world, including Kyushu, Japan, and are known to cause formidable economic losses annually. Currently effective, long-term and environmentally-friendly strategies to protect crop plants from plant-parasitic nematodes remain lacking. Chemotaxis thus may be a viable approach to control nematode

infections in agriculture, as chemo-attractants can be applied in fields to direct nematodes away from vulnerable crop plants[4]. The identification and characterization of RKN chemo-attractants may serve as the foundation to develop novel strategies to reduce RKN infections in agriculture.

Currently, I am interested to expand the characterization of inter-specific communication beyond plants and nematodes. The soil is a highly complex ecosystem that house many micro-organisms aside from nematodes. Many of these microbes preferentially occupy the soil region adjacent to the plant roots, or reside within the roots, in order to take advantages of the metabolites secreted by plants[4]. One important group of such microbes are the rhizobacteria that colonize roots of legume plants and form special organs call nodules, and provide the host plants with organic nitrogen. The rhizobacteria nodules and RKN galls are thematically similar in that both are induced novel organs that house micro-organisms in roots. Yet these organs have very different outcomes as rhizobacteria are functionally symbionts while RKN are considered parasites. I am interested in how these two micro-organisms affect each other when infecting the same host plant. Furthermore, I'd like to investigate how RKN and rhizobacteria root colonization affect the composition of other micro-organisms that inhabit the surface or within plant roots. Currently I am optimizing the experimental conditions using the model legume plant *Lotus japonicus*, which can be infected by both RKN and the compatible rhizobacterium *Mesorhizobium loti* (Fig. 2). In addition, I'm also optimizing the experimental condition to screen for soil microbes that colonize plant roots.

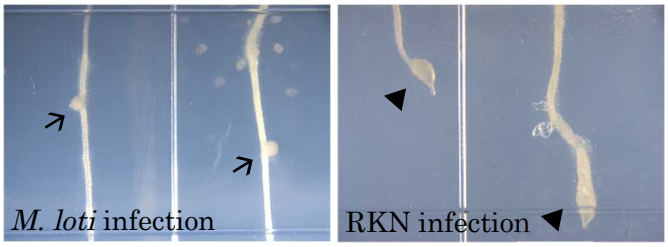


Fig. 2. *L. japonicus* infected with *M. loti* (left panel) and RKN (right panel). Arrows denote *M. loti* nodules, arrowheads denote RKN galls.

3. Prospect for further research collaboration with other university/institution

Currently we are working with Prof. Masayoshi Kawaguchi (National Institute for Basic Biology) on the propagation and handling of *L. japonicus* and *M. loti* experimental systems. In the future, pending on the direction of the research, we may rely on Prof. Kawaguchi to access *L. japonicus* and *M. loti* mutants with compromised root colonization. We also plan to collaborate with Dr. Bruno Favery (The Institut national de la recherche agronomique, France) and Prof. Carolina Escobar Lucas (University of Castilla-La Mancha, Spain) to access other species of plant-parasitic nematodes. Lastly, we are also open to collaboration with experts in microbiome genome sequencing and analysis.

4. Application plan of KAKENHI and other external grants

I am planning to apply for the Kakenhi Grant-in-Aid for Scientific Research (C) of FY2022. I am also open to contribute to joint grant applications where my research interests can coincide with broader topics.

[1]Tsai AY et al. (2019) Molecular Plant 12(1): 99-112
[2]Tsai AY et al. (2021) Plant Cell Physiol. pcab099
[3]Tsai AY et al. (2021) Science Advances 7(27): eabh4182
[4]Tsai AY et al. (2020) Frontiers in Plant Science 11: 1167

No.5-6	Development of novel highly processable super/high conducting materials composed of purely organic small molecules		
Name	Akira Ueda		
Affiliation Contact	Faculty of Advanced Science and Technology Email: aueda@kumamoto-u.ac.jp	Title	Associate Professor
Research Field	Chemistry, especially Physical Chemistry and Functional Materials Chemistry		

1. Overview and achievements

The development of superconducting or high-conducting materials is crucially important not only from the viewpoint of fundamental science but also from the viewpoint of practical applications for electronics. In particular, such materials composed of organic molecules are expected to have several unique features different from those of inorganic conductors, such as structural diversity of the component molecules and their aggregates and also high flexibility and processability of the materials themselves. However, this kind of highly processable high-conducting organic materials is limited to polymer-based ones; therefore, in this project, this researcher aims to develop a new type of highly processable super/high conducting materials composed of purely organic "small" molecules, to lead to a breakthrough in this research field and also to open a new possibility to create innovative science and technology for building a well-being society.

In FY2021, on the basis of his original molecular design strategy, this researcher has successfully developed three kinds of new conducting materials composed of purely organic small molecules and characterized them in the crystalline state as the first step. They are found to have unique structures different from those of the conventional organic conductors and to show sufficiently high electrical conductivity, which proves the novelty and originality of the present molecular design. A part of these results was reported in some academic conferences and now the research paper is in preparation (to be published in early 2022).

2. Significance of the research and progress status

The significance of this research is to challenge the establishment of a novel methodology for developing superconducting or high-conducting organic materials. The present practical superconductors are inorganic ones, such as Nb-Ti alloy and cuprates; in which there are some intrinsic problems, such as the rarity of the elements and the difficulty in the processing. On the other hand, organic materials are composed of the common elements and have some advantages against inorganics, such as light weight, flexible and highly processable, and thus are expected as promising candidates for the next-generation superconductors.

As described above, the research in FY2021 has successfully revealed that the molecular design strategy proposed by this researcher is promising to achieve the purpose of this project. The desired superconductivity and high processability are to be realized by further chemical modification in the near future.

3. Prospect for further research collaboration with other university/institution

This researcher has published more than 60 original papers in collaboration with a wide range of researchers in other universities/institutions including overseas ones (a recent example: *npj Quant. Mater.* **6**, 87, (2021)). Device fabrication and specialized physical measurements of the materials developed in this project will be performed in collaboration with them.

4. Application plan of KAKENHI and other external grants.

This researcher has received a JSPS KAKENHI (C) (FY2019–FY2022). On the basis of the above-mentioned research results, he will apply for JSPS KAKENHI (B) and also for PRESTO (Sakigake) and FOREST (Sohatsu) programs.

6. Start-up Program

for Formulation of Joint Research Hub by Crossing Departments

No.	Name	Project Title
6-1	**Shinya Hayami**	Construction of antiviral social and agricultural infrastructures based on nanomaterials
6-2	**Tetsuya Kida**	Valorization of “Blue Carbon” for Sustainable Well-Being
6-3	**Ruda Lee**	The Effect of Urban Forestry on Lung Health in Fine Dust Environment
6-4	**Yoshitaka Nakanishi**	The science of interactions, communications, and fusions in boundaries (FUREAI Science)

No.6-1	Construction of antiviral social and agricultural infrastructures based on nanomaterials		
Research Field(s)	Science Engineering Medical Pharmacy Others（ ）		
Coordinator			
Name	Shinya Hayami		
Affiliation	Faculty of Advanced Science and Technology Email: hayami@kumamoto-u.ac.jp	Title	Professor

Members		
Name	Title	Affiliation
Terumasa Ikeda	Associate Prof	The Joint Research Center for Human Retroviru
Yukie Takahashi	Researcher	IRCMS
Taiki Amagasaki	Prof	FAST
Shintaro Ida	Prof	IINa
Shinichiro Sawa	Prof	FAST

1. Overview and achievements

Nanomaterials have attracted attention as a source of innovation in various fields, and by combining nanotechnology and biotechnology, nanomaterials with unique physicochemical properties have shown remarkable advantages in the field of medicine. Recently, graphene oxide (GO) has attracted much attention due to its excellent biocompatibility and physicochemical properties. The GO nanosheets have tremendous potential as an innovative material because of their ability to skillfully combine the functions of the host layer, the nanosheet, with those of the interlayer guest species. With the thirst for innovation as a truly useful material, the use of nanosheets is becoming extremely valuable. The impact of various viruses on health has become a major social issue, and the development of antiviral materials that can meet social needs has been proposed, but the direction of practical application has yet to be determined. In addition, environmental problems are becoming more serious, and it is necessary to develop antiviral and environmental purification materials with a view to their true practical use. In this study, we focus on nanomaterials such as graphene oxide (GO) nanosheets and aim to develop true antiviral materials and establish an agricultural infrastructure by integrating materials chemistry, medicine, information science, and agriculture.

2. Prospects for the future and anticipated results

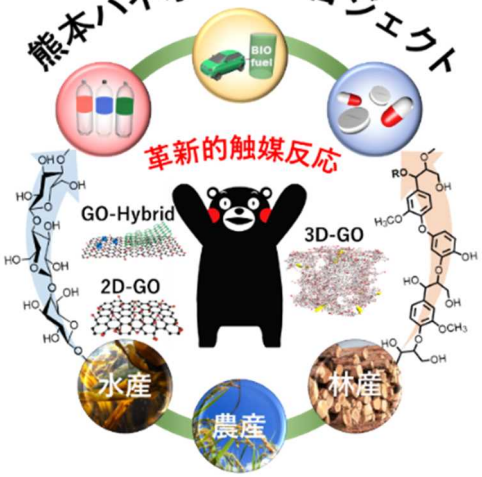
(1) Development of antiviral materials in GO and other nanomaterials
(2) Development of farm improvement materials in GO and other nanomaterials
(3) Confirmation and mechanism elucidation of antiviral activity of GO and its derivatives
(4) Feedback to the development of antiviral materials by materials informatics
(5) Establishment of society through antiviral and farm monitoring and management by AI

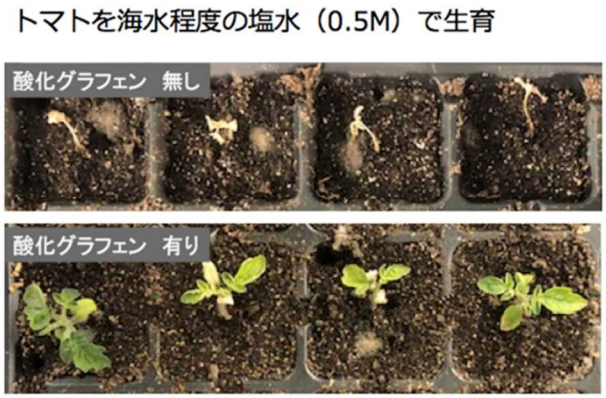
3. Application plan of KAKENHI and other external grants

We have not received any for this research project, but we plan to apply for large-scale projects from NEDO and JST in near future.

4. Possibility about an international collaboration with institutions and universities in abroad

Currently, preliminarily experiments are in progress and the research is limited to intra-group collaborations, but other research topics, such as biomass research, are being conducted in collaboration with Australia and the Philippines. In addition, this research needs to be developed globally, and global research development and collaboration will be conducted as the research progresses.





No.6-2	Valorization of “Blue Carbon” for Sustainable Well-Being		
Research Field(s)	Science Engineering Medical Pharmacy Others（Interdisciplinary）		
Coordinator			
Name	Tetsuya Kida		
Affiliation	Faculty of Advanced Science and Technology Email: tetsuya@kumamoto-u.ac.jp	Title	Professor

Members		
Name	Title	Affiliation
QUITAIN Armando	Professor	Headquarters for Admission and Education/Division for Promotion of Global Education
INOMATA Yusuke	Assistant Professor	Faculty of Advanced Science and Technology
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AHMAD Muhammad Sohail	Specially Appointed Assistant Professor	Faculty of Advanced Science and Technology
ASSABUMRUNGRAT Suttichai	Professor	Chulalongkorn University (Thailand)/Faculty of Engineering
AVISO Kathleen	Professor	De La Salle University (Philippines)/Faculty of Engineering
GOODFELLOW Ian	Professor	Cambridge University (UK)/Department of Pathology
HOSMILLO Myra	Research Associate	Cambridge University (UK)/Department of Pathology
LOTA Maria Margarita M.	Assistant Professor	University of the Philippines-Manila(Philippines)/Department of Medical Microbiology
DAYRIT Geraldine	Assistant Professor	University of the Philippines-Manila(Philippines)/Department of Medical Microbiology
PABLO Carol Geraldine	Assistant Professor	University of Santo Tomas (Philippines)/Department of Pharmacy
KOIKE Ursula	Professor	Headquarters for Admission and Education/Division for Promotion of Global Education
SIMS Lander	Lecturer	Headquarters for Admission and Education/Division for Promotion of Global Education
DEVKOTA Hari Prasad	Assistant Professor	Headquarters for Admission and Education
RICKARD Joshua	Associate Professor	Center for International Education

WANG Jincao	Lecturer	Center for International Education
AXT Alexander Florian	Assistant Professor	Center for International Education
CHOI Sangjin	Assistant Professor	Center for International Education

1. Overview and achievements

The existing general framework for scientific research normally begins with experimental work carried out in the laboratory, followed by long and tedious assessment stages for commercialization that also consider societal acceptance. In this way, most research output can take many years to be socially implemented, or in some cases, not fully utilized. This research will attempt to radically change this existing framework by carrying out interdisciplinary research covering technology and various societal aspects such as:

●social, cultural, political, history, science and technology, and education right from the initial stage of research, as we investigate the possibility of utilizing

●green technologies for sustainable coastal communities using “blue carbon” (carbon stored in coastal and marine ecosystems

In AY2021, we have initially explored the possibility of applying green technologies for producing platform chemicals from sugars obtained from seaweed polysaccharides, e.g., fucose, galactose and glucose. These will then be converted to biochemicals and biofuels to support sustainability of the coastal community and neighboring areas.

2. Prospects for the future and anticipated results

The scientific group will further work on the scientific and technological aspects of converting seaweeds into useful chemicals in the laboratory including analysis of the products, life cycle analysis and process integration. The medicine/pharmacy group will analyze the efficacy of the obtained chemicals on certain diseases or viruses. Simultaneously, the sociology/history/ politics group will assess the applicability of the technology by reaching out to the local community, and study the historical and socio-cultural aspects. Concerns and issues to the implementation of the technology such as political and environmental will also be considered. We will also propose ways to educate the stakeholders including students in the community.

The team will collaborate with various institutions overseas to broaden the assessment of the applicability of the approach. To keep the community informed, we will host forums to which we invite experts to share visions of how we might resolve the challenges in the local community.

3. Application plan of KAKENHI and other external grants

The following external grant applications were prepared and submitted in AY2021:

a. KAKENHI Grant-in-Aid for Challenging Research (Exploratory) AY2022~AY2023
b. JST e-ASIA Project (SICORP) AY2023~AY2025

4. Possibility about an international collaboration with institutions and universities in abroad

A memorandum of understanding for collaborative research has been initiated between Kumamoto University and the University of the Philippines-Manila. This connection with the University of the Philippines will further extend the network to other institutions such as Cambridge University

(UK) and University of Santo Tomas (Philippines).

Collaboration with a more extended network of top ASEAN universities can be further strengthened if the applied JST e-ASIA Project could be approved.

No.6-3	**The Effect of Urban Forestry on Lung Health in Fine Dust Environment**		
Research Field(s)	(Science) (Engineering) (Medical) Pharmacy Others( )		
Coordinator			
Name	Ruda Lee		
Affiliation	Institute of Industrial Nanomaterials Email: aeju-lee@kumamoto-u.ac.jp	Title	Associate Professor
Members			
Name	Title	Affiliation	
Woojin LEE	Research Associate	Kongju National University	
Jung Hoon CHOI	Professor	Kangwon National University	
Myeung Hee NAM	Principle Investigator	Korea Basic Science Institute	

1. Overview and achievements

One of our era's greatest scourges is air pollution, on account not only of its impact on climate change but also its impact on public and individual health due to increased morbidity and mortality. There are many pollutants that are major factors in disease in humans. Among them, Particulate Matter (PM 2.5), particles of variable but very small diameter, penetrate the respiratory system via inhalation, causing respiratory and cardiovascular diseases, reproductive and central nervous system dysfunctions, and cancer. From an environmental perspective, urban forests tend to enhance regional biodiversity, mitigate stormwater management demands, and improve air quality. The only way to tackle this problem is through public awareness coupled with a multidisciplinary approach by scientific experts. This research unit performs interdisciplinary research among engineers, scientists, and veterinarians for suggesting ways how to protect lung health under air pollution circumstances and prevent the production of fine dust. We demonstrated that phytoncide reduced lung inflammation after or before treatment.

2. Prospects for the future and anticipated results

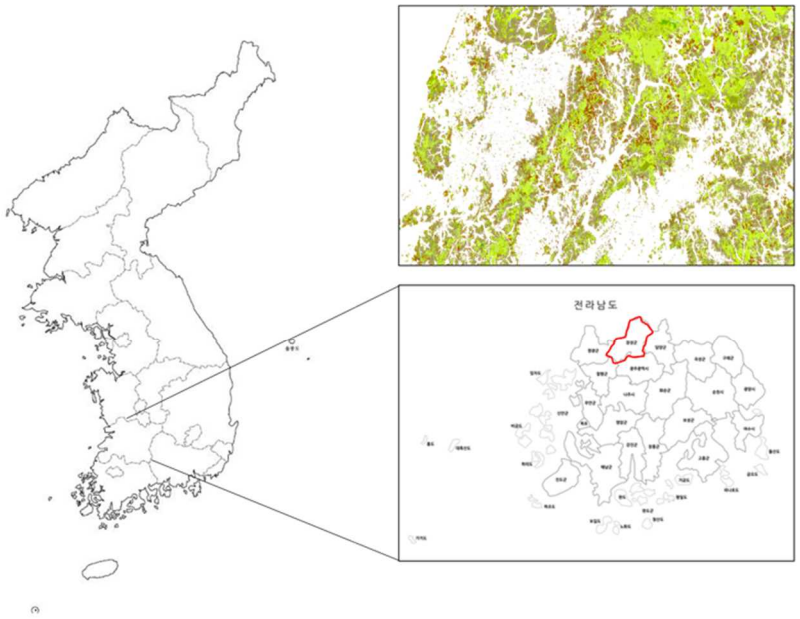
This research was the first discussion between inflammation and phytoncide in animal lung inflammation models. We will search how to act the phytoncide under the fine dust air pollution based on the result. Phytocide will be purified from Cypress and confirmed as the ingredient by LC/MS and NMR. We will set up an acceptable dust-related lung disease model and test the protective effect of phytoncide. The treatment effect will be confirmed in lung tissues and blood and bronchoalveolar lavage fluid (BALF) by LC/MS. Currently, we start to prepare manuscripts for publication with previous results of phytoncide in the environmental science engineering field.

3. Application plan of KAKENHI and other external grants

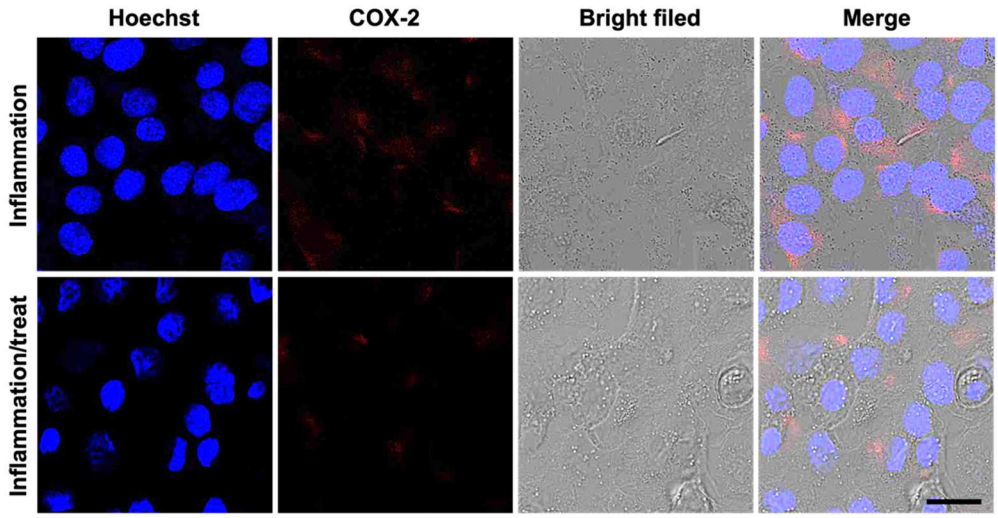
We have a plan to apply Bilateral grant between Japan and Korea in FY2022. Also, Dr. Woojin Lee will apply for the Sejong fellowship in FY2022 based on this research outcome.

4. Possibility about an international collaboration with institutions and universities in abroad

\ Seoul National University has special devices for fine dust research, so we have plan to expand collaboration in FY2022. Furthermore, the relation between air pollution and child welfare will be researched with Department of Civil engineering, BAUHOUS, Germany in the future.



The largest Chamaecyparis obtusa (hinoki) area in Korea



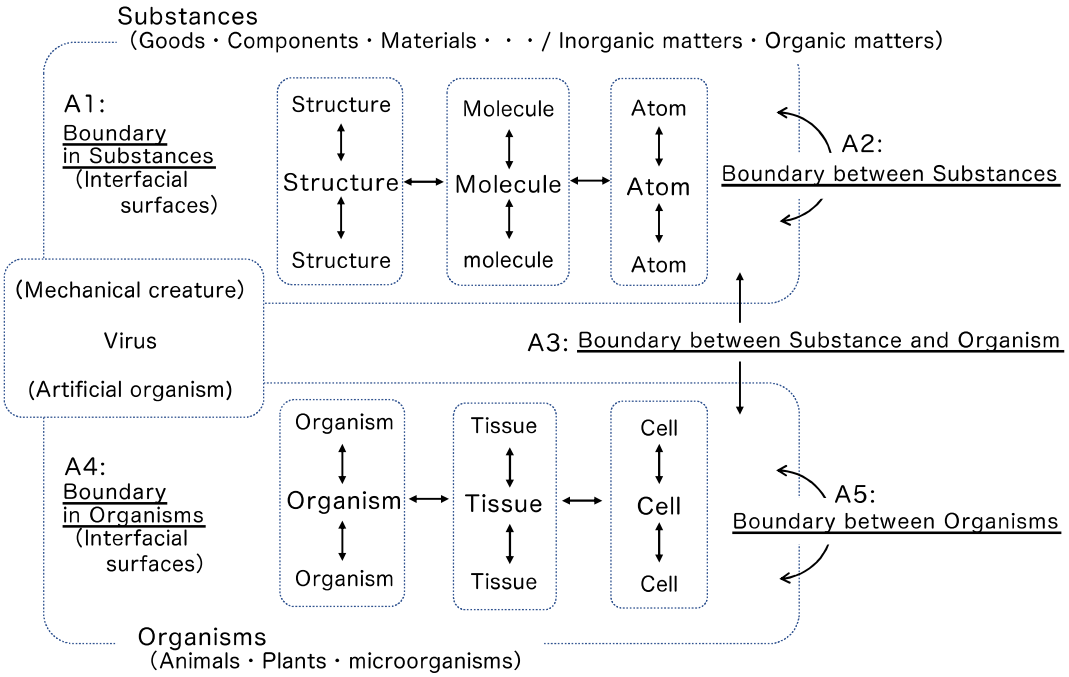
Representative images of anti-inflammation effects of Phytoncide in human pulmonary endothelial cell.

No.6-4	The science of interactions, communications, and fusions in boundaries (FUREAI Science)		
Research Field(s)	[Science] [Engineering] [Medical] Pharmacy Others( )		
Coordinator			
Name	Yoshitaka Nakanishi		
Affiliation	Faculty of Advanced Science and Technology Email: y-naka@mech.kumamoto-u.ac.jp	Title	Professor

Members		
Name	Title	Affiliation
Kei Toda	Professor	Faculty of Advanced Science and Technology
Yoshihiro Komohara	Professor	Faculty of Life Sciences
Yuta Nakashima	Associate Professor	Faculty of Advanced Science and Technology
Yukio Fujiwara	Lecturer	Faculty of Life Sciences

1. Overview and achievements

"FUREAI Science," which is the science of interactions, communications, and fusions in boundaries, was launched by the joint research hub. "FUREAI" in Japanese includes various meanings, including physical/sensory/emotional interactions, communications, and fusions observed in multiscale of substance–substance/organism–organism/substance–organism.

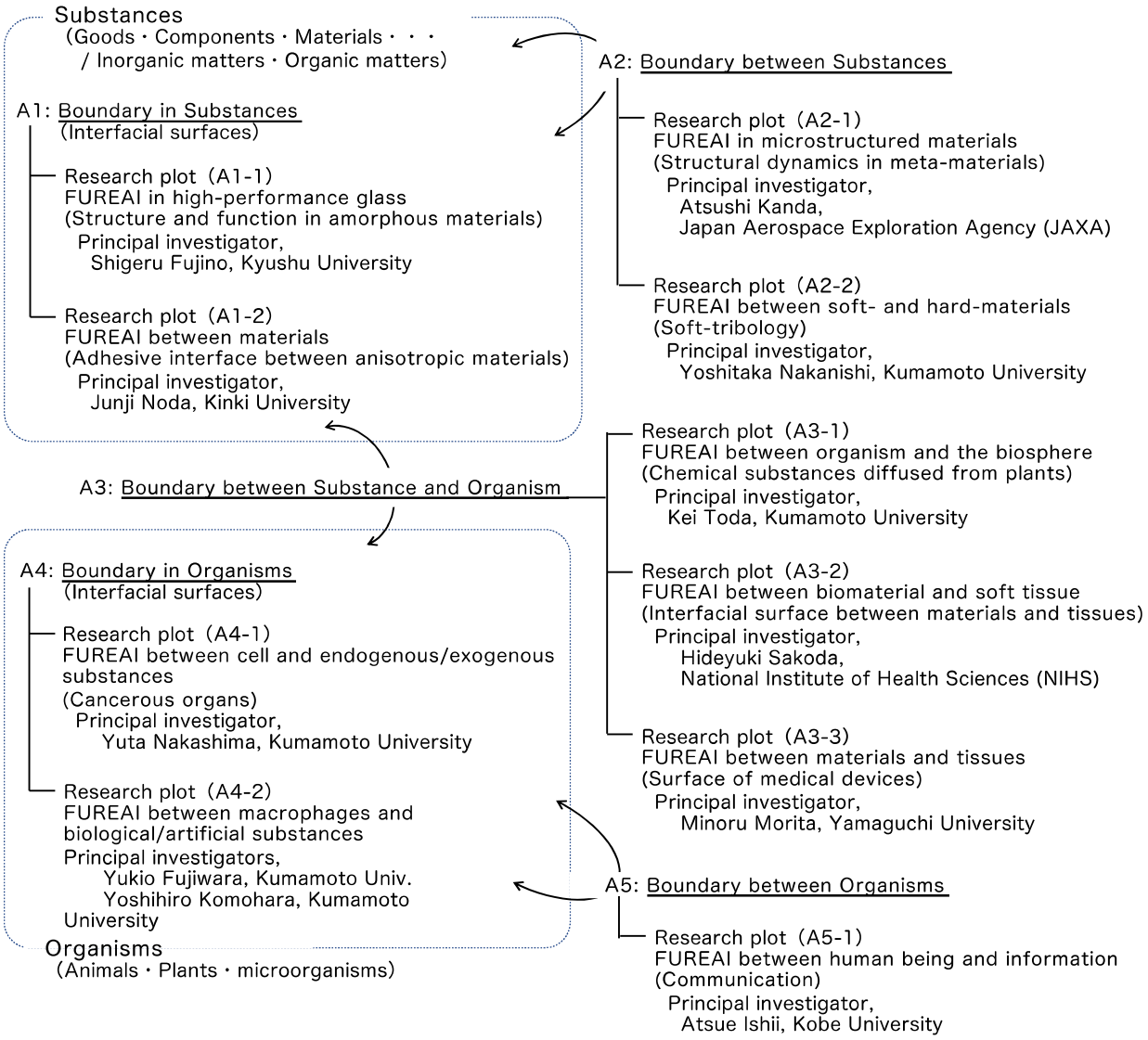


The sciences for interactions, communications and fusions in boundaries (FUREAI Science)

Researchers with different areas of expertise explain various phenomena through “the FUREAI Scientific method.” The wide range of topics proposed by the researchers stimulate scientific discussions. New ideas and approaches are revealed in these discussions, thus creating transformative research areas.

2.Prospects for the future and anticipated results

Currently, the joint research hub comprises 10 principal investigators. The headquarters is located in Kumamoto University. Although a huge organization has been established, the FUREAI Science method enables smoother communication between the principal investigators. The joint research hub has already produced several new frontier research plots.



3.Application plan of KAKENHI and other external grants

The joint research hub is currently preparing applications to Grant-in-Aid for Transformative Research Areas (A).

4.Possibility about an international collaboration with institutions and universities in abroad

Each principal investigator in the joint research hub has already launched or prepared academic research activities. The list below presents the collaboration with international institutions and universities.

Institution or University	Agreement
Chinese Academy of Sciences, China	Memorandum of understanding
Dalian University of Technology China	Academic exchange agreement Student exchange agreement
Uniersitas Brawijaya Indonesia	Academic exchange agreement Student exchange agreement
The University of Adelaide Australia	
The University of New South Wales Australia	
University of Pennsylvania USA	
University of Pittsburgh USA	
University of Twente The Netherlands	Academic exchange agreement
University of Groningen The Netherlands	
University of Bretagne-Sud France	
Gazi University Turkey	Academic exchange agreement Student exchange agreement
Kankiri Karatekin University Turkey	Academic exchange agreement Student exchange agreement

7. IROAST Young Internship Researchers

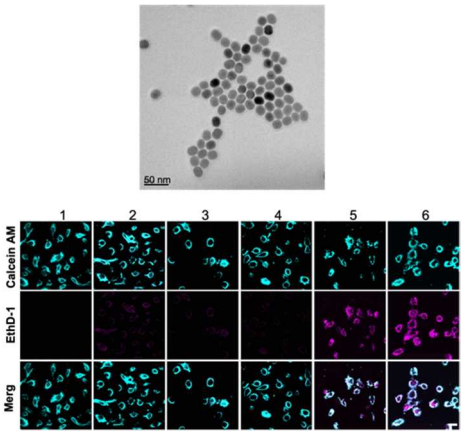
No.	Name	Project Title	Acceptance period
7-1	**Venkata Nanda Kishor Babu Adusumalli**	Multifunctional upconversion nanoparticles for imaging and treatment of Parkinson's disease	2021.09.01-2021.10.27
7-2	**Min Soo Kang**	Development of Biodegradable Drug delivery Nanoparticle based Poloxamer	2021.09.01-2021.10.27
7-3	**Woojin Lee**	Urban Planning for Lung Health in the Post-Corona Era	2021.09.01-2021.10.27
7-4	**Yue Wen**	Seismic design of resilient concrete structures under long-period ground motion	2022.01.17-2022.02.18
7-5	**Fuchao Zhao**	Seismic Design and FEM simulation of Demountable Precast RC Wall Structures	2022.01.17-2022.02.25
7-6	**Wei Liu**	The bond performance mechanism of the composite layer–original concrete interface under the main aggressive environment	2022.01.20-2022.02.18
7-7	**Yunjian He**	Bond performance between carbon fiber reinforced polymer bars and ultra-high-performance concrete	2022.01.20-2022.02.25
7-8	**Chenggong Cai**	Study on Oxygen Diffusion of Eco Concrete subjected to Loads	2022.01.31-2022.02.21

No.7-1	Multifunctional upconversion nanoparticles for imaging and treatment of Parkinson's disease		
Name	Venkata Nanda Kishor Babu Adusumalli		
Affiliation	School of Chemical Engineering, Chonnam National University, Republic of Korea Email: kishor.adusumalli8@gmail.com	Title/ Status	Postdoctoral Fellow
Research Field	Advanced Green Bio		
Period of Internship	September 1, 2021 - October 27, 2021		
Host Professor	Ruda Lee		
Affiliation	IROAST Email: aeju-lee@kumamoto-u.ac.jp	Title	Associate Professor

To use the 800 nm NIR as an excitation source, I tried to synthesize Nd^{3+}-doped upconversion nanoparticles (UCNPs) by the thermal decomposition method. To minimize non-fluorescent self-quenching between Nd^{3+} ions and lanthanides ions (e.g., Yb^{3+}, Er^{3+}), I designed core-shell structured nanoparticles. The core is Yb^{3+} and Er^{3+}-codoped $NaYF_4$ that emits green and red emission by 980 nm NIR excitation. The shell is Nd^{3+}-doped $NaYF_4$ that will absorb 800 nm NIR photons then transfer the energy into Yb^{3+} ions to activate upconversion luminescence. As a target iron (Fe^{3+})-recognizing component, the organic dye will be designed and synthesized. The organic dye will absorb 800 nm NIR light, but it will not transfer the energy to the Nd^{3+} ions resulting in no upconversion luminescence. In the presence of the target, the organic dye will transfer the energy of the absorbed NIR photons into the Nd^{3+} ions resulting in upconversion emission.

Previously, my research focused on the synthesis of UCNPs, optimization for PL efficiency improvement, and characterization of optical properties. I learned that functional nanomaterials can be applied to various biomedical applications.

Because this internship was conducted online due to COVID-19, only limited research experience is possible. Of course, regular online meetings with Prof. Lee have been very helpful to me, but if there is an opportunity in the future, I would like to utilize my nanomaterials developed in Korea to cell and animal models in Prof. Lee's laboratory in Kumamoto University.



No.7-2	Development of Biodegradable Drug delivery Nanoparticle based Poloxamer		
Name	Min Soo Kang		
Affiliation	Dept. of Anatomy, College of Veterinary Medicine, Kangwon National University Email: imkangms@kangwon.ac.kr	Title/ Status	Ph.D Candidate
Research Field	Advanced Green Bio		
Period of Internship	September 1, 2021 - October 27, 2021		
Host Professor	Ruda Lee		
Affiliation	IROAST Email: aeju-lee@kumamoto-u.ac.jp	Title	Associate Professor

Engaged Tasks During Internship periods

Date	Weeks	Engaged tasks
2021. 9. 1 ~ 2021. 9. 22	1st week - 3rd week	Poloxamer-PhoB synthesis, Set up NPs synthesis condition
2021. 9. 23 ~ 2021. 10. 14	4th week - 6th week	Ischemic cellular model imaging, western blot, real-time PCR
2021. 10. 15 ~ 2021. 10. 27	7th week – 8th week	NPs shipping for animal test, Figure arrangement

1. Detail activities per week

1st week: (2021. 9. 1 ~ 2021. 9. 7)

- Preparation materials for manufacturing of appropriate PLGA concentration

2nd week (2021. 9. 8 ~ 2021. 9. 15)

- preparation for manufacturing of appropriate Poloxamer-Rho B concentration
- Starting manufacturing Poloxamer-Rho B synthesis.

3rd week (2021. 9. 16 ~ 2021. 9. 22)

- Manufactured NPs synthesis under the several conditions
- The decision of suitable manufacturing condition for Poloxamer-Rho Bsynthesis,

4th week (2021. 9. 23 ~ 2021. 29)

- Confirmation of manufactured Poloxamer-Rho B NPs stability

5th ~ 6th weeks. (2021. 9. 30 ~ 2021. 10. 14)

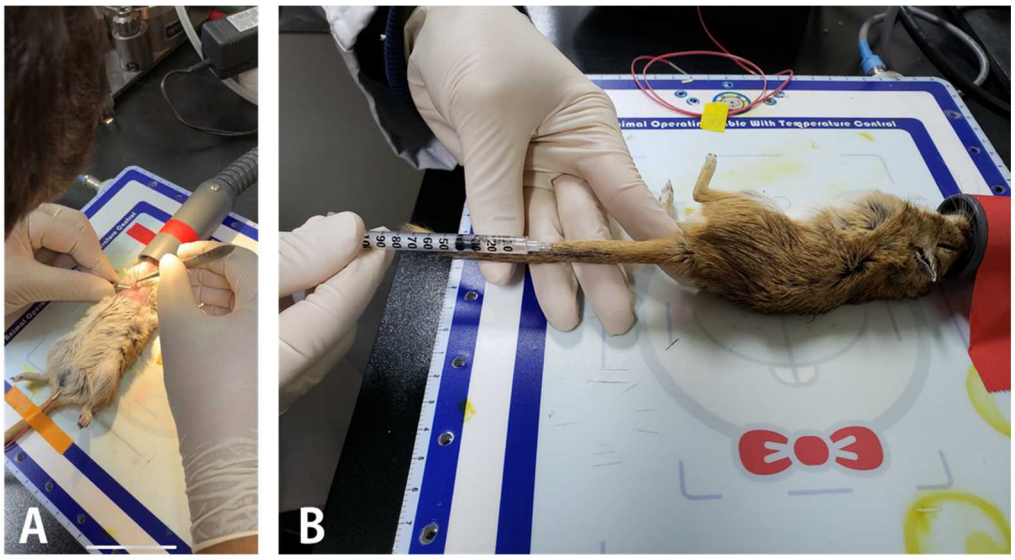
- Setup the in vitro ischemic cellular model under several conditions.
- Application of manufactured Poloxamer-Rho BNPs to analyze intracellular uptake and toxicity
- Confirmation of intracellularization of Poloxamer-Rho B NPs using fluorescent imaging.

7th week (2021. 10. 15 ~ 2021. 10. 21)

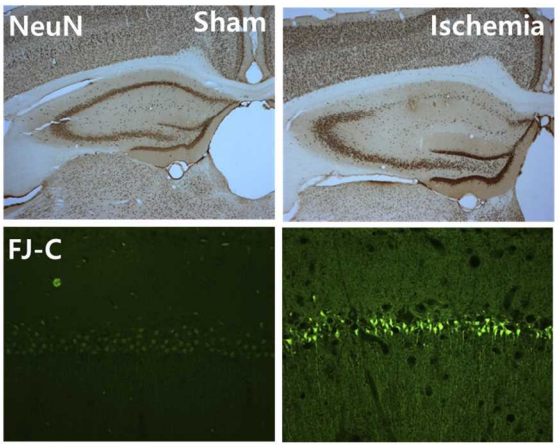
- Set up the ischemic animal models and application of Poloxamer-Rho B NPS intravenous injection via tail vein

8~9th weeks: (2021. 10. 22 ~ 2021. 10. 27)

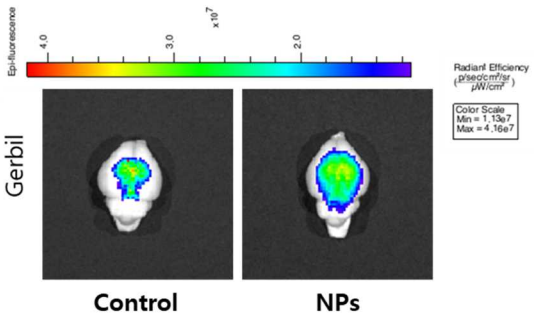
- Sacrificed animals and made cryoprotected brain tissue for analysis of distribution ischemic brain structures
- Histological analysis of toxicity on the major organs
- Preparation of IROAST Internship Program final report



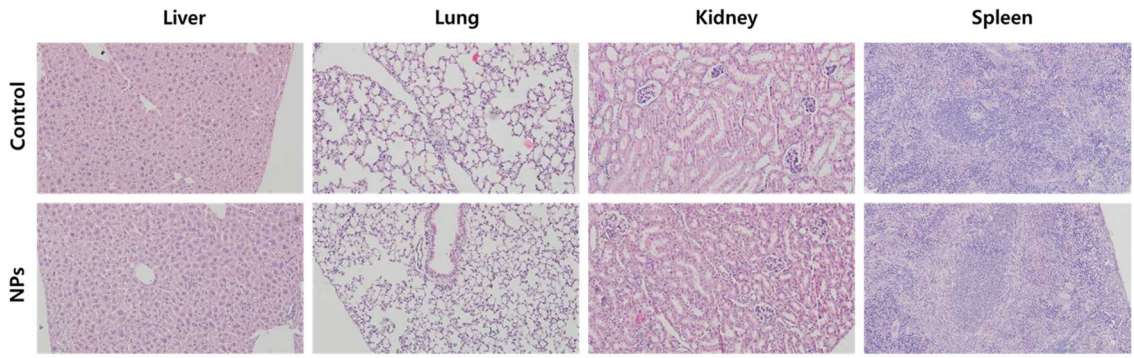
A, Induction of brain Ischemia. B, Intravenous injection via tail vein



Histological analysis of Ischemic brain



Distribution of Poloxamer-Rho B NPs in the ischemic brain



Histological toxicity analysis of Poloxamer-Rho B NPs in the ischemic gerbil model after Poloxamer-Rho B NPs injection

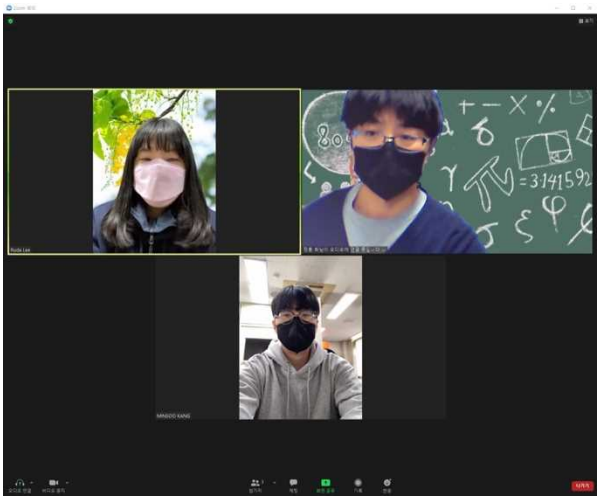
2. Future research plans

I. Further immunohistological analysis of ischemic brain
- Astroglial changes after Poloxamer-Rho B NPs injection
- Microglial changes after Poloxamer-Rho B NPs injection

II. Further development of NPs using the various size of poloxamers

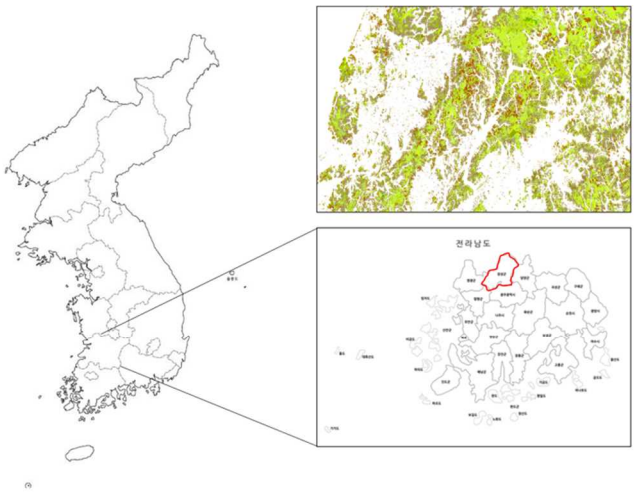
III. Development of drug delivery system using the Poloxamer-Rho B NPs for protection of brain ischemic condition and therapy

Prof. Lee and my supervisor, Prof. Choi are closely collaborating for brain disorder diseases. We have a plan to load drugs inside the Poloxamer NPs and track the therapeutic efficacy. The paper will be submitted in 2022 to the top 5% brain disease journal.

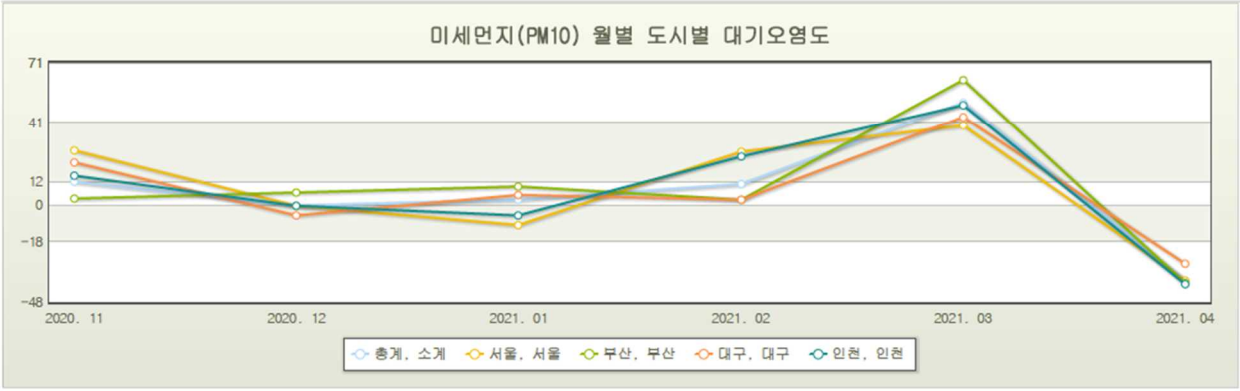


No.7-3	Urban Planning for Lung Health in the Post-Corona Era		
Name	Woojin Lee		
Affiliation	Department of Urban Convergence System Engineering, Kongju National University Email: mocksha@naver.com	Title/ Status	Research Associate (Post Doctor)
Research Field	Advanced Green Bio		
Period of Internship	September 1, 2021 - October 27, 2021		
Host Professor	Ruda Lee		
Affiliation	IROAST Email: aeju-lee@kumamoto-u.ac.jp	Title	Associate Professor

For selecting the research era, I searched the Korea Statistical Office website. As a result, I found that Janseong city has the largest Hinoki forest in Korea. We already know that phytoncide is good for mental health and anti-bacteria. However, there is no research on the benefit of urban forest in post-corona. We performed big data analysis as well as got scientific prove for enhancing research quality.



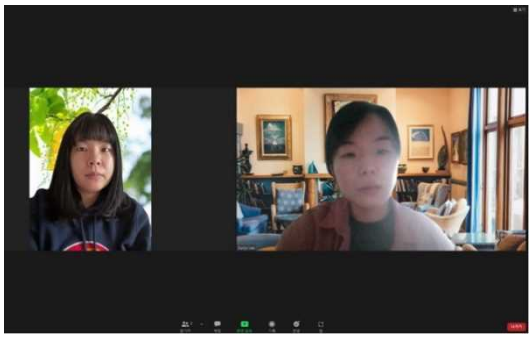
The largest Chamaecyparis obtusa (hinoki) area in Korea



Monthly fine dust changes in the big cities at Korea

As my research field is far from Prof. Lee's field, it was hard to understand each other. For example, the research size was big differences. Prof. Lee's research is focused on small-size materials, meanwhile, I am concerning the national scale. In the beginning, we thought of different directions for the subject. During the internship period, we had a zoom meeting every week and keep closely discussing the project. Finally, we decide the most proper area in Korea and start to search the relation between urban forest and lung health. For that, I and an Otolaryngologist analyze big data from Korea Statistical Office. It was a good chance to understand different research fields and perform real interdisciplinary research.

In the present, environmental issues are important all around the world. So, interdisciplinary research collaboration is mandatory. I will stay at University as an Assistant Professor. I took the first step with Prof. Lee. This research will be an example of medicine and environmental engineering can make synergy for Well-Being Society.



No.7-4	Seismic design of resilient concrete structures under long-period ground motion		
Name	Yue Wen		
Affiliation	Nanjing University of Science and Technology Email: 2575376822@qq.com	Title/ Status	Graduate Student
Research Field	Environmental Science		
Period of Internship	January 17, 2022-February 18, 2022		
Host Professor	Gaochuang Cai		
Affiliation	IROAST Email: cai@kumamoto-u.ac.jp	Title	Associate Professor

1. Research Background

Nowadays, earthquakes are more and more frequent, for instance, the 1995 Kobe earthquake, the 2008 Sichuan earthquake, and the 2011 Eastern Japan earthquake [1,2]. The most important thing in the structural seismic design is that the structural system must contain sufficient ductility and energy-absorption capacity to withstand large seismic forces [3]. As very commonly used seismic structures, reinforced concrete (RC) structures are widely used in Japan. To ensure that these structures have sufficient seismic capacity, ductile RC structures have been widely accepted in the past 40-50 years. Because such a structure can usually resist earthquakes effectively, ensuring that the structures do not collapse during the earthquake. However, recent research trends show that not only the collapse resistance of the structures is concerned, but the repairability of the structures at post-earthquake is also important. This is because it involves the post-earthquake restoration of the structure and the reconstruction of the earthquake-affected area, not only in terms of time but also in terms of cost.

However, in the post-earthquake field surveys of the major earthquakes, I mentioned above, many RC structures have large residual deformations after the earthquakes. These will not only increase the maintenance and repairing cost of the building, but also make it more difficult to obtain faster disaster restoration and reconstruction. After a strong earthquake, because the damage is unpredictable [4], how to repair the building structures is also a big problem, usually, such a structure will be demolished. This causes a waste of resources. Therefore, as for structural seismic design, the research trends are to make the buildings maintain serviceability without large residual deformations even after being subjected to strong earthquakes.

2. Tasks of the internship

We began this internship on 2022/01/21, there is a kickoff meeting to explain the details of the program.

In the first week, I did the literature investigation on resilient concrete structures, which is to outline the review, understand the key to the resilience of RC structure and understand the concepts of resilient concrete, seismic and stress-hardening.

Then in the second week, I did the literature review of how to control the residual displacement of the structures at post-earthquake, which is mainly to summarize the methods to control the residual displacement-stressing technology, de-bonding tech, and low-bond-high strength steel rebars.

After that, in the third and fourth weeks, I investigated the current research results and comment on the technologies to assess the methods and comparison analysis.

3. Results

3.1 Outline of the literature review

The structure will be as follows:

1. Introduction

Current technology

- self-centering capability /drift hardening
- previous research overview

2. Reinforcements

2.1 PC technology and PT tendons

2.2 De-bonding of steel reinforcement

(1) complete de-bonding

(2) partly DB

2.3 FRP rebars

2.4 Self-centering reinforcement

2.5 High-performance materials-SMA reinforcement

2.6 Hybrid approach

3. Concrete (only control the damage, possible)

4. External confinement and resistance

5. Others

3.2 Methods to control the residual displacement of the structures

Pre-stressing technology

3.2.1 Cast-in-place concrete approach

3.2.2

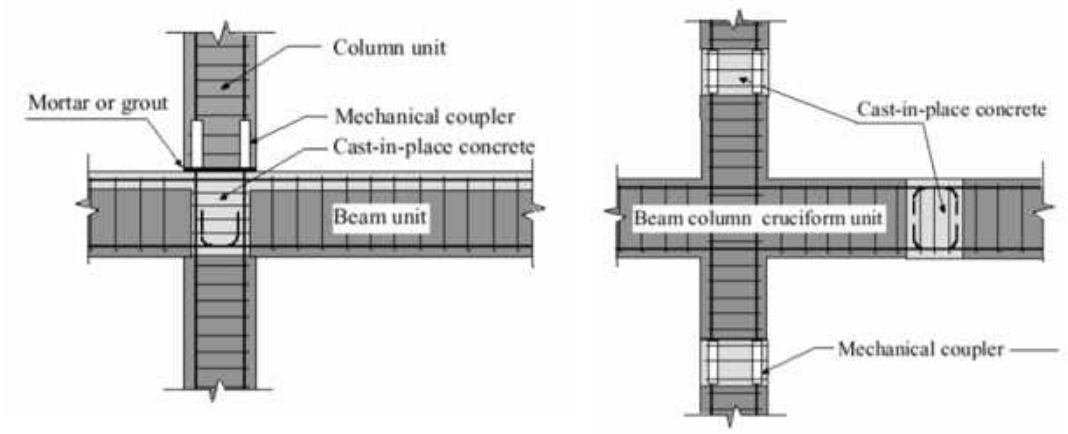


Fig 3-1 Cast-in-place concrete approach

3.2.3 Jointed ductile and hybrid systems

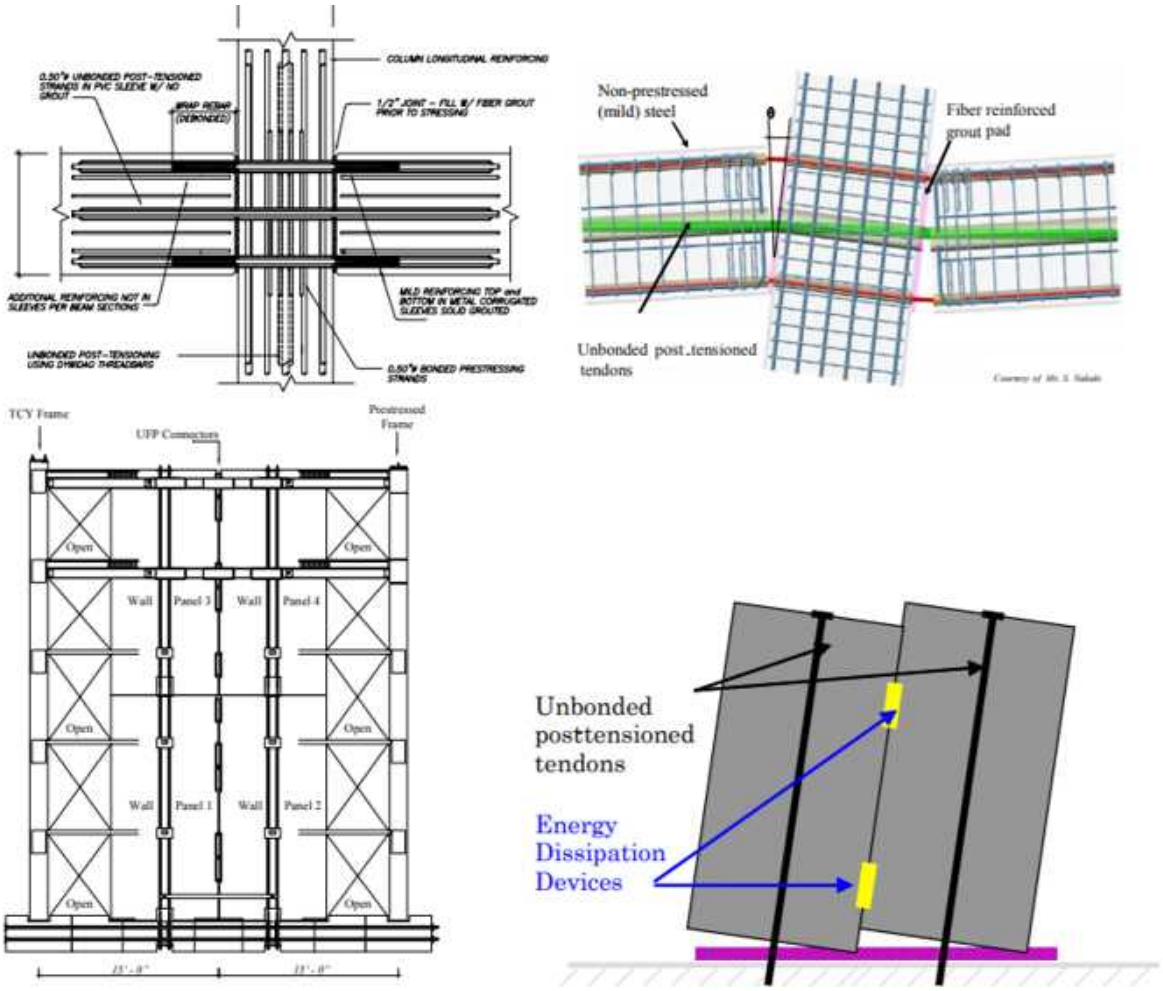


Fig3-2 Jointed ductile and hybrid systems

De-bonding tech

Bonding is a preferred method compared to drilling process steps for riveting or screwing since it allows the transfer of forces during load without degrading the fibers.

Advantages	Disadvantages
Load distribution	Temperature limit
Bonding of fragile materials	Ageing
Bonding of materials of different kind	Reliability
Bonding of thin materials	Sensibility to the environment depending of the
High resistance	type of adhesive
Retains shape	Surface pre-treatment
Flexibility of conception	Price?
Reduction of the number of pieces	Time of preparation
Water tightness / air tightness	Non destructive tests
Aesthetic	Separation of the parts for repair, rework or recycling
Vibration absorption	
Protection against corrosion	
Electric and thermal insulation	

Three main ways can be combined to modify the bonding joint in order to obtain a debonding property. The first way is to modify the interface substrate/adhesive. The second way is to modify the chemical structure of the adhesive, so that after a trigger, mostly temperature, the crosslinking step is "reversed". The last method is to add in the adhesive reactive fillers that will attack or destroy the adhesive after triggered activation.

3.3 Current research results on the technologies

3.3.1 Motivation of High-Performance DRSRS Systems

For the sake of protecting the lives of the occupants, structures are typically designed for “life-safety” performance according to the most modern building codes and are expected to undergo significant structural or nonstructural damage referred to as residual deformation during a severe earthquake.

3.3.2 Basic Principles and Methodology of High-Performance DRSRS Systems

The conventional seismic resisting structural system undertakes two responsibilities simultaneously

3.3.2.1 resisting the earthquake force through strong stiffness (energy dissipation devices)

3.3.2.2 dissipating the earthquake energy through inelastic buckling or yielding of longitudinal bars and crushing of concrete at compression zone (base isolation)

3.3.3 Replaceable Structural Elements

3.3.3.1 Bridge Engineering Structure

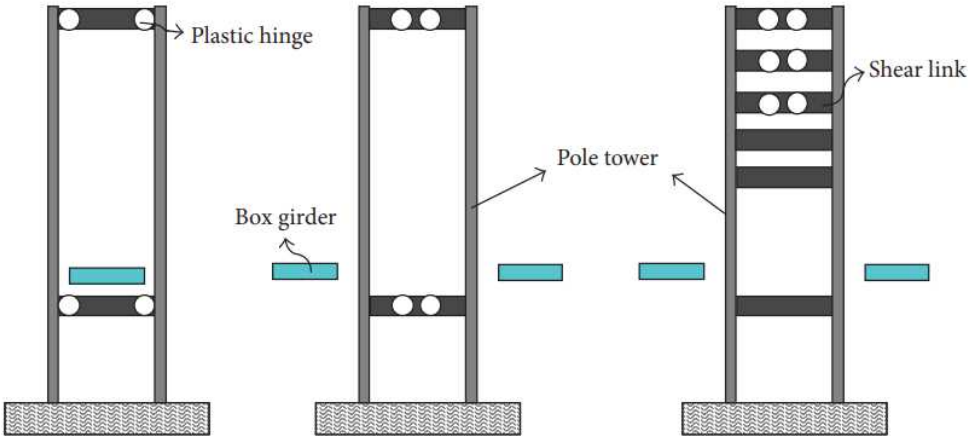


Fig3-3 Bridge Engineering Structure

3.3.4 Coupling Beam of Shear Wall System

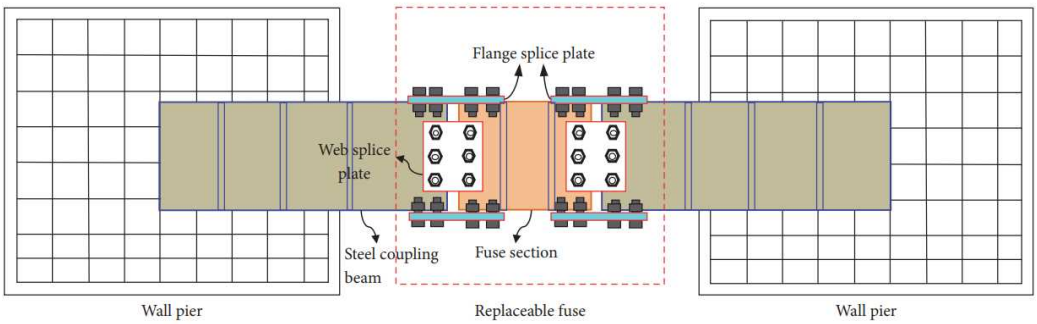


Fig3-4 Coupling Beam of Shear Wall System

3.3.5 Frame Structural System

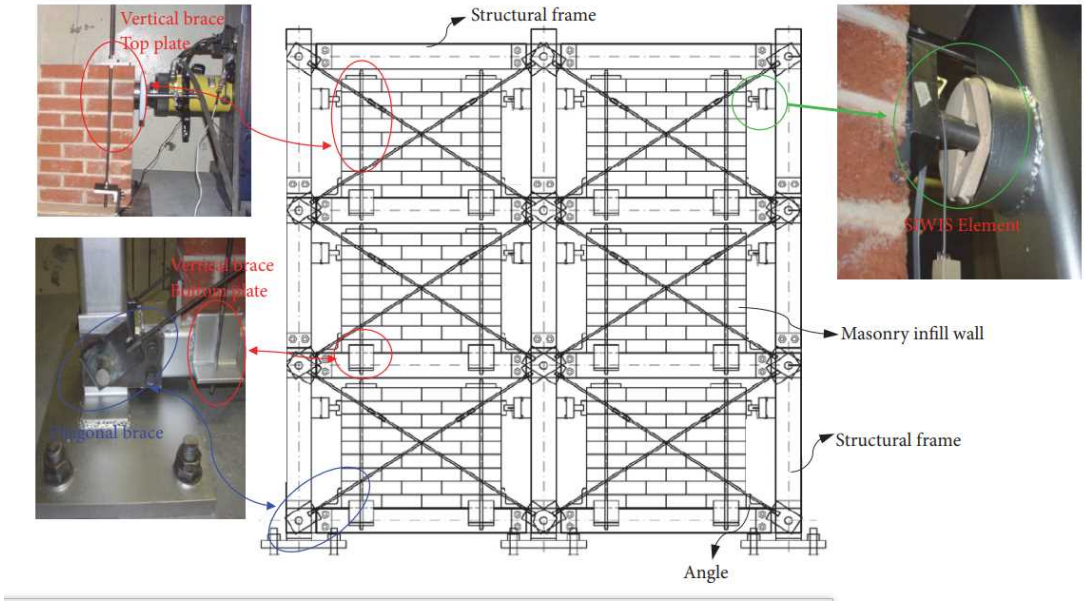


Fig3-5 Frame Structural System

3.3.6 Rocking Seismic Resisting Structural Systems

1. Rocking Bridge Pier Structure
2. Rocking Concrete Frame System
3. Rocking Steel Frame System
4. Rocking Concrete Shear Wall System
5. Rocking Masonry Structural Wall System

3.3.7 Self-Centering Seismic Resisting Structural Systems

3.3.7.1Self-Centering RC Frame System

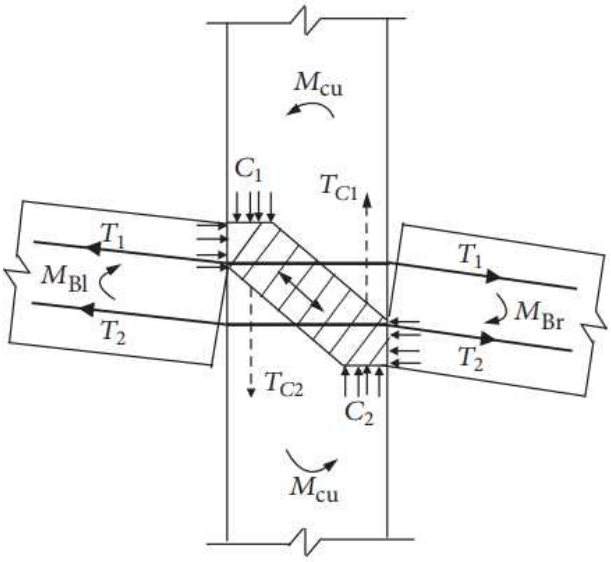


Fig3-6 Self-Centering RC Frame System

3.3.7.2 Self-Centering RC Shear Wall System

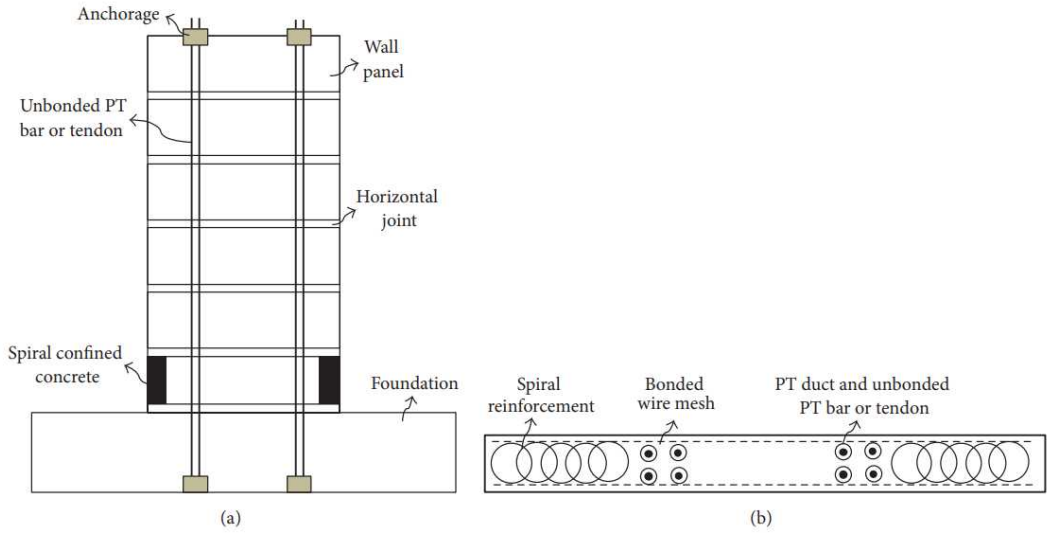


Fig3-7 Self-Centering RC Shear Wall System

3.3.7.3Self-Centering Steel Frame System

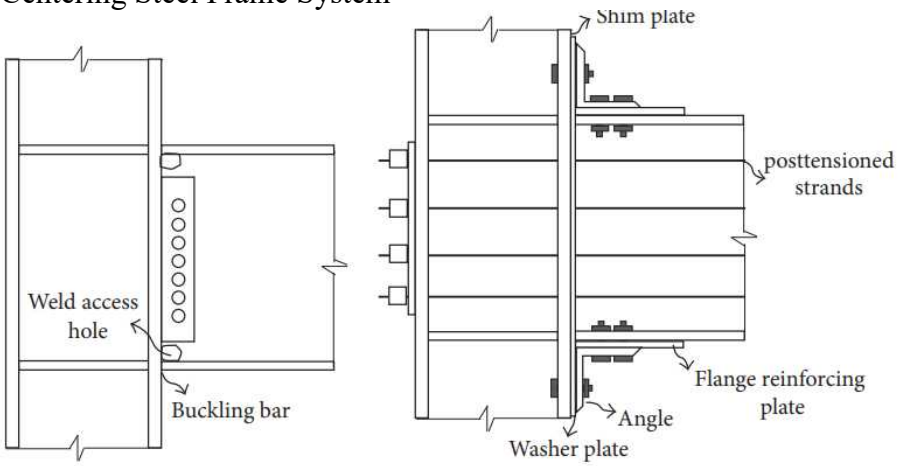


Fig3-8 Self-Centering Steel Frame System

3.3.7.4 Self-Centering Masonry Structural Wall System
3.3.7.5 Self-Centering Timber Structural System
3.3.7.6 Self-Centering Bridge Pier Structural System

3.3.8 Analysis and Design Seismic Behavior of DRSRS System

3.3.9 Current Research Challenges in High-Performance DRSRS Systems

4. Achievement

A literature review paper will be submitted to the Journal of Building Engineering (Q1, IF 5.318) based on this internship, which will be entitled "Self-centering concrete structures-the state of the art".

5. Future Research Plan

Firstly, the paper of the literature review will be published in June this year based on the tasks which have been engaged in during this internship.

Then after that, I will do a series of experiments at Kumamoto University about resilient concrete structures. The material and structure experiments will be conducted under multiple cyclic loads, and the constitutive models will also be established.

After that, based on the constitutive models the finite elements will be established. The time-history analysis of structures will be conducted.

According to all the research, two purposes will be achieved. The first one is to develop a resilient structure of concrete columns with ultra-high-strength materials. The second one is to optimize the structural design and member usage.

Reference

1]. Takeuchi, T., Sun, Y., Tani, M., & Shing, P. S. B. (2021). Seismic Performance of Concrete Columns Reinforced with Weakly Bonded Ultrahigh-Strength Longitudinal Bars. *Journal of Structural Engineering*, *147*(1), 04020290.

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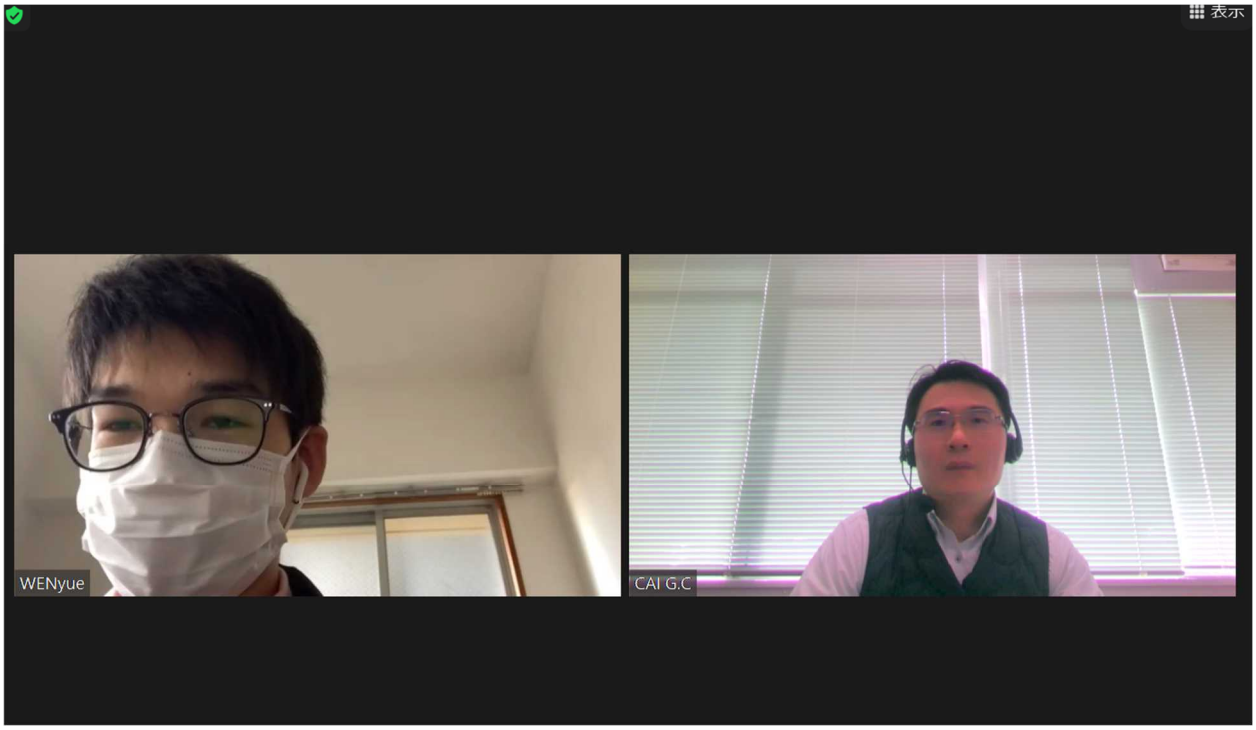
Appendix

The following photos show what the internship looked like at that time.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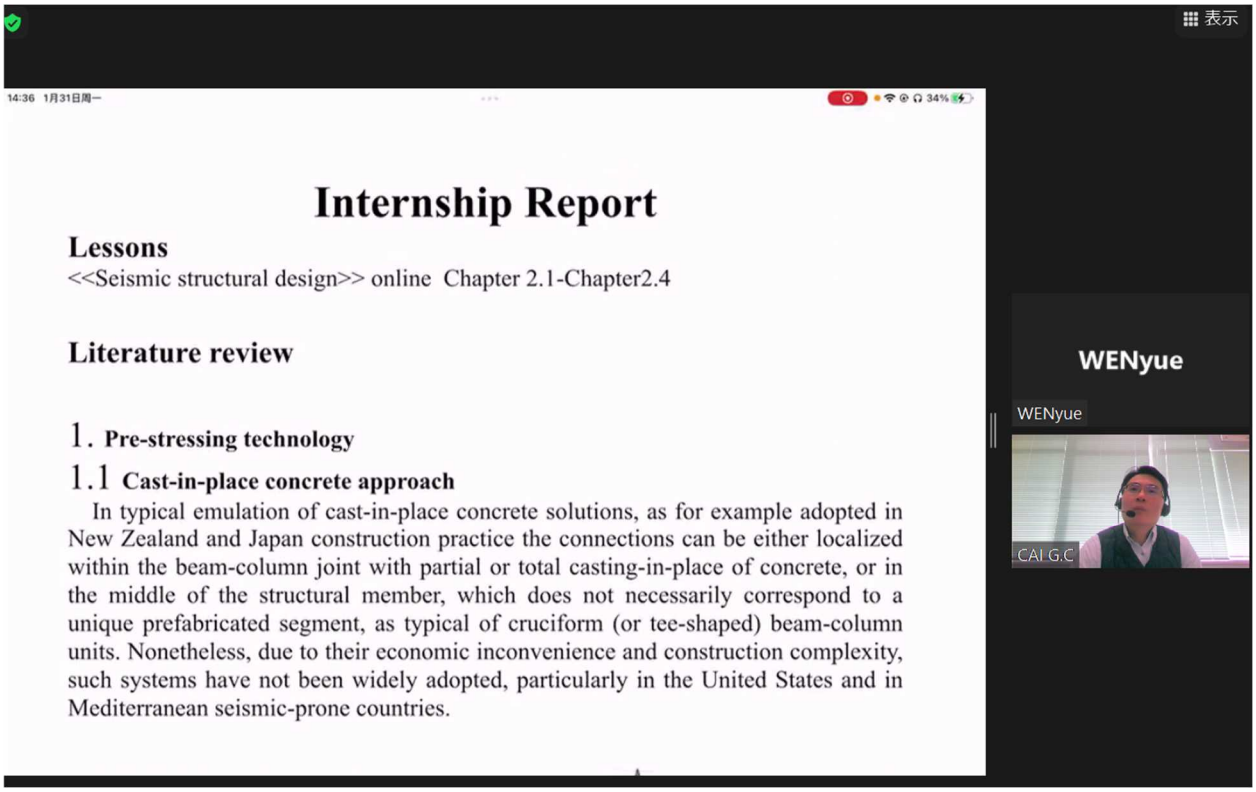
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Internship Report
Lessons
<<Seismic structural design>> online Chapter 2.1-Chapter2.4
Literature review
1. Pre-stressing technology
1.1 Cast-in-place concrete approach
In typical emulation of cast-in-place concrete solutions, as for example adopted in New Zealand and Japan construction practice the connections can be either localized within the beam-column joint with partial or total casting-in-place of concrete, or in the middle of the structural member, which does not necessarily correspond to a unique prefabricated segment, as typical of cruciform (or tee-shaped) beam-column units. Nonetheless, due to their economic inconvenience and construction complexity, such systems have not been widely adopted, particularly in the United States and in Mediterranean seismic-prone countries.
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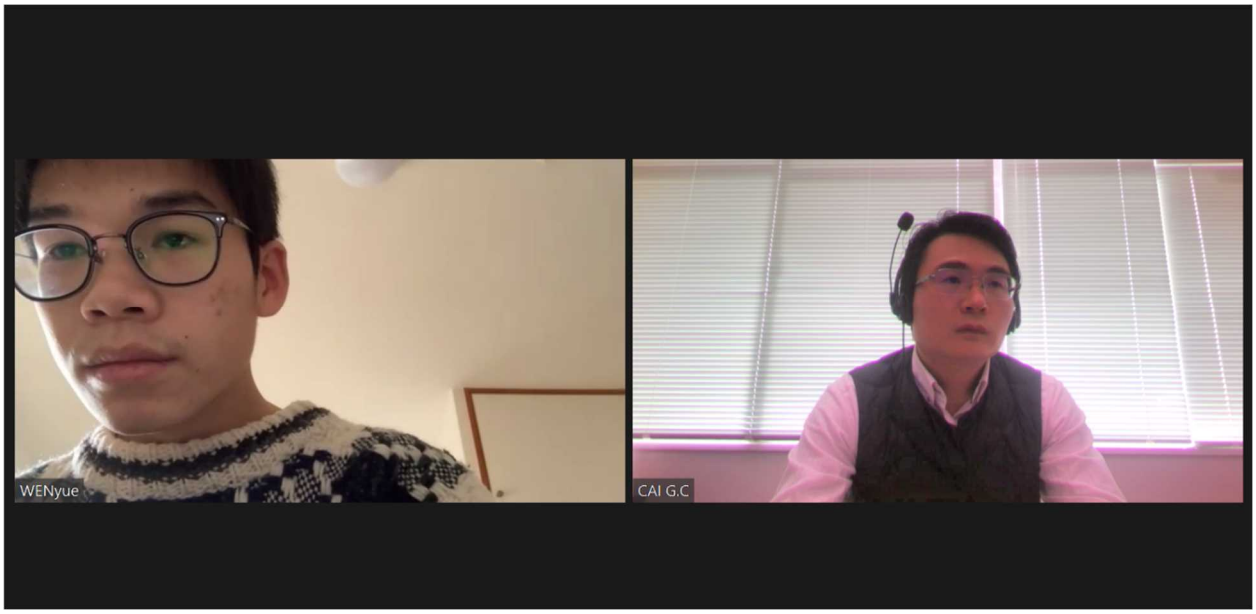
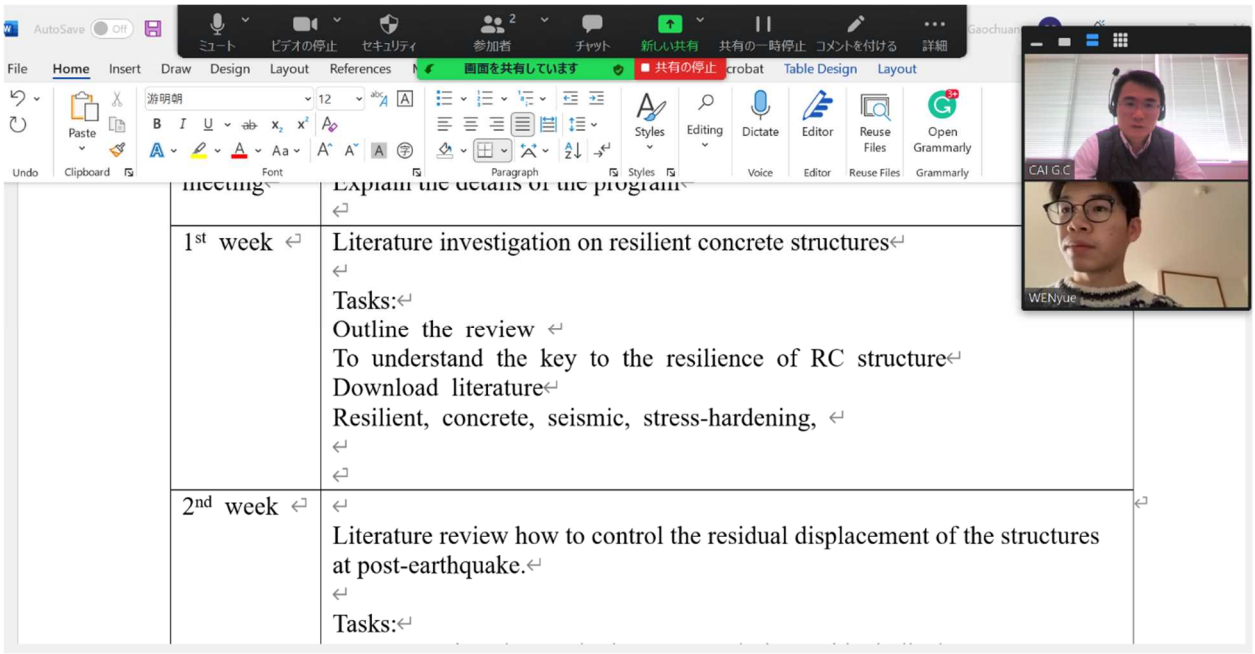




	Explain the details of the program
1st week	Literature investigation on resilient concrete structures Tasks: Outline the review To understand the key to the resilience of RC structure Download literature Resilient, concrete, seismic, stress-hardening,
2nd week	Literature review how to control the residual displacement of the structures at post-earthquake. Tasks:

No.7-5	Seismic Design and FEM simulation of Demountable Precast RC Wall Structures		
Name	Fuchao Zhao		
Affiliation	University of Lyon Email: fuchao.zhao@foxmail.com	Title/ Status	Visiting Ph.D. Researcher
Research Field	Disaster prevention and mitigation		
Period of Internship	January 17, 2022-February 25, 2022		
Host Professor	Gaochuang Cai		
Affiliation	IROAST, Kumamoto University Email: cai@kumamoto-u.ac.jp	Title	Associate Professors

Research background and objectives

Most Reinforced concrete (RC) structures are constructed using the conventional monolithic casting method. When the structure ends its life span for damaged by load effects or degraded for environmental impacts, it has to be demolished. This process usually wastes a lot of valuable materials. Structure with a dry connection hardly requires post-casting. Through dry connection, the precast concrete (PC) structures are easy to assemble quickly and the structural components are demounted and reused to extend their lifespan.

Considering the unique structural characteristics of dry connection, the design method is different from the conventional design method of monolithic casting structure. However, there is a lack of the overall seismic design theory based on dry connection. Meanwhile, the research on the influence of the deformation of the connection on the structural performance is relatively less. It is vital to research the seismic behavior and the design method of the demountable PC wall panel.

The main tasks are as follows:

- Clarifying the damage mechanism, failure mode, force-transfer mechanism, and energy dissipation performance of demountable PC wall panel building system.
- Investigating the influence of the deformation of joints on the drift of the overall structure.
- Develop the calculation methods for predicting the shear capacity of the wall panels with bolted connections.

Experimental investigation

A lightweight precast panel building system with simple bolted connections was proposed, as shown in Fig.1. The application of lightweight concrete is expected to be easy to manufacture and transport which can significantly improve construction efficiency.

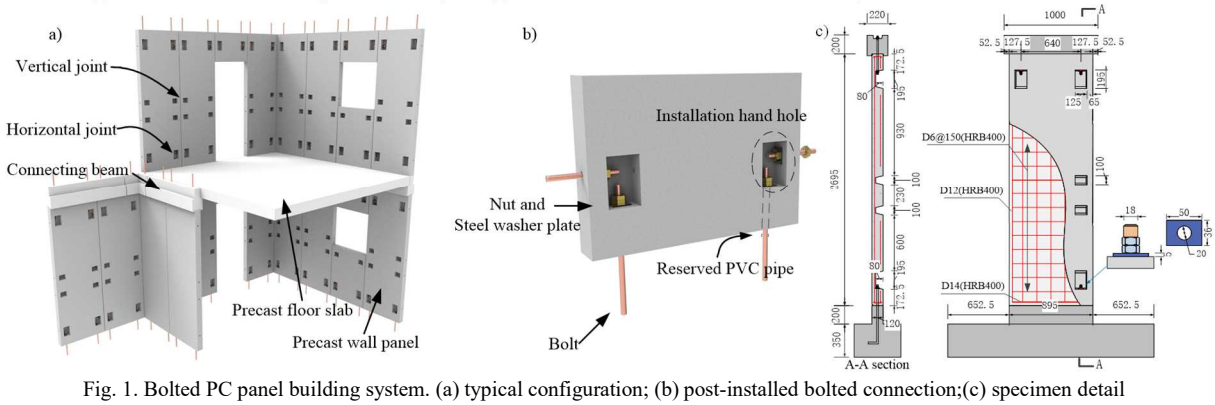


Fig. 1. Bolted PC panel building system. (a) typical configuration; (b) post-installed bolted connection;(c) specimen detail

To analyze the seismic performances of the bolted connection wall panel, three full-scale specimens with different axial loads and concrete compressive strength were designed and tested by a quasi-static cyclic load. In general, all the bolted panels presented significant lateral deformability and failed with a concrete crushing with several flexural and flexural-shear cracks around the tension bolts. The failure of the joints is mainly attributed to the yield of the bolts with several flexural-shear cracks surrounding them. For the deformation performance, the top horizontal displacement of the specimens could be divided into (1) flexural and shear deformation displacement of the wall panel and (2) the slippage and (3) the rotational displacement of the horizontal joints. And the rotational deformation caused by the distortion of steel bolts was prevalent, and it often accounts for a large proportion of overall lateral displacement.

Finite element analysis

The FEA models of the PC wall panels (Fig.2) were established by using commercial software, ABAQUS. The concrete damaged plasticity model was used to model concrete behavior, which assumed that there was no associated potential flow rule and used the yield surface to illustrate the different evolution of strength under tension and compression. In the FEA models, a surface-to-surface interaction occurs between connecting beam-PC wall, between PC wall-foundation beam, and between plate-concrete, respectively. The displacement-controlled loading process was carried out by using the dynamic implicit method in ABAQUS.

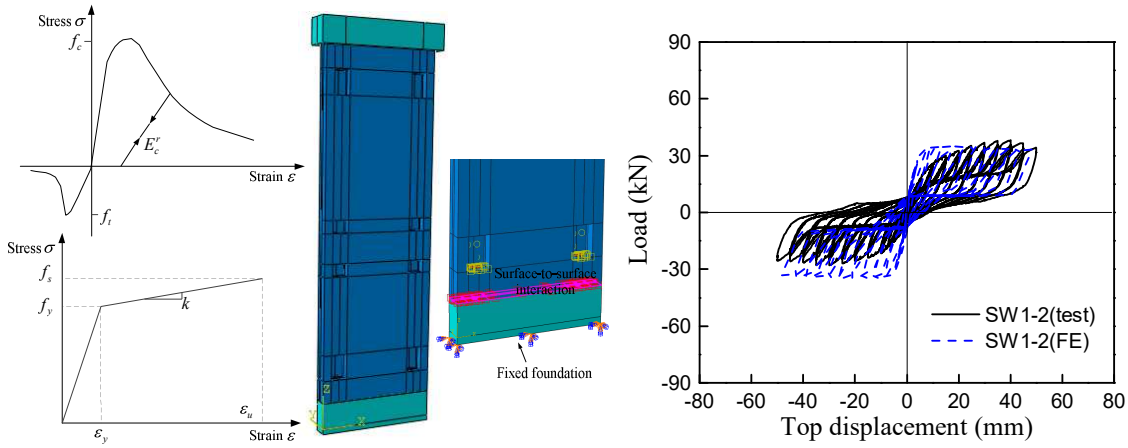


Fig. 2. FEA model and comparison of a typical test specimen

Applying proposed FEA models, a parametric study was conducted to assess the effects of main structural variables on the seismic behavior of the wall panels.

Calculation method

Combined with the preliminary experimental phenomenon and numerical analysis, it is considered that the pressure is transmitted through the concrete contact in the compression zone, and the tension is transmitted by the tension bolt in the horizontal joint section. The idealized internal force transfer mechanism is proposed in Fig.3 that can be used to determine the bearing capacity. It can be seen that the possible failure modes in the bolted PC wall structures may include: (i) failure of the steel bolts, and (ii) pull-shear damage of the reinforced concrete around the joint. So the tensile capacity of the steel bolt was defined as the minimum of the bearing capacities corresponding to the failure modes. Based on this, a simplified calculation method was proposed to predict the bearing capacity and initial stiffness of the PC wall panels with bolted connections. Fig.4 summarizes the results of bearing capacity predicted by FEA and calculated by the proposed calculation model. The calculation model proposed in this study evaluates the

bearing capacity and initial stiffness of all specimens with good accuracy.

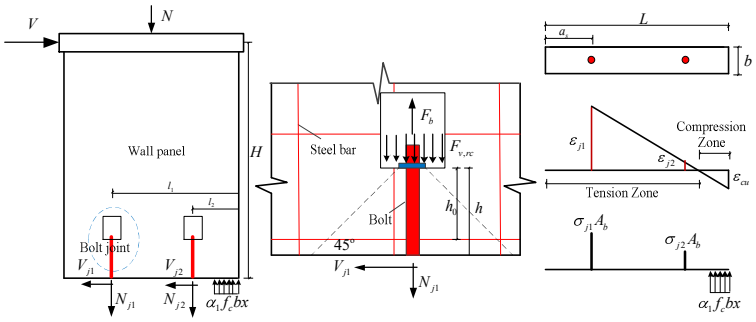


Fig. 3. Schematic outline of forces acting on the horizontal joints

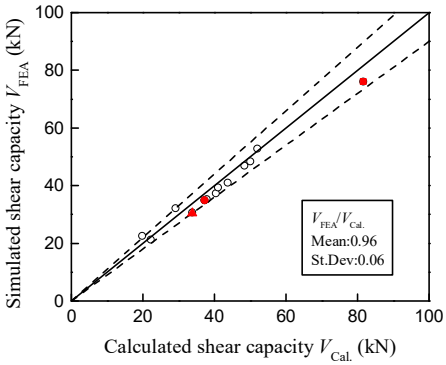


Fig. 4. Comparison between the FEA and calculated results

Achievement

All parts reported here were deeply discussed and summarized in a scientific article that has been submitted to the ***Journal of Building Engineering*** (ELSEVIER, Q1, IF 5.318, ranking it 13/136 in civil engineering).

Acknowledgment

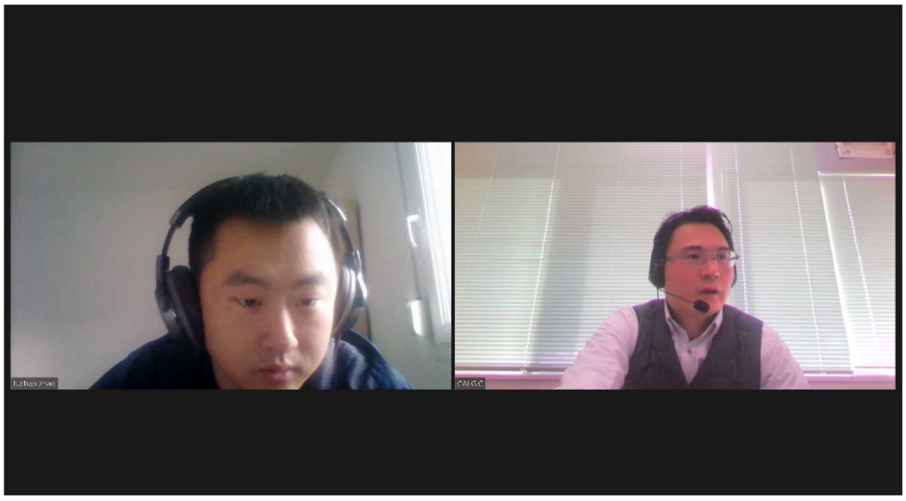
I have been a part of the IROAST internship program from January 17 until February 25. My research interests and passion are in the field of demountable PC structure. Under the supervision of Prof. CAI, I completed the analysis of the test results and the improvement of the FE model. Due to the COVID-19, the internship program has to change to online. However, I still deeply feel the warm help from Prof.CAI as well as the Kumamoto University for the experience.

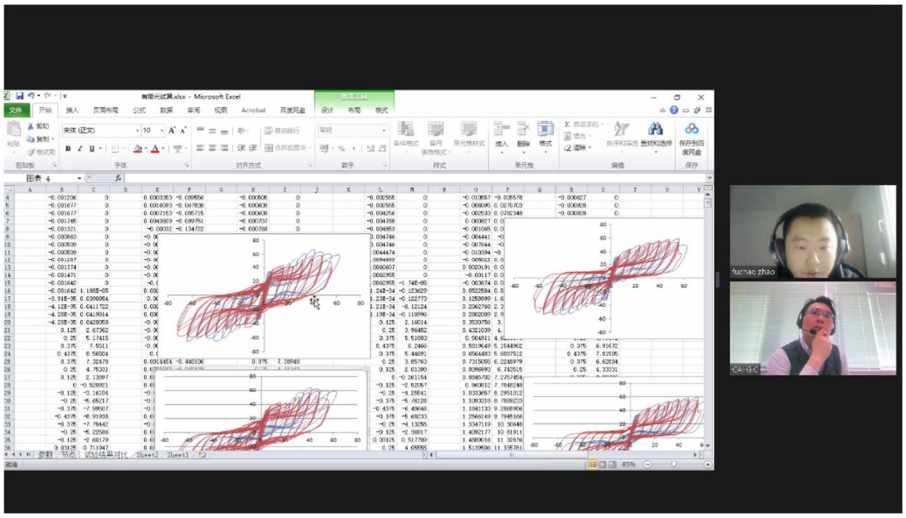
Future research plans

- Summarize the different bolt connection forms. Clarifying the differences in failure modes, hysteresis behavior, stiffness, and strain distribution of PC structure with different bolt connection types
- Investigating the influence of vertical joints on the deformation and strength of the overall structure.
- Investigating the ductility performance of wall panels with bolted connection, and carrying out the performance-based seismic design index of the structure.

Appendix

The following photos show what the internship looked like at that time.





No.7-6	The bond performance mechanism of the composite layer–original concrete interface under the main aggressive environment		
Name	Wei Liu		
Affiliation	Université de Lyon, ENISE Email: liuwei_fem@163.com	Title/ Status	PhD Student
Research Field	Composite materials and structures, finite element analysis		
Period of Internship	January 20, 2022-February 18, 2022		
Host Professor	Dr. Gaochuang Cai		
Affiliation	IROAST Email: cai@kumamoto-u.ac.jp	Title	Associate Professor

1. Details of activities

The IROAST research internship program provided me a great chance to have more experience in researching **the bond performance mechanism of the composite layer–original concrete interface under the main aggressive environment**.

1.1 Background

Textile-reinforced concrete(TRC) has emerged in recent years as a new and valuable cement-based composite reinforcement construction material with superior tensile strength and ductility(Fiore et al., 2015). Due to its excellent mechanical properties, good crack limit performance and superior properties on corrosion resistance, the structural designers and architects have developed many exotic light-weight and stiff structures including new structural panels, impact, blast resistance, repair and retrofit, earthquake remediation, strengthening of unreinforced masonry walls, and beam-column connections(Wang et al., 2018). Meanwhile, the mechanical properties and durability under main aggressive environment and various impacts such as chloride salt erosion environment and periodic wet-dry cycles, hot-cold cycle, freeze-thaw cycle, and high temperature is primarily governed by interfacial bond characteristics between fabrics and matrix. Such aggressive environments represent very severe conditions to which the material is subjected. Therefore, the bond performance mechanism of the interface is a key issue when considering composite structural material. However, there is a lack of information about TRC/TRM in these fields.

During the IROAST research internship, two parts of the tasks have been completed. One is the literature investigation of the TRC-concrete bond behavior under various impacts and another is the finite element analysis(FEA) of tensile properties of TRC thin layers using the Concrete Damaged Plasticity (CDP) model. The tasks I engaged in and the results of the research project are described in the following sections.

1.2 Literature investigation

When a TRC/TRM layer is exposed to an external environment, it may be the subject of various attacks, and its durability can be reduced. Therefore, the bond performance mechanism of the TRC composite layer-original concrete interface becomes one of the most essential scientific problems. In fact, the effectiveness of the strengthening systems is influenced significantly by the bond properties of the adhesive between the advanced composite and substrate interface(Al-Jaberi et al., 2019). Within this frame, the understanding of the TRC-original concrete interface deterioration mechanism under chloride ion, wet-dry and freeze-thaw cycles environmental conditions is an instrumental topic and has concentrated many previous works. Furthermore, reliable methods need to be developed both theoretically, experimentally and numerically.

In the last few years, an increasing interest has been given to the use of TRC/TRM as alternatives for conventional reinforcements in composites. The development of commercially viable composite materials based on resource-saving is on the rise. In this sense, TRC/TRM as reinforcements for cement mortar composites constitutes a very interesting topic for researchers. Figure 1 shows the number of publications of TRC/TRM in recent years. As we can see in the picture, in the nearest few years, the number of publications every year is four to five times what it was a decade before. Furthermore, in the process of literature investigation, it can be found that most of the research focused on experimental methods, at the same time, numerical simulation and theoretical research are relatively small. The main experimental methods are pull-out tests(Shiping Yin et al., 2019), uniaxial tensile tests(Colombo et al., 2015), Tensile test(Michels et al., 2014), double-side shear test(Shi-ping Yin et al., 2018), direct shear (Al-Jaberi et al., 2019),four-point bending test(Bisby et al., 2011) and six-point bending test(Michels et al., 2014) et al.

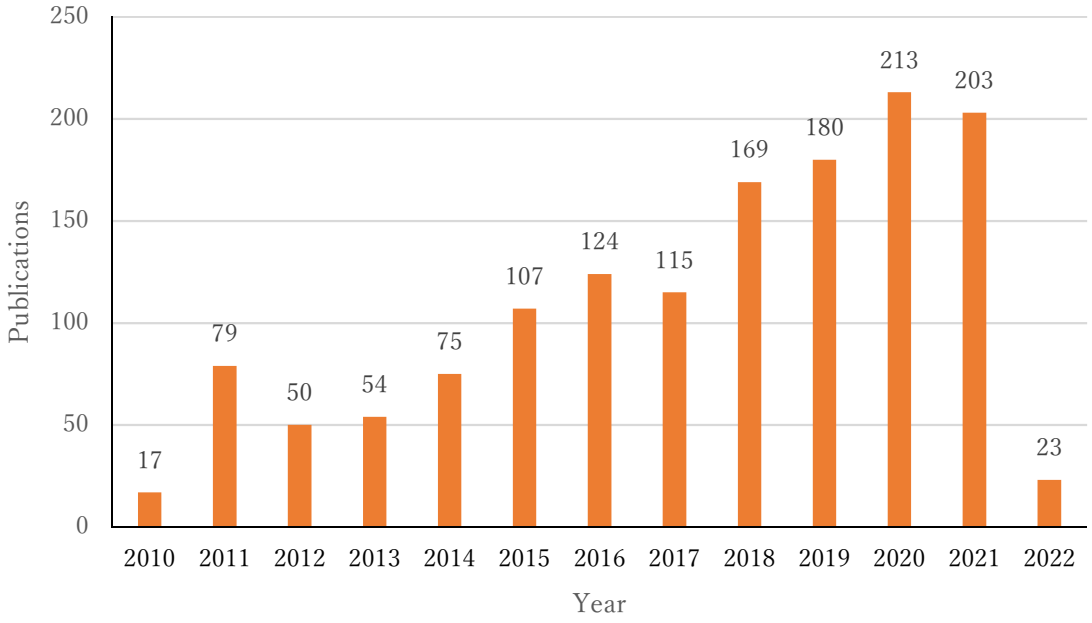


Figure 1 The number of publications of TRC/TRM in recent years

Table 1lists the overview of previous studies regarding TRC/TRM and its sub-topics obtained from a literature investigation in Web of Science. As shown in this table, interfacial bond behavior and flexural behavior of TRC/TRM attract the main attention of researchers. The top three authors with the most published papers in related fields and the number of their publications are also listed here. It can be found that most of the studies have been performed in Germany, China, and Italy.

Table 1 Overview of previous research on TRC/TRM and related topics

Topic	Sub-topic	Total number of publications*	Authors (top three of publications)	Country	Number
Textile reinforced mortar Or Textile reinforced concrete	-	1,614	Hegger Josef	Germany	75
			Curbach Manfred	Germany	59
			Yin Shiping	China	56
	Bond behavior	549	De Felice Gianmarco	Italy	24
			De Santis Stefano	Italy	13
			Bournas Dionysios A.	England	19
	Shear strengthening	234	De Felice Gianmarco	Italy	16
			De Santis Stefano	Italy	16
			Larbi, Amir Si	France	12

	Flexural behavior	405	Yin Shiping	China	23
			Xu Shilang	China	10
			Gopinath Smitha	India	7
	Seismic behavior	139	Triantafillou Thanasis C.	Greece	18
			Bournas Dionysios A.	Greece	11
			Yin Shiping	China	8
	Pullout properties	75	Mechtcherine Viktor	Germany	13
			Hempel Simone	Germany	7
			Butler Marko	Germany	5
	Corrosion environment	31	Yin Shiping	China	14
			Li Yao	China	4
			Yu Yulin	China	4
	Wet-dry cycle	18	Yin Shiping	China	9
			Jing Lei	China	3
			Al-Lami Karrar	Italy	2
	Hot-cold cycle	2	Azimpour-Shishevan Farzin	Iran	1
			Mumenya		1
	Freeze-thaw cycle	22	Yin Shiping	China	4
			Colombo Isabella Giorgia	Italy	2
			Colombo Matteo	Italy	2
	High temperature	164	Cherif Chokri	Germany	6
			Choi Kyoung-Kyu	South Korea	5
			Bournas Dionysios A.	England	4

* The statistical period is from 1950 to 2022 and the database is updated to 22/02/2022.

Figure 2 is the percentage of publications on TRC/TRM research subtopics. Although some of these statistics are repetitive, it largely reflects research trends in the TRC field. As mentioned above, research on TRC is mainly focused on the experimental test. As a new type of composite material, its application scenarios will inevitably become more and more extensive with the deepening of research.

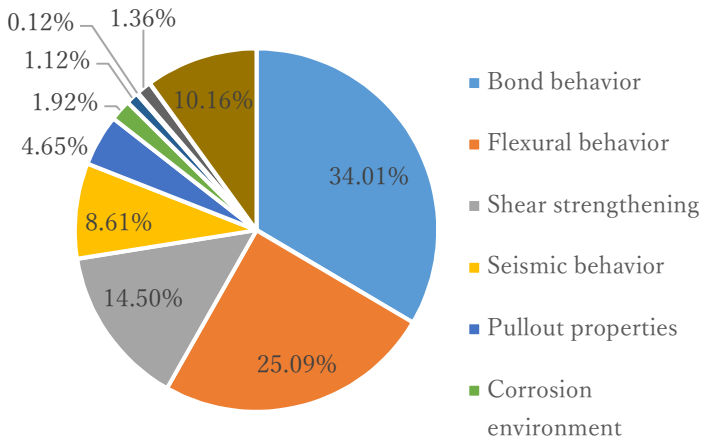


Figure 2 Percentage of publications on TRC/TRM research subtopics

1.3 Finite element modeling and results

Nonlinear finite element analysis of tensile properties of TRC thin layers under static loading was conducted to investigate their failures modes in terms of pullout load and cracking patterns. Among the constitutive models for simulating the behavior of concrete, the concrete damaged

plasticity(CDP) model that ABAQUS offers was chosen.

In geometrical modeling of the TRC thin layer, the length of the model is 500mm, the width is 60mm, and the thickness is 10mm. A pressure of 5MPa was applied to steel plates and its dimension was length 160mm×width 60mm×thickness 1mm. The loading scheme was displacement controlled by a loading rate equal to 0.05mm/s. To model specimens having internal AFRP, an 8-node linear tetrahedral element(C3D8) was used for the concrete, AFRP, and steel plates. In the C3D8 element, each node has three translational degrees of freedom in the x, y, and z directions.

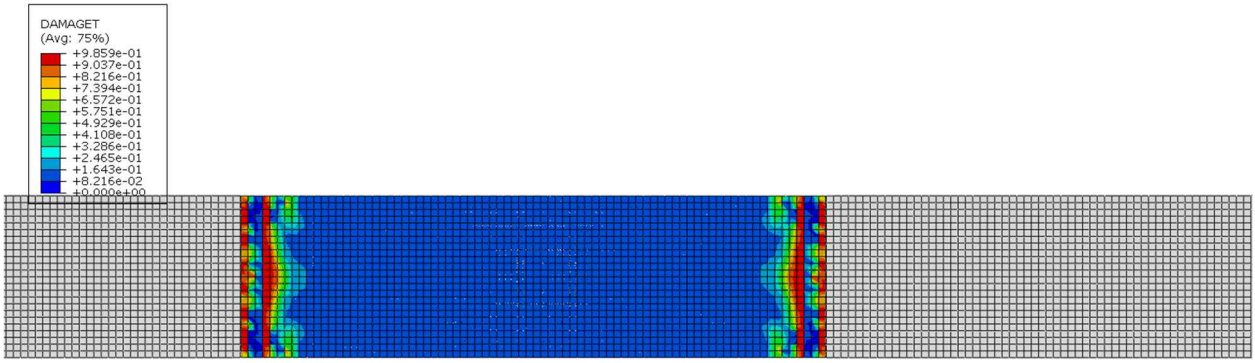


Figure 3 Cracking pattern of TRM specimen

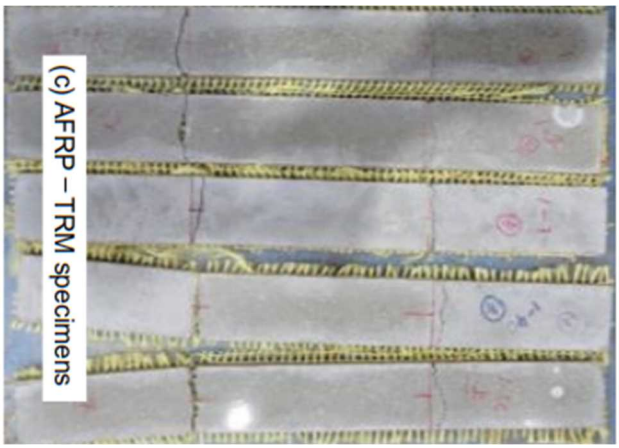


Figure 4 Ultimate cracks and damages of TRM thin layer

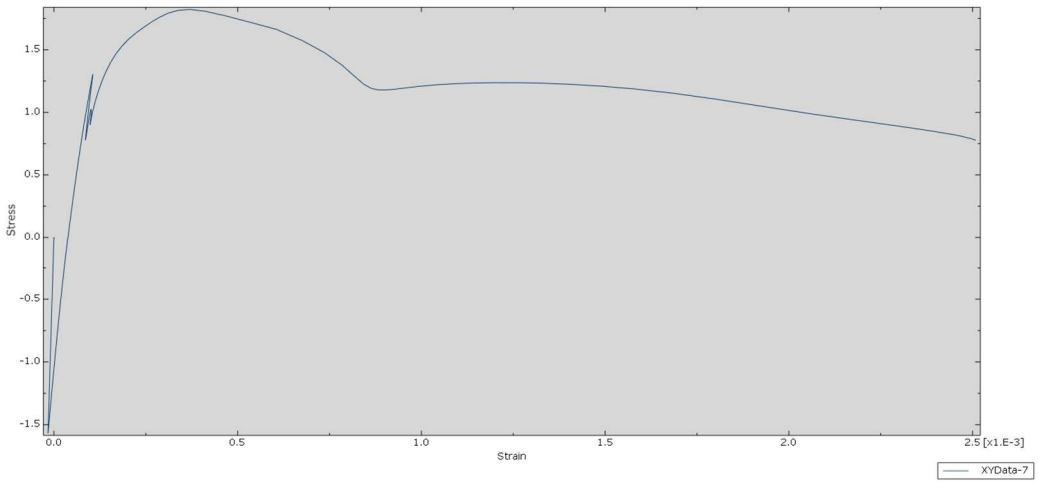


Figure 5 Tensile responses of TRM thin layer

Figure 3 represents the failure mode of the simulated TRC layer. A failure occurred at the end fixture of the specimens. The main reason was considered that the textile mesh was too weak for the TRM thin layer. Figure 4 shows the experiment result. Through comparing the two figures, it can be found that the results of the cracking pattern matches well.

Figure 5 shows the tensile responses of the TRM thin layer. It shows that up to the tensile strength of the AFRP, the stress of TRM grew rapidly before the first crack appeared and the stress of concrete reaches 0.78MPa. After that, the stress-strain curve continues to grow until a second crack appears. and the ultimate stress of concrete reached to 1.81MPa. However, after the peak load, the stress of concrete decreases with the increase of strain, which indicated that the AFRP's contribution to resisting tensile load has increased. From the numerical simulation results, it can be found that the size of the loading displacement, the pressure of the steel plates, and the loading time (loading step) have a great influence on the results.

2. Future research plans

At present, a number of studies on literature investigation have been done during the IROAST internship. However, there are still some aspects that need to be further studied in the future, the most crucial among them is the numerical simulation method on the bond performance mechanism of the TRC interface under the main aggressive environment and it is necessary to engage in this research field. On the other hand, the current numerical simulation analysis needs to be completed as soon as possible.

3. Achievement

Based on the above research work, two papers will be published. One is a literature review paper about the bond performance mechanism of the composite layer–original concrete interface under the main aggressive environment. And another is about the tensile properties of an improved TRC.

4. Acknowledgement

I am extremely grateful to Kumamoto University for fully supporting this project. The organizing committee of the IROAST research internship program made great efforts to make the program go on wheels. Participating in the IROAST Research Internship Program at Kumamoto University was a great honor and an unforgettable experience. Finally, I especially appreciate Dr. CAI for helping me complete this research. Without his guidance, none of this would have been possible.

5. References

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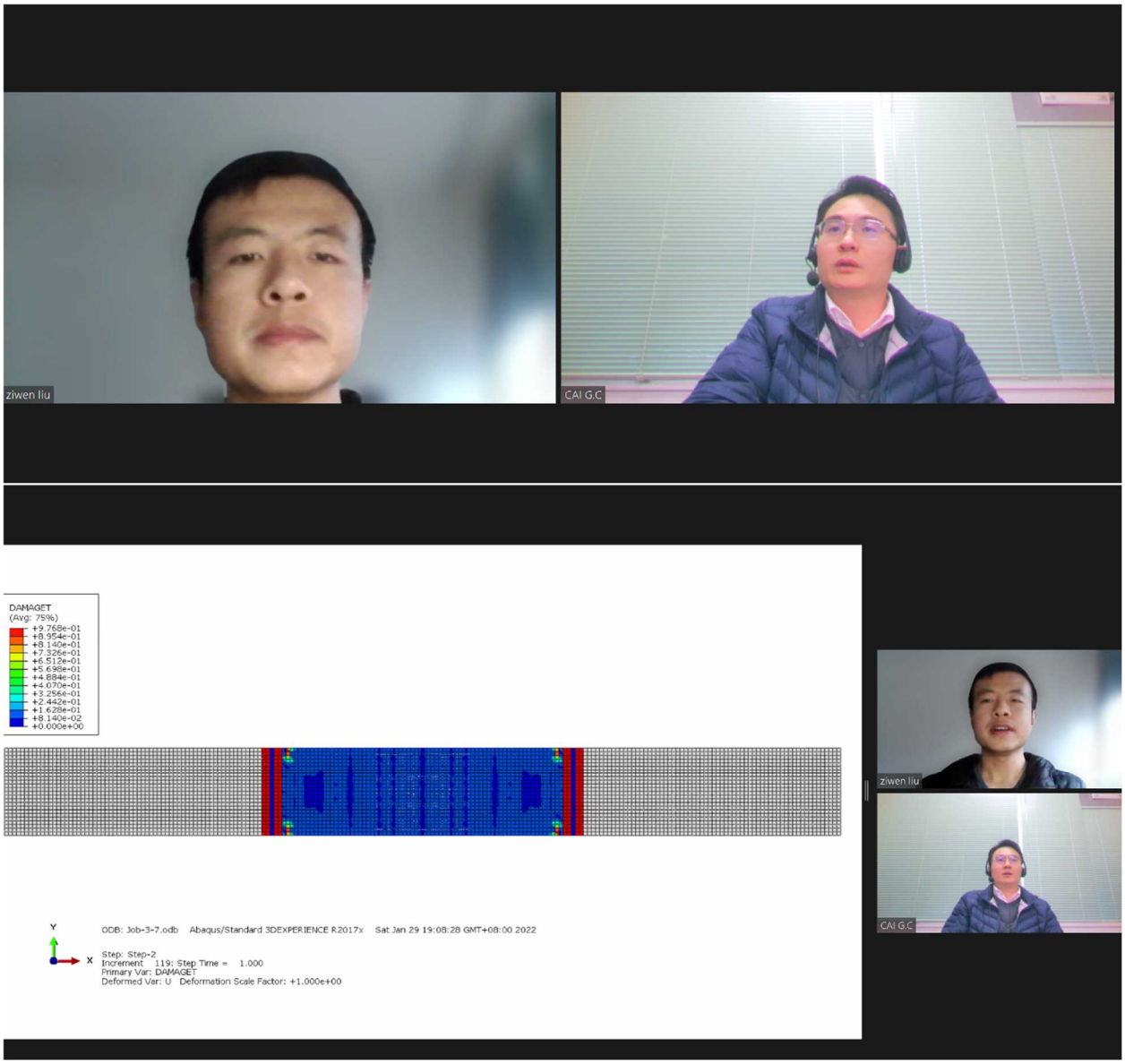
Yin, S., Li, Y., Jin, Z., & Li, P. (2018). Interfacial Properties of Textile-Reinforced Concrete and Concrete in Chloride Freezing-and-Thawing Cycle. *ACI Materials Journal*, *115*(2).

Yin, S., Jing, L., Yin, M., & Wang, B. (2019). Mechanical properties of textile reinforced concrete under chloride wet-dry and freeze-thaw cycle environments. *Cement and Concrete Composites*, *96*, 118–127.

Appendix

The following photos show what the internship looked like at that time.



No.7-7	Bond performance between carbon fiber reinforced polymer bars and ultra-high-performance concrete		
Name	Yunjian He		
Affiliation	Zhengzhou University Email: heyunjian1996@163.com	Title/ Status	Graduate Student
Research Field	Concrete Structures		
Period of Internship	January 20-February 25, 2022		
Host Professor	Gaochuang Cai		
Affiliation	IROAST Email: cai@kumamoto-u.ac.jp	Title	Associate Professor

Due to various reasons, this year's internship was an online internship. Although I was not able to go to Kumamoto University, the online internship increased the opportunity for me to communicate and exchange ideas with my host professor, Gaochuang CAI. Whenever I asked Professor Cai for advice, he always replied quickly and explained patiently. I sincerely thank Professor CAI for his help. The topic of my internship program is “Bond performance between carbon fiber reinforced polymer bars and ultra-high-performance concrete”, and I will describe what I have gained from this internship in the following aspects.

Research background

Carbon fiber reinforced polymer (CFRP) bars are characterized by high tensile strength, corrosion resistance and lightweight, and can be used to replace steel bars to fundamentally solve the corrosion problem of steel bars. However, CFRP bars are brittle materials and in combination with conventional concrete, the ductility of the structure is often poor. To improve the ductility of CFRP reinforced concrete structures, ultra-high performance concrete (UHPC) with high compressive strength and large ultimate compressive strain can be used instead of conventional concrete. The combined structure made of CFRP bars and UHPC will have excellent durability. In addition, UHPC structures tend to be smaller in size, which greatly reduces the dead weight of the structure, reduces the amount of cement used, and is in line with the low carbon concept. The precondition for CFRP bars and UHPC to work together is a reliable bond and anchorage between them. For this purpose, this program investigated the bond performance between CFRP bars and UHPC using the hinged beam test, which can take into account the combined effect of bending moment and shear force, better simulate the bonding of FRP bars at the end of the beam, and is more in line with the actual state of force than the pull-out test.

Tasks and results

1. Analysis of the test result

In Fig. 1 each curve showed an almost infinite slope at the initial stage, and the bond strength was mainly provided by the chemical adhesive force and static friction at this time. As the load continues to increase, the chemical adhesive force was lost, the bond stress turned to be provided by friction and mechanical interlocking together, and the CFRP tendon surface ribs were gradually peeled off. When the bond stress reached its peak, the ribs in the bond section had all been destroyed, and the bond stress dropped to its lowest point when the slip reached slightly less than one rib spacing. Subsequently, the bond stress gradually rose, which was due to the rib on the free end entering the bonded section, increasing the mechanical interlocking and friction at the bonded interface. After the slip passed through approximately another one rib spacing, the bond stress dropped to its lowest point again and the tendons on the free end side gradually slipped into the bond section, causing the curve to fluctuate periodically. At the end of the test, the beam was split as shown in Fig.2 which revealed that the entire outer surface at the bonded section was attached to the concrete surface and the ribs had been completely peeled off from the inner core material. It was worth noting that the number of peak points in the bond-slip curve was equal to the number of ribs entering the bond section from the free end.

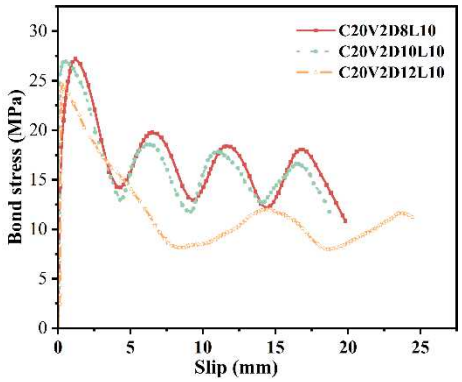


Fig.1 Bond-slip curves under different diameter

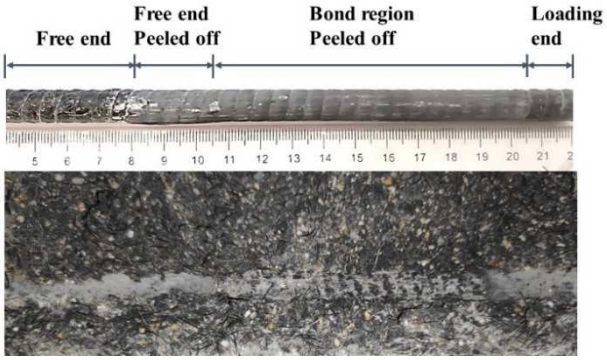


Fig.2 Bond failure

Fig. 3 showed the bond strength and slip of the test. When the diameter was increased from 8mm to 10mm, the ultimate and residual bond strengths were reduced by 6% and 11% respectively. The 12mm CFRP tendon, on the other hand, had a different surface form, which was notable for a greater slip in the descending section of the curve and a smaller ratio of residual bond strength to ultimate bond strength. The slip (s_u) corresponding to ultimate bond strength increased almost linearly with increasing rib spacing, for S8 and S10 CFRP bars with a rib spacing of 5.25mm and D12 CFRP bars with a rib spacing of 10.2mm, the slip s_u was 4.16mm, 4.27mm, and 9.11mm, respectively. Meanwhile, the residual section can be regarded as a sinusoidal curve with one rib spacing as the period, which provided a reference basis for modeling the bond stress-slip constitutive relation of CFRP tendons in UHPC.

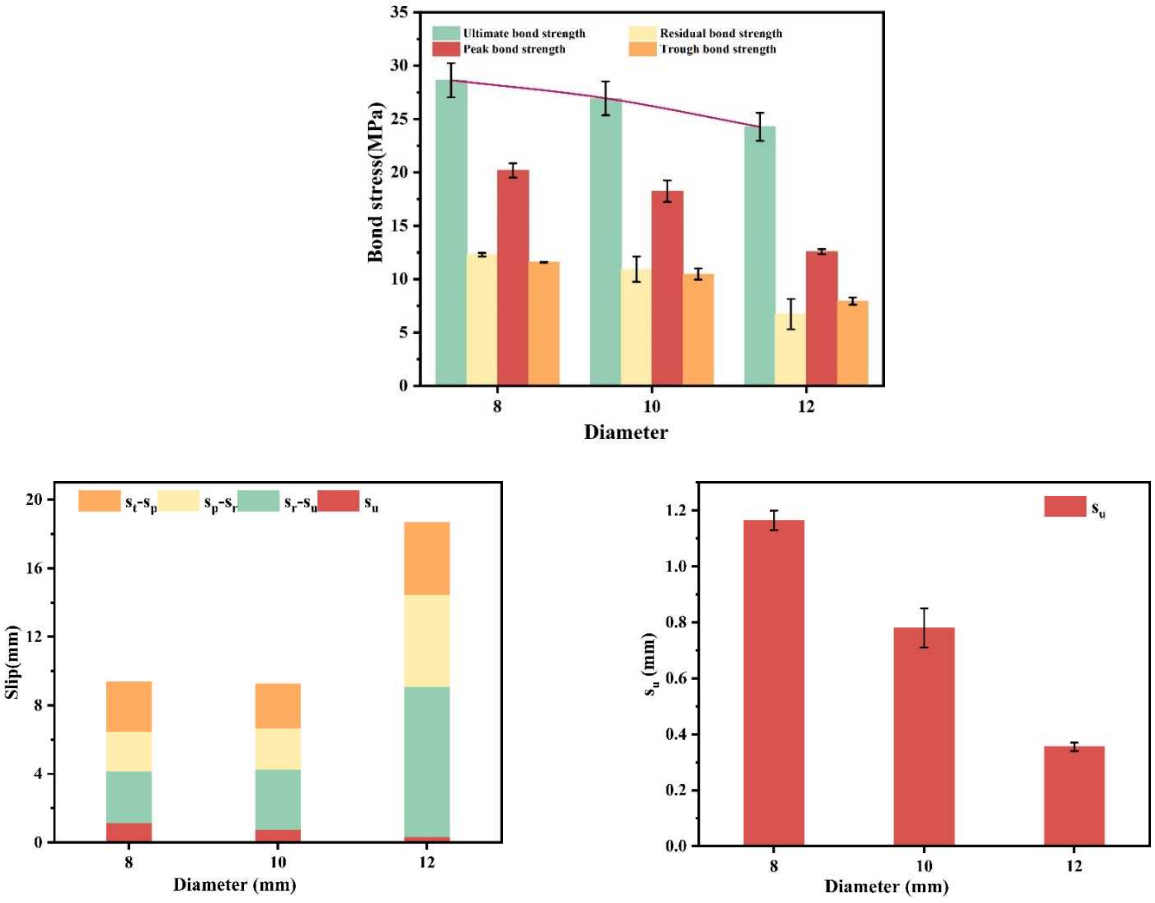


Fig.3 Bond strength and slip under different diameter

2. Calculation of bond strength between CFRP tendons and UHPC

ACI440.1R-15 used a linear regression of Wambeke and Shield's database of 269 beam tests

established to derive the formula for calculating the bond strength of FRP bars to concrete. Combined with the data in this paper, it was found that as the bond length decreases from 10db, to 7.5db, 5db, and 2.5db successively, the predicted value of ACI for the bond strength of this test increased almost linearly, which was due to the fact that the ACI calculation formula for db/le had a large fixed factor, and it can be predicted that as the bond length continues to decrease from 2.5db, the calculated ACI value will be greater than the measured value. Referring to the ACI calculation method, the bond strength calculation equation was obtained by fitting the data from this test through linear regression which can reflect the bond strength of CFRP tendons and UHPC more accurately as shown in Fig. 4.

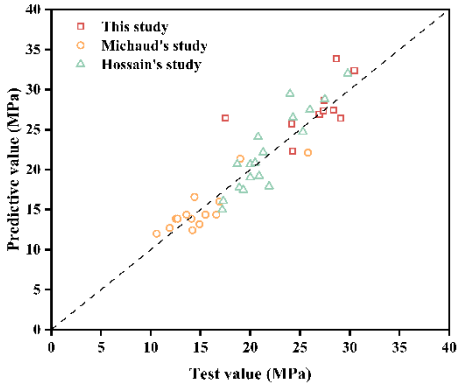


Fig.4 Fitting results of bond strength calculation formula

3. Development length and bond stress-slip constitutive relationship between CFRP tendons and UHPC

Development length was obtained by combined equilibrium formula and bond strength formula. Taking the data from this test and giving a conservative value, the basic development length of CFRP bars in UHPC can be obtained as 40db. This research described the whole process of bond stress-slip constitutive relation in three stages: ascending section, descending section, and residual section. According to previous studies, there were Malvar model, MBPE model and CMR model for the bond-slip constitutive relationship between FRP bars and concrete. Since the Malvar model had a complex form and the initial slope was not infinite, which was not consistent with the actual situation. To obtain a more accurate fitted model, ascending section of the MBPE model was compared with the CMR model. By comparing the fitting results, it was found that the CMR model fitted the rising section better (mean R2 = 0.98, C.V.= 0.78%) than the MBPE model (mean R2 = 0.79, C.V.= 13.8%). A sine function was used to represent the descending section of the bond-slip curve (mean R2 = 0.99, C.V.= 2.29%) and a decaying sine function to represent the periodic fluctuations in the residual section (mean R2 = 0.78, C.V.= 13.9%), achieving a relatively well-fitted result. Fig. 5 listed the experimental and model curves of bond-slip curves with different CFRP tendon diameters.

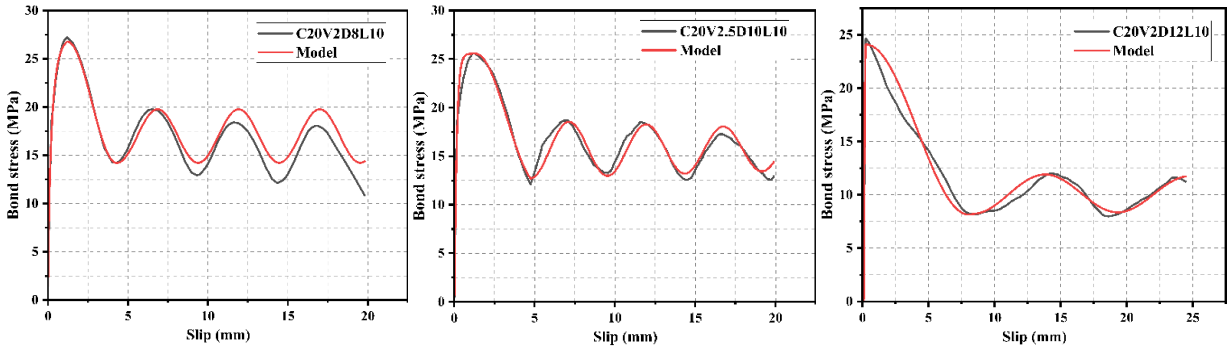


Fig. 5 The experimental and model curves

Achievement

All parts reported here were deeply discussed and summarized in a scientific article that has been submitted to the journal of ***Construction and Building Materials*** (ELSEVIER, Q1, IF 6.141, ranking it 7/136 in civil engineering).

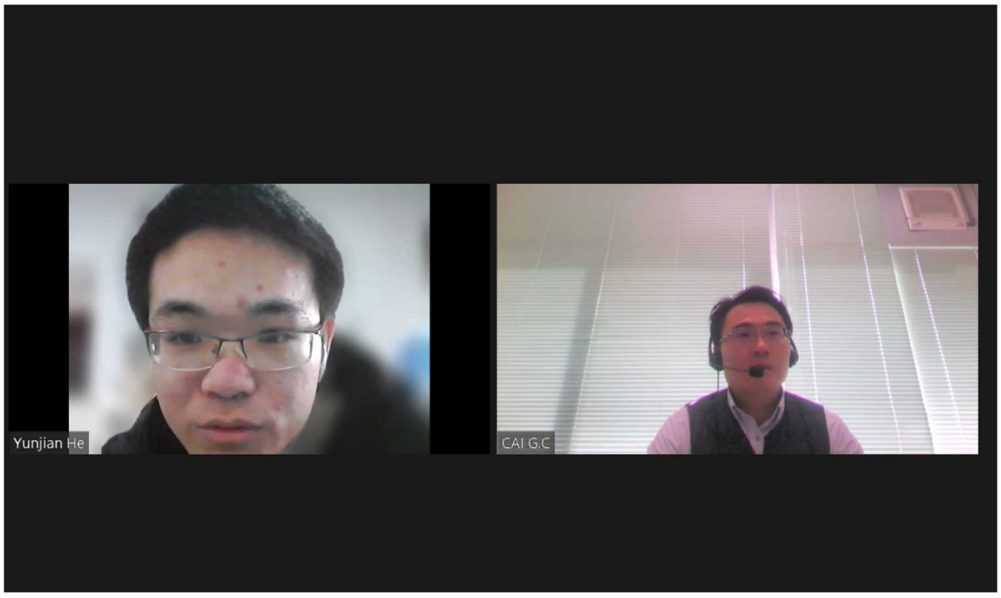
Future research plans

Japan is an earthquake-prone country and is a world leader in structural seismic technology. Currently, most of the experimental studies on the seismic performance of FRP strengthened RC structures are focused on ordinary ground motions, and there is a lack of quantitative assessment of the performance and damage of FRP strengthened RC structures subjected to long-period ground motions. However long-period ground motion is rich in low-frequency components, it is easy to produce a "resonance-like" effect with the building structure with a long self-oscillation period, thus causing some special earthquake damage. Therefore, the seismic strengthening of existing long-period structures requires consideration of the effects of long-period ground motion. At the same time, the residual seismic performance of the strengthened structures after long-period ground motions has also been little studied, so it is necessary to study the repair methods and the seismic performance of the repaired damaged structures. The research results will have realistic engineering significance and important theoretical value for guiding the strengthened design. In this research, the performance of FRP strengthened RC columns under long-period ground motions will be analyzed and compared with normal ground motions to analyze the similarities and differences between them, and the residual seismic performance of the strengthened columns after experiencing long-period ground motions will be investigated. In addition, the numerical analysis will be used to investigate the key parameters affecting the FRP strengthened RC structures. The main research includes:

- Studying the compressive strength, ductility, and uniaxial compression constitutive model of FRP-confined concrete;
- Investigating the damage modes, damage mechanisms and energy dissipation performance of FRP strengthened RC structures under long-period ground motion and making comparative analysis with common ground motions;
- Considering the effects of different test parameters such as FRP strengthening methods, lateral displacements, and types of ground motions on the seismic performance of the structure, and conducting parametric analysis of the seismic performance of FRP strengthened RC columns using finite element numerical models;
- Suggesting and verifying several repair methods for damaged columns and studying the recovery of seismic performance of repaired columns under seismic re-activation;
- Combining experimental data and finite element calculations to establish the damage model of FRP-reinforced RC structures under long-period ground motion.

Appendix

The following photos show what the internship looked like at that time.



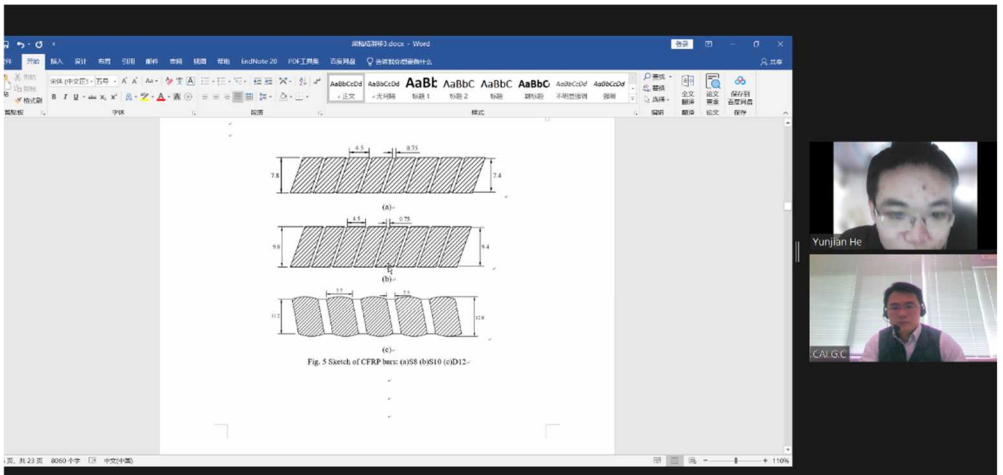
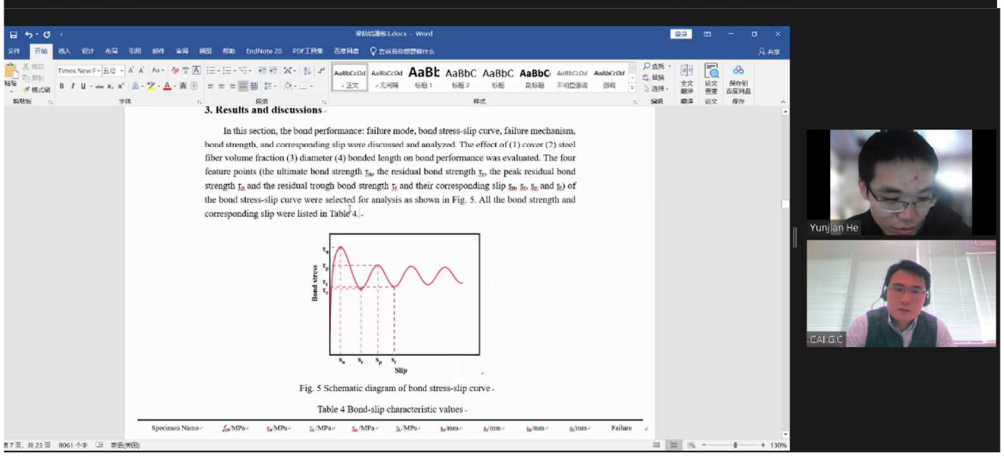


Fig. 5 Sketch of CFRP bars: (a)S8 (b)S10 (c)D12



3. Results and discussions

In this section, the bond performance: failure mode, bond stress-slip curve, failure mechanism, bond strength, and corresponding slip were discussed and analyzed. The effect of (1) cover (2) steel fiber volume fraction (3) diameter (4) bonded length on bond performance was evaluated. The four feature points (the ultimate bond strength τ_m, the residual bond strength τ_r, the peak residual bond strength τ_n and the residual trough bond strength τ_t and their corresponding slip s_m, s_r, s_n and s_t) of the bond stress-slip curve were selected for analysis as shown in Fig. 5. All the bond strength and corresponding slip were listed in Table 4.

Fig. 5 Schematic diagram of bond stress-slip curve

Table 4 Bond-slip characteristic values

Specimen Name	f_{cu}/MPa	τ_m/MPa	τ_r/MPa	τ_n/MPa	τ_t/MPa	s_m/mm	s_r/mm	s_n/mm	Failure

No.7-8	Study on Oxygen Diffusion of Eco Concrete subjected to Loads		
Name	Chenggong Cai		
Affiliation	Jiangsu University of Science and Technology Email: 331361674@qq.com	Title/ Status	Graduate Student
Research Field	Green Energy/ Environmental Science		
Period of Internship	January 31-February 21, 2022		
Host Professor	Gaochuang Cai		
Affiliation	IROAST Email: cai@kumamoto-u.ac.jp	Title	Associate Professor

First of all, I am honored to have this opportunity to exchange and study with Professor Cai from Kumamoto University. It is a very pleasant process. Due to the COVID-19, this exchange and study were forced to use online video, but this did not stop our enthusiasm for academic exchanges. Here, I would like to thank Professor Cai again for his concern and help to me, which made me feel the strong academic atmosphere of Kumamoto University. Thank you very much.

Secondly, in terms of academic research, I mainly study the oxygen diffusion under ecological concrete load. In the early stage of the research, I mainly conducted a background investigation on the research on the gas diffusion of ecological concrete, starting with the device and physical experimental method for measuring the gas diffusion coefficient. Secondly, based on background research, the experimental method of gas diffusion research under ecological concrete load is determined. Finally, combined with COMSOL simulation analysis software, an oxygen diffusion model was established, and the oxygen diffusion of ecological concrete under different loads was studied and analyzed by using the model. The ultimate goal of this study is to obtain the oxygen diffusion rate in concrete to predict reinforcement corrosion and ultimately improve the durability of concrete.

In the future, I will actively use the combination of the ecological concrete gas diffusion research test method and numerical analysis software simulation method to carry out further research. An ecological concrete model with different aggregate distributions and an oxygen diffusion prediction system under different loads are established to provide a reference for predicting steel corrosion in the future. At the same time, after this research, the unexpectedly discovered factors such as temperature, saturation, and load coupling effect analysis of ecological concrete gas diffusion will be closer to the actual project, and more intuitively understand the life state of concrete in the actual project service state, which will It is of great significance to the study of concrete durability.

1. Existing Oxygen Diffusion Plant

Through the investigation of the background of concrete gas diffusion, we found that researchers Geng Ou et al. developed a concrete oxygen diffusion coefficient test device. The device is used to determine the relationship between the oxygen diffusion coefficient of concrete materials and concrete water-cement ratio, relative humidity, and ambient temperature. Influence last.

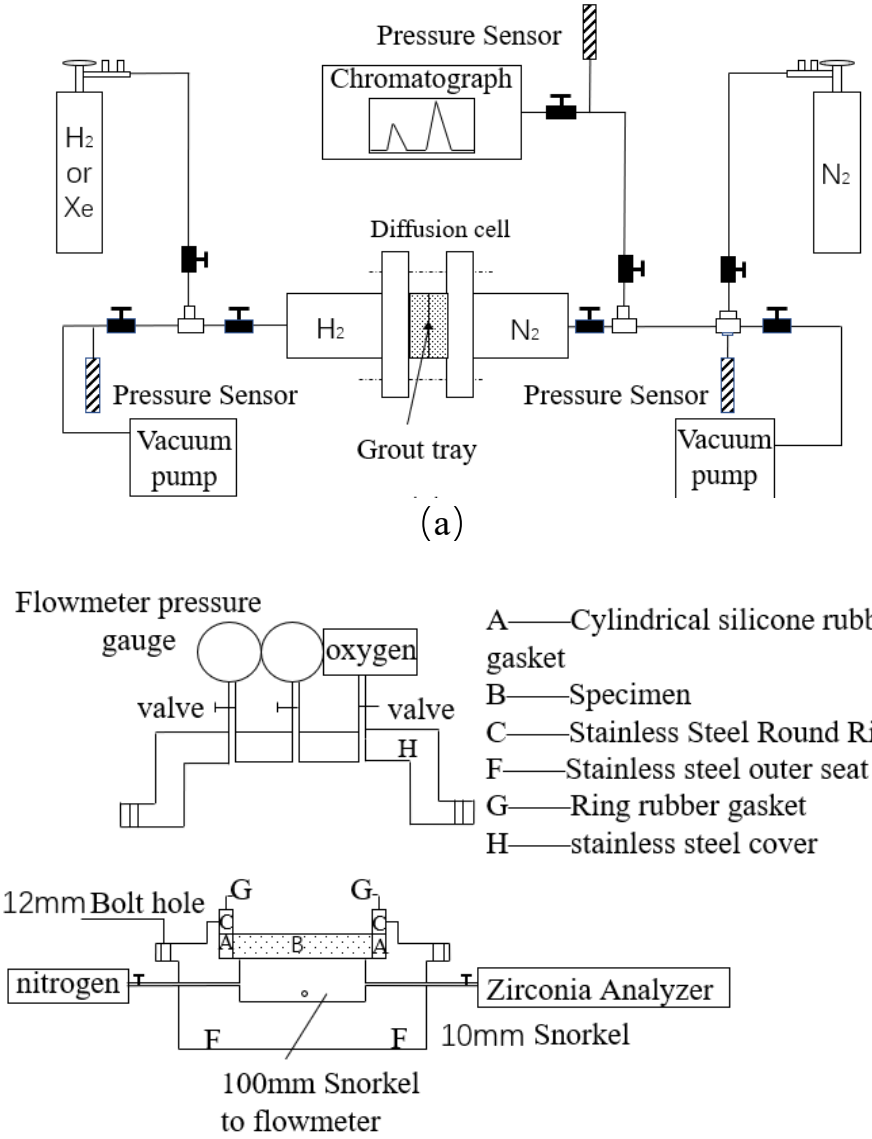
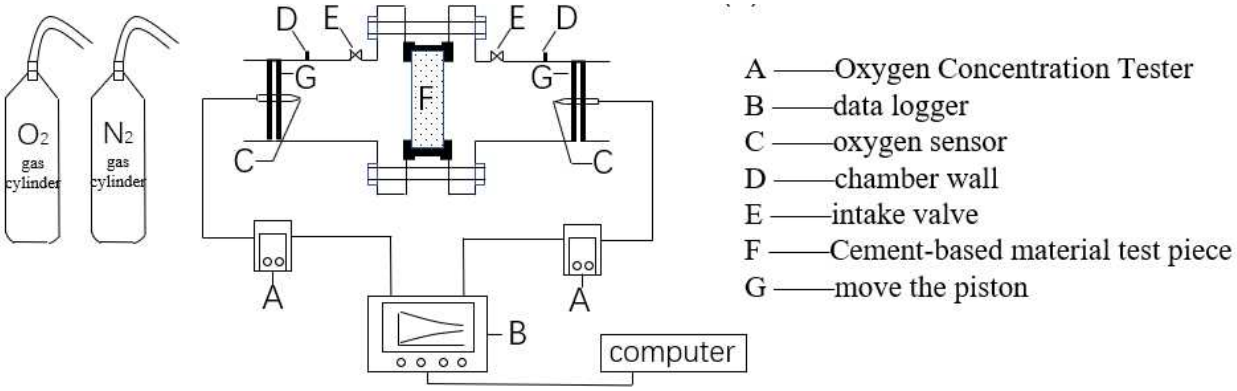


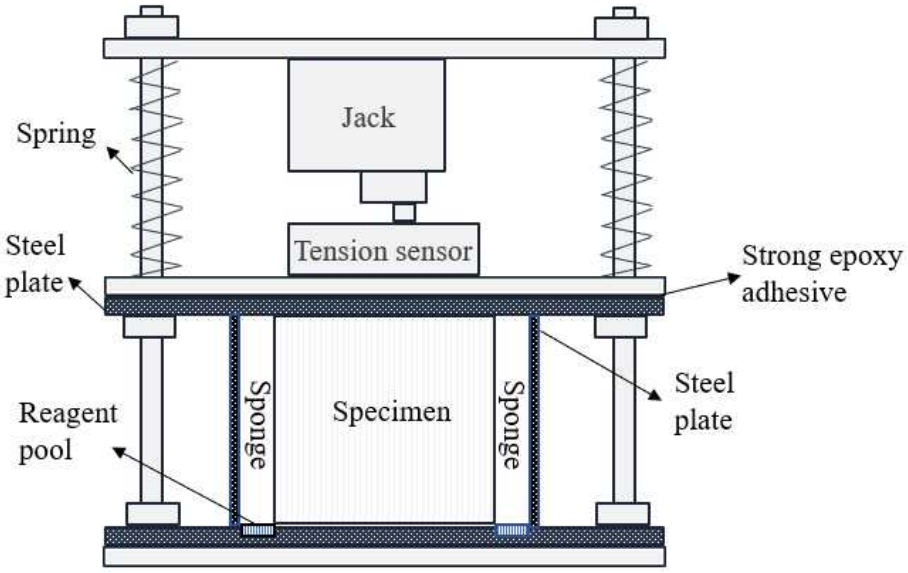
Fig1. Existing Oxygen Diffusion Coefficient Measuring Devices

2. The measuring device for this study

With the research background of the above-mentioned oxygen diffusion coefficient measuring device, combined with the load factor of this subject, we have redesigned the oxygen diffusion coefficient measuring device of concrete. The device includes two parts, the first part is the oxygen concentration measurement part, and the second part is the loading device, the combination of the two is used to measure the oxygen diffusion coefficient of the bio-concrete under the load. Among them, the upper and lower parts of the specimen are subjected to load, and a group of opposite surfaces around them is in contact with the sponge soaked in water so that the subsequent saturation affects the oxygen diffusion, and the other group of opposite surfaces is tested for the oxygen diffusion coefficient. The specific measurement device diagram is shown in Figure 2.



(a) Oxygen Diffusion Coefficient Determination Section



(b) Loader section

Fig2. Device for measuring oxygen diffusion coefficient of ecological concrete under load

3. Numerical Simulation

Here we use COMSOL software to establish an oxygen diffusion model, the aggregates inside the model are randomly distributed, and use the same set of data to simply test the oxygen diffusion of ecological concrete generated by different loads. Among them, considering the influence of load factors on oxygen diffusion, when establishing the oxygen diffusion model, we use cracks to represent the influence of load factors on the specimen. We simplified the cracks generated by the load on the model into one crack and three cracks for comparative analysis. It is not difficult to find that the oxygen diffusion rate of the samples at both cracks is significantly faster than that of the uncracked area, and the diffusion rate of the sample interface transition area is significantly faster. In addition, through careful observation, it can be found that at the same time and the same temperature, the oxygen diffusion rate of the three-crack specimen is faster than that of the one-crack specimen. Moreover, the oxygen diffusion rate in the interface transition area of both is inconsistent with the surrounding area, and the related research on oxygen diffusion in the interface transition area will be reflected in the follow-up research.

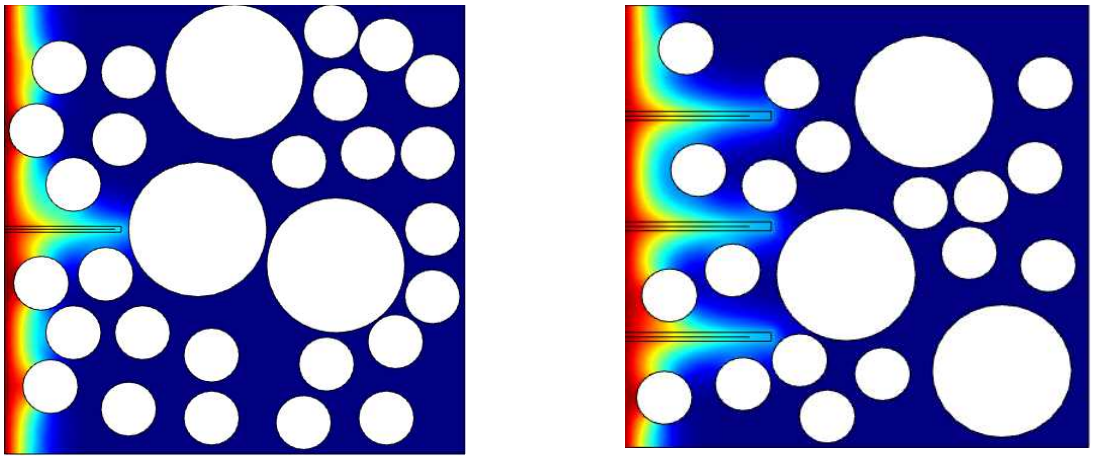


Fig 3. COMSOL numerical simulation results of oxygen diffusion in concrete

The following photo shows what the internship looked like at that time.

Publications Supported by IROAST Publication Support Program

No.	Name	Publication Information
1	**Hiroki Matsuo** IROAST	Polarization and Dielectric Properties of BiFeO3-BaTiO3 Superlattice-Structured Ferroelectric Films
2	**Ruda Lee** IROAST	Biomimetic Bacterial Membrane vesicles for drug delivery applications
3	**Takahiro Hosono** FAST	Origins and pathways of deeply derived carbon and fluids observed in hot spring waters from non-active volcanic fields, western Kumamoto, Japan
4	**Kei Toda** FAST	Biogenic diamines and their amide derivatives are present in the forest atmosphere and may play a role in particle formation

Winning Awards

No.	Name	Name of award/Institute /Date of receiving award
1	**Kei Ishida** CWMD	Intelligence, Informatics and Infrastructure Outstanding Potential Paper Award (2021) Subcommittee on AI Application in Structural Engineering November 29, 2021
2	**Hiroki Matsuo** IROAST	The 18th JACG Best Presentation Awards (2021) Japanese Association for Crystal Growth (JACG) December 13 2021.

IROAST Symposiums

No.	Title	Organizer	Date
1	7th IROAST Symposium -Advanced Research in Science and Technology for Developing Social Well-Being-	**Kazuki Takashima** Director, IROAST	November 22, 2021
2	8th IROAST Symposium on X-Ray CT Visualization for Socio -Cultural Engineering & Environmental Materials on X-Earth "Challenge of Medicine, Science - Engineering Collaboration"	**Toshifumi Mukunoki** Professor, FAST **Akira Sato** Associate Professor, FAST	December 7, 2021 ~ December 8, 2021,
3	9th IROAST Symposium "Nano-organics and Nano-hybrids"	**Makoto Takafuji** Professor, FAST	January 21, 2022

FAST: Faculty of Advanced Science and Technology

IROAST Symposium Report 1

<table>
<tr><td rowspan="2">Organizer 1</td><td>Name</td><td colspan="3">Kazuki Takashima</td></tr>
<tr><td>Affiliation</td><td>IROAST</td><td>Title</td><td>Director</td></tr>
<tr><td>Symposium Title</td><td colspan="4">7th IROAST Symposium -Advanced Research in Science and Technology for Developing Social Well-Being-</td></tr>
<tr><td>Venue</td><td colspan="4">Hybrid style
Online: Zoom
Venue: Meeting Rm. A, Kurokami South C2 (Faculty of Engineering Bldg. I)</td></tr>
<tr><td>Time & Date</td><td colspan="4">13:30-15:30, November 22, 2021</td></tr>
<tr><td>Speaker’s Name/ Title/Affiliation</td><td colspan="4">Higaki Takumi (Assoc. Prof., FAST, KU)
Matsuo Hiroki (Assoc. Prof., IROAST, KU)
Lee Ruda (Assoc. Prof., IROAST, KU)
Nakashima Yuta (Assoc. Prof., FAST, KU)
Aida Mitsuhiro (Prof., IROAST, KU)
FAST: Faculty of Advanced Science and Technology</td></tr>
<tr><td rowspan="4">Number of Participants</td><td rowspan="3">From KU</td><td>Faculty: 42 (Int'l participants: 3)</td><td rowspan="4">Total</td><td rowspan="4">139</td></tr>
<tr><td>Students: 18 (Int'l participants: 0)</td></tr>
<tr><td>Others: 19</td></tr>
<tr><td>From outside KU</td><td>60 (Int'l participants: 2)</td></tr>
</table>

On November 22, the International Research Organization for Advanced Science and Technology (IROAST) of Kumamoto University held the 7th Kumamoto University IROAST Symposium in a hybrid online and in-person style.
This symposium was held as part of the National University Festa 2021 with the aim of introducing cutting-edge innovative research by IROAST and its wide application to applied technologies.

In his opening remarks, President Hisao Ogawa emphasized the importance of the development of science and technology for the realization of people’s physical and mental well-being. Then, I, Kazuki Takashima, Director of IROAST, introduced IROAST and the many outstanding results obtained through international joint research with world-class universities and research institutes, as well as cross-disciplinary research projects, such as medical-engineering collaboration. He also discussed the prospects for how future research can contribute to the development of a well-being society, new human-friendly science and technology, and safe and secure society. After that, five young researchers gave presentations on their researches developed from their unique perspectives and exchanged opinions with the participants. After the symposium, videos of each presentation were distributed on the symposium’s special website, which was open only to registered participants until the end of November, and a Q&A section was set up with the presenters.

In the end, more than 139 people, including those from the education and industry sectors, registered for the symposium, which was a great success as IROAST’s extensive research were widely shared and active discussions were held with the participants. In the future, we will continue to lead the University’s efforts to improve its research capabilities by conducting advanced international joint research with overseas universities and research institutes.

Symposium Poster

KU President Ogawa Hisao

IROAST Director Takashima Kazuki

Assoc. Prof. Higaki Takumi

Assoc. Prof. Matsuo Hiroki

Assoc. Prof. Lee Ruda

Assoc. Prof. Nakashima Yuta


Prof. Aida Mitsuhiro

IROAST Symposium Report 2

<table>
<tr><td rowspan="2">Organizer 1</td><td>Name</td><td colspan="3">Toshifumi Mukunoki</td></tr>
<tr><td>Affiliation</td><td>Faculty of Advanced Science and Technology</td><td>Title</td><td>Professor</td></tr>
<tr><td rowspan="2">Organizer 2</td><td>Name</td><td colspan="3">Akira Sato</td></tr>
<tr><td>Affiliation</td><td>Faculty of Advanced Science and Technology</td><td>Title</td><td>Associate Prof.</td></tr>
<tr><td>Symposium Title</td><td colspan="4">8th IROAST Symposium on X-Ray CT Visualization for Socio-Cultural Engineering & Environmental Materials on X-Earth
“Challenge of Medicine, Science - Engineering Collaboration”</td></tr>
<tr><td>Venue</td><td colspan="4">Online via Zoom</td></tr>
<tr><td>Time & Date</td><td colspan="4">Tue, December 7, 2021,
Morning session 9:00-12:30, Afternoon session 17:00-18:50
Wed, December 8, 2021,
Morning session 9:00-14:30, Afternoon session 16:00-18:45</td></tr>
<tr><td>Speaker’s Name/ Title/Affiliation</td><td colspan="4">Melvin Diaz, PhD, Korea Maritime & Ocean University, Korea
Agus Sasmito, Associate Professor, McGill University, Canada
Toshifumi Mukunoki, Professor, FAST, KU
Akira Sato, Associate Professor, FAST, KU
Kenichi Okubo, Nikon Solutions Co., Ltd.
Alessandro Tengattini, PhD, Université Grenoble Alpes, France
Ilija Vego, PhD candidate, Université Grenoble Alpes, France
Yuichiro Arima, Associate Professor, IRCMS, KU
Buluke, Researcher, KU hospital
Patrice Jean Delmas, Associate Professor, The University of Auckland, New Zealand
Sanae Takasugi, Bruker Japan
Zeinab Aliabadian, Postdoctoral fellow, FAST, KU
Jiaxi Yang, Doctoral student, FAST, KU
Hideharu Sugimoto, PhD candidate, FAST, KU
Shuhei Matsumoto, FAST, KU
Kamil Souček, The Czech Academy of Science, Czech Republic
Eomzi Yang, PhD candidate, Yonsei University, Korea</td></tr>
<tr><td rowspan="6">Number of Participants</td><td rowspan="3">From KU</td><td>Faculty: 17
(Int'l participants: 4)</td><td rowspan="6">Total</td><td rowspan="6">185</td></tr>
<tr><td>Students: 37
(Int'l participants: 7)</td></tr>
<tr><td>Other: 6</td></tr>
<tr><td rowspan="3">From outside KU</td><td>Faculty: 71
(Int'l participants:53)</td></tr>
<tr><td>Students: 20
(Int'l participants: 14)</td></tr>
<tr><td>Other: 34</td></tr>
</table>

1. Symposium Overview

X-Earth Center has organized several international workshops over the last decade as a place to establish an international network and provide international education whilst boosting international exchanges. In 2020, two new X-ray CT scanners were introduced to the X-Earth Center: a high-power, high-resolution micro-focused X-ray CT scanner and a nano-focused X-ray CT scanner, both of which have been in operation since April, 2021. So now X-Earth center can use three different kinds of CT devise. The newly introduced micro-focused X-ray CT scanner is an excellent device that can irradiate more powerful X-rays than the previous device. Also, the new micro-focused X-ray CT has an environment that allows various mechanical experiments to be performed in the CT chamber. Then, the nano-focused X-ray CT scanner is a device that can also be called a 3D X-ray microscope with nano-scale resolution. By overcoming the technical limitations with these novel CT systems, we are now able to make a further contribution. Kumamoto University is a rare academic institution in Japan and abroad with this kind of research environment. Our research activity using these newly introduced CTs has just begun.

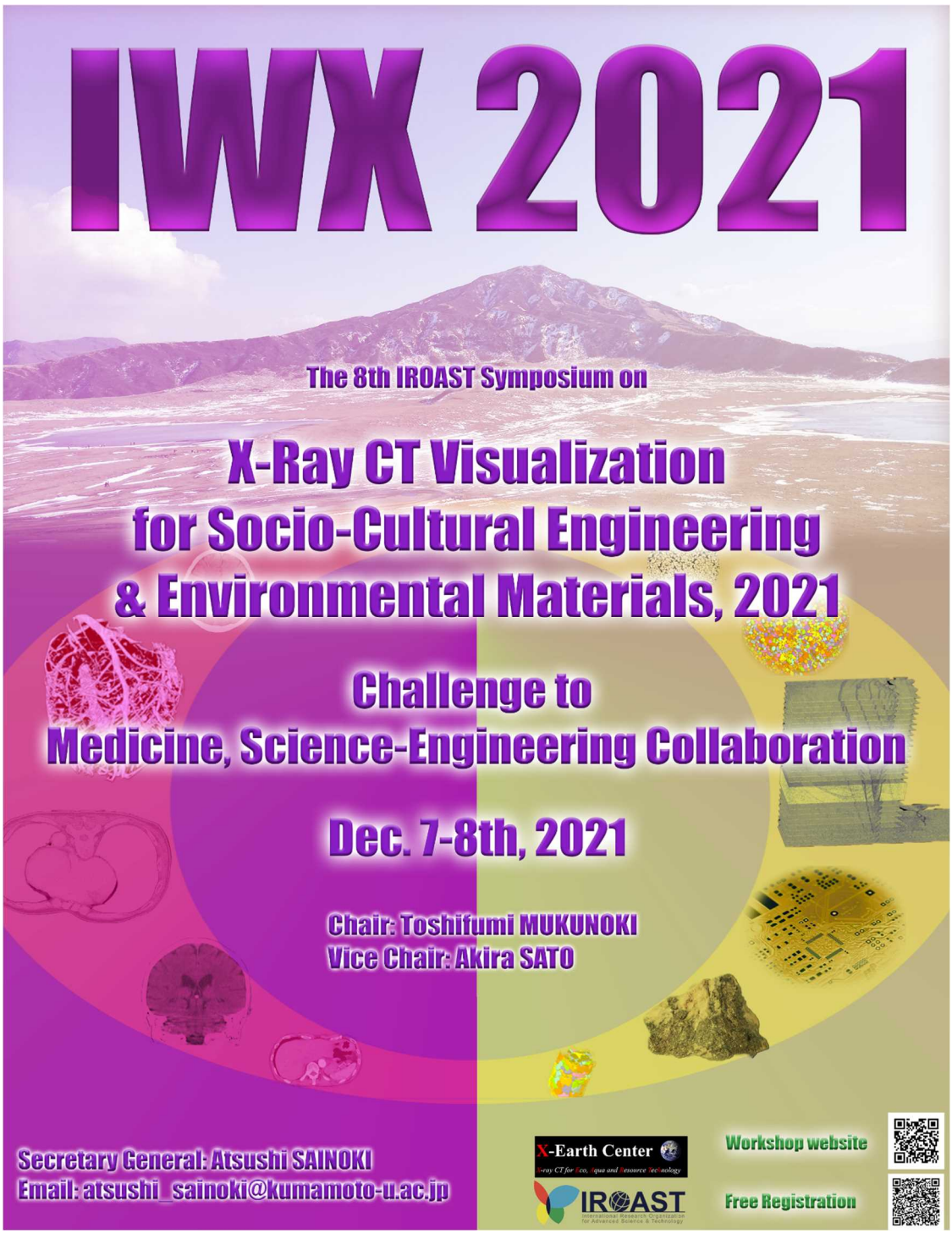
In light of the installation of the new X-ray CT scanners, X-Earth center has decided to hold the 8th international workshop with the help of IROAST. This workshop aims at further extending the engineering field of application, disseminating research outcomes obtained from the cooperation with the field of medicine, and developing the cooperation between fields of engineering and science. Furthermore, another objective of this workshop is to provide an opportunity to enhance international cooperative research through exchanges with graduate students and distinguished researchers.

2. Symposium Outcomes and Future Plan

Eventually, 185 participants made a registration for this workshop from all over the world, including South Korea, Australia, Canada, China, Czech Republic, France, Indonesia, USA, New Zealand, Mauritius, Makassar, Vietnam, and Zambia. All the attendees enjoyed this workshop whilst being intellectually stimulated by cutting-edge technologies and research outcomes. The presentations covered a wide range of topics in fields of engineering, science, and medicine, such as study on liquid-liquid two-phase flow mechanism in pore scale for granular materials and visualization of blood vessel microstructure by CT. As there are not many opportunities for researchers to see researches in the other fields, it seemed that such presentations attracted much attention. In addition to that, the student session has provided an opportunity for PhD candidates at Kumamoto University to give a presentation in English and to communicate with outstanding oversea researchers, which provided a valuable experience for them.

We are planning to hold the 9th IWX in the near future. Our goal is the same, but we will try to gather speakers of which fields are different from those of the 8th IWX. In this way, the attendees can enjoy the next IWX as well.

3. Poster & Photos



Professor Mukunoki, Kumamoto University

Associate Professor Sato, Kumamoto University

Professor Sasmito, McGill University

Dr. Tengattini, Université Grenoble Alpes

Dr. Buluke, Kumamoto University

Professor Delmas, University Auckland

IROAST Symposium Report 3

<table>
<tr><td rowspan="2">Organizer 1</td><td>Name</td><td colspan="3">Makoto Takafuji</td></tr>
<tr><td>Affiliation</td><td>Faculty of Advanced Science and Technology</td><td>Title</td><td>Professor</td></tr>
<tr><td>Symposium Title</td><td colspan="4">9th IROAST Symposium “Nano-organics and Nano-hybrids”</td></tr>
<tr><td>Venue</td><td colspan="4">Online via Zoom</td></tr>
<tr><td>Time & Date</td><td colspan="4">Fri, January 21, 2022
10:00-17:20</td></tr>
<tr><td>Speaker’s Name/ Title/Affiliation</td><td colspan="4">Yutaka Okazaki, Assistant Prof., Kyoto University
Takunori Harada, Associate Prof., Oita University
Yoshiro Kaneko, Associate Prof., Kagoshima University
Shunsuke Shiba, Assistant Prof., Ehime University
Yasuchika Hasegawa, Professor, Hokkaido University
Hiroshi Yabu, Professor, Tohoku University
Aya Tanatani, Professor, Ochanomizu University
Tatsuo Taniguchi, Professor, Chiba University
Takashi Hirose, Associate Prof., Kyoto University
Yutaka Kuwahara, Assistant Prof., Faculty of Advanced Science and Technology, Kumamoto University</td></tr>
<tr><td rowspan="6">Number of Participants</td><td rowspan="3">From KU</td><td>Faculty: 21
(Int'l participants: 0)</td><td rowspan="6">Total</td><td rowspan="6">124</td></tr>
<tr><td>Students: 74
(Int'l participants: 4)</td></tr>
<tr><td>Other</td></tr>
<tr><td rowspan="3">From outside KU</td><td>Faculty: 23
(Int'l participants: 0)</td></tr>
<tr><td>Students: 6
(Int'l participants: 0)</td></tr>
<tr><td>Other</td></tr>
</table>

Please describe the following 1 to 3.

1. Symposium Overview

The 9th IROAST symposium titled “Nano-organics and Nano-hybrids” was held on January 21st, 2022 online by the Zoom instead of planed a face-to-face international meeting at Kumamoto University, due to the COVID-19 world crisis. This symposium involved ten invited lectures by Japanese researchers from Hokkaido to Kagoshima. More than 120 participants including almost 80 students joined this symposium.

Invited lectures: Y. Okazaki (Kyoto University), T. Harada (Oita University), Y. Kaneko (Kagoshima University), S. Shiba (Ehime University) Y. Hasegawa (Hokkaido University), H. Yabu (Tohoku University), A. Tanatani (Ochanomizu University), T. Taniguchi (Chiba University) T. Hirose (Kyoto University), Y. Kuwahara (Kumamoto University)

Organizing committee members: Makoto Takafuji, Masashi Kunitake, Tsuyoshi Fukaminato, Soichiro Yoshimoto, Satoshi Watanabe and Nanami Hano from Kumamoto Univ.

2. Symposium Outcomes and Future Plan (e.g. about contribution to the development of young researchers and the initiation of international collaborative research aiming for the publication of international collaborative papers, etc.)

The “Nano-organics and Nano-hybrids” research unit of IROAST has several international collaboration research projects, with some grants, with researchers from France, China, Spain, Turkey, Bangladesh, Lithuania and USA. These international collaborations will contribute to the development of young researchers and graduate students at Kumamoto University, and the start of new international collaborations with Kumamoto University.

3. Others

Makoto Takafuji,
Symposium organizer

Kazuki TAKASHIMA,
Director of the IROAST

Invited lectures

IROAST Seminars

No.	Title	Organizer	Date
1	The 77th IROAST Seminar -Discussion seminar for Study on particle and fluid behaviors in granular materials using micro tomography-	**Toshifumi Mukunoki** Professor, FAST **Gioacchino Viggiani** Professor, UGA Visiting Professor, IROAST	May 12, 2021
2	The 78th ~ 81st IROAST Seminar - IROAST Research Unit Research Presentation Series FY2021 (1st Session-4thSession)-	**Kei Toda** Vice Director, IROAST	December 22, 2021 January 26, 2022 February 21, 2022 March 2, 2022
3	The 82nd IROAST Seminar -Robotic Vision and Mapping toward Inspection and Maintenance-	**Makoto Kumon** Professor,FAST	January 7, 2022
4	The 8th IRCMS-IROAST Joint Seminar (76th IRCMS Seminar/ 83rd IROAST Seminar) -Creation of joint researches which develops interdisciplinary research fields-	**Kazuki Takashima** Director, IROAST **Toshio Suda** Director, IRCMS	March 8, 2022

IRCMS: International Research Center for Medical Sciences, Kumamoto University

FAST: Faculty of Advanced Science and Technology

UGA: 3SR, Grenoble University, Alps

IROAST Seminar Report 1

Organizer 1	Name	Toshifumi Mukunoki		
	Affiliation	X-Earth Center, Faculty of Advanced Science and Technology	Title	Professor
Organizer 2	Name	Gioacchino Viggiani		
	Affiliation	3SR, Grenoble University, Alps (UGA)	Title	Professor
Seminar Title	Discussion seminar for Study on particle and fluid behaviors in granular materials using micro tomography			
Venue	Online seminar by Zoom			
Time & Date	16:00-19:00, May 12, 2021			
Speaker's Name/ Title/Affiliation	Professor Gioacchino Viggiani's Lab ・Dr. Cyrille Couture, 3SR ・PhD candidate Gustavo Pinzón Professor Mukunoki Toshifumi's Lab ・PhD candidate Nohara Shintaro, Central Research Institute of Electric Power Industry ・Dr. Sato Takahiro, Technical Division, Faculty of Engineering, KU			

Number of Participants *Including speakers	From KU	Faculty: 6 (Int'l participants: 0)	Total	43
		Students: 27 (Int'l participants: 5)		
	From outside KU	Faculty: 9 (Int'l participants: 9)		
		Students: 1 (Int'l participants: 1)		

1.Seminar Overview

Program of seminar

Time (CEST)	Time (JST)	Talk
09:00-09:15	16:00-16:15	**Opening** *Prof. Kazuki Takashima (KU)* *Prof. Gioacchino Viggiani (UGA)* *Prof. Toshifumi Mukunoki (KU)*
09:15-09:45	16:15-16:45	**Evaluation of particle structure evolution in shearing process using X-ray CT** *Shintaro Nohara (KU)*
09:45-10:15	16:45-17:15	**Experimental study on 3D fingering of immiscible fluids in porous media** *Cyrille Couture (UGA)*
10:15-10:30	17:15-17:30	Break
10:30-11:00	17:30-18:00	**An experimental study on the influence of grain shape on fabric and the mechanical properties** *Takahiro Sato (KU)*
11:00-11:30	18:00-18:30	**Strain localisation in inherently anisotropic granular materials measured using x-ray tomography** *Gustavo Pinzón (UGA)*
11:30-12:00	18:30-19:00	**Closing discussion** *Prof. Gioacchino Viggiani*

Prof. Mukunoki took a charge of the entire seminar and so he was MC. Prof. Takashima, who was a new director of IROAST gave his opening speech. Then, Prof. Viggiani reviewed the collaborated activities of X-Earth center organized by Prof. Otani and 3SR and his activity as a visiting professor of IROAST so far.

This seminar had two speakers from each and each of them gave 20-25 minutes presentation and 10 minutes discussion.

2. Seminar Outcomes and Future Plan

Of the four speakers, three (Mr. Nohara, Dr. Sato, and Mr. Gustavo) modeled soil particle shape as an ellipsoid to obtain the movement (displacement and rotation) of particles under loading, and used it to evaluate the deformation behavior of granular materials more microscopically. We were able to exchange information on reference papers, and there was a suggestion to consider using each other's image analysis methods to evaluate the same phenomenon, which may lead to joint research. In addition, one of the other researchers (Dr. Cyrille) was studying the phenomenon of oil seepage in soil, which was in line with Prof. Mukunoki's research theme, and we proposed to actively promote discussions in the future.

3. Comments from Prof. Viggiani

It was a very fruitful and good seminar as both institutions were able to give suggestions and comments on each other's research.

4. Others

At the end of the meeting, Prof. Mukunoki gave a short notice of IWX2021 to be held on December 7-8, 2021, and students who will be studying at Grenoble University from this September introduced themselves, and the meeting ended peacefully.

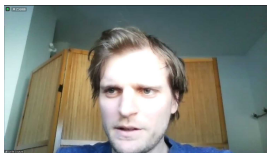
Prof. Takashima (KU)
Director of IROAST

Prof. Viggiani (UGA)
Visiting professor of IROAST

Prof. Mukunoki (KU)
Organizer

Prof. Otani (KU)
Trustee and Vice President of Kumamoto University

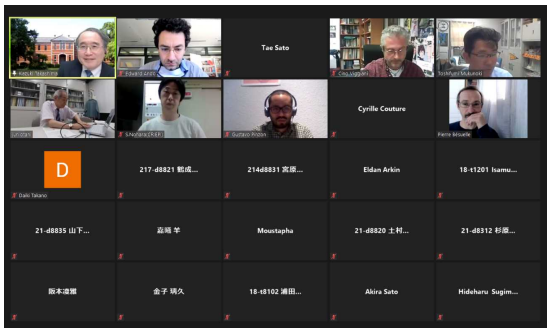
Mr. Nohara (KU)



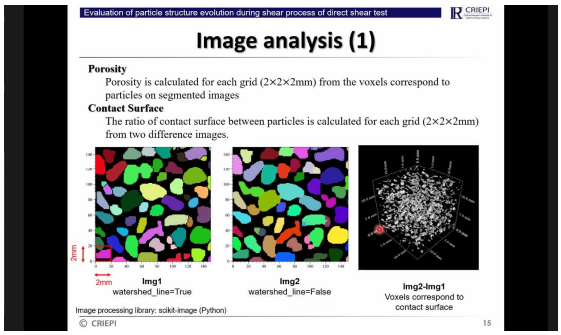
Dr. Couture (UGA)

Dr. Sato (KU)

Mr. Pinzón (UGA)



Scene 1 of seminar



Scene 2 of seminar

IROAST Seminar Report 2

<table>
<tr><td rowspan="2">Organizer 1</td><td>Name</td><td colspan="3">Kei Toda</td></tr>
<tr><td>Affiliation</td><td>IROAST</td><td>Title</td><td>Vice Director</td></tr>
<tr><td>Seminar Title</td><td colspan="4">The 78th ~ 81st IROAST Seminar
-IROAST Research Unit Research Presentation Series FY2021-</td></tr>
<tr><td>Venue</td><td colspan="4">Online seminar by Zoom</td></tr>
<tr><td>Time & Date</td><td colspan="4">12:00-12:45 on;
December 22, 2021
January 26, 2022
February 21, 2022
March 2, 2022</td></tr>
<tr><td>Speaker’s Name/
Title/Affiliation</td><td colspan="4">--The 78th seminar --
Mitsuhiro Aida, Professor, IROAST
Makiko Kobayashi, Associate Professor, FAST
Ruda Lee, Associate Professor, IROAST

--The 79th seminar --
Mitsuru Sasaki, Associate Professor, IINa
Keitaro Takahashi, Professor, FAST
Takumi Higaki, Associate Professor, FAST

--The 80th seminar --
Kei Ishida, Associate Professor, CWMD
Atsushi Sainoki, Associate Professor, FAST
Shin-ichi Ohira, Professor, FAST

--The 81st seminar --
Gaochuang Cai, Associate Professor, IROAST
Yutaka Kuwahara, Assistant Professor, FAST
Hiroki Matsuo, Associate Professor, IROAST</td></tr>
<tr><td rowspan="5">Number of
Participants
*Including speakers</td><td rowspan="3">From KU</td><td>Faculty: 48
(Int'l participants: 7)</td><td rowspan="5">Total</td><td rowspan="5">90</td></tr>
<tr><td>Students: 16
(Int'l participants: 4)</td></tr>
<tr><td>Others: 24</td></tr>
<tr><td rowspan="2">From outside KU</td><td>Faculty: 2
(Int'l participants: 0)</td></tr>
<tr><td>Students: 0
(Int'l participants: 0)</td></tr>
<tr><td colspan="5">The 78th ~ 81st IROAST Seminar entitled IROAST Research Unit Research Presentation Series FY2021 were held from 12:00 to 12:45 between December 2021 to March 2022.
In this presentation series, 12 IROAST Research Unit representative speakers reported their work progress and introduce their research.
The seminar was held 4 times. Though the seminars were held in remote in limited time, audiences frequently asked questions and discussions were actively carried out. We were also able to confirm the progress of young researchers' progresses. We could share the research results that are expected to impact on future science and to be applied in advanced technology.
Recently, there have been few opportunities among IROAST researchers to get to know each other because of the COVID-19 situation. However, the young research members could understand seeds and aims of other members through this seminar.
It is expected that joint research will develop on this occasion. It is hoped that we will be able to have face-to-face meetings or hybrid meetings soon next fiscal year.</td></tr>
</table>

Opening＆Closing

Kazuki Takashima,
Director of IROAST

Kei Toda
Vice-director of IROAST

The 78th seminar

Prof. Aida, IROAST

Assoc. Prof. Kobayashi, FAST

Assoc. Prof. Lee, IROAST

The 79th seminar

Assoc. Prof. Sasaki, IINa

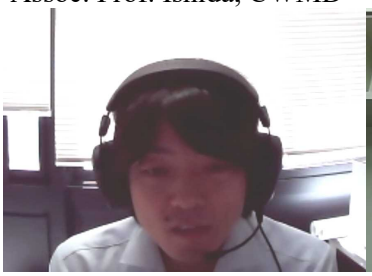
Prof. Takahashi, FAST

Assoc. Prof. Higaki, FAST

The 80th seminar

Assoc. Prof. Ishida, CWMD

Prof. Ohira, FAST



Assoc. Prof. Sainoki, FAST

Assist. Prof. Ito, FAST (from Sainoki Unit)

The 81st seminar

Assoc. Prof. Cai, IROAST

Assist. Prof. Kuwahara, FAST

Assoc. Prof. Matsuo, IROAST

IROAST Seminar Report 3

<table>
<tr><td rowspan="2">Organizer 1</td><td>Name</td><td colspan="3">Makoto Kumon</td></tr>
<tr><td>Affiliation</td><td>Faculty of Advanced Science and Technology</td><td>Title</td><td>Professor</td></tr>
<tr><td>Seminar Title</td><td colspan="4">Robotic Vision and Mapping toward Inspection and Maintenance
（The 82nd IROAST seminar）</td></tr>
<tr><td>Venue</td><td colspan="4">Online seminar by Zoom</td></tr>
<tr><td>Time & Date</td><td colspan="4">14:40-16:10, January 7, 2022</td></tr>
<tr><td>Speaker’s Name/ Title/Affiliation</td><td colspan="4">Tomonari Furukawa/Professor/University of Virginia</td></tr>
<tr><td rowspan="5">Number of Participants
*Including speakers</td><td rowspan="3">From KU</td><td>Faculty: 5
(Int'l participants: 0)</td><td rowspan="5">Total</td><td rowspan="5">28</td></tr>
<tr><td>Students: 17
(Int'l participants: 5)</td></tr>
<tr><td>Others: 5</td></tr>
<tr><td rowspan="2">From outside KU</td><td>Faculty: 1
(Int'l participants: 0)</td></tr>
<tr><td>Students: 0
(Int'l participants: 0)</td></tr>
</table>

1. Seminar Overview

The talk was about the framework of the robotic vision system to realize significantly accurate map of the environment that is useful for not only the navigation but also for the industrial level inspection and maintenance. The framework proposes multi-stage approach that consists of the coarse and rough but global mapping step, and the fine and precise local mapping step.
The second half of the talk was about the novel accurate three-dimensional reconstruction method using photometric-stereo approach. The method handles both speculator and diffusive reflection to provide pixel resolution normal information of the surface, and the surface structure can be obtained by integrating the normal distribution under mild assumptions.

2. Seminar Outcomes and Future Plan

Building Inspection and Maintenance (BIM) was a new viewpoint for the use of robotic systems in the practical purposes, and the talk revealed how the academic works and approaches could be translated into the industry. The host is certain that this talk broadened the participants’, especially young researchers’ minds on their own researches.
Photometric-stereo based three-dimension reconstruction as a robot sensor is a novel approach, and some of the students who attended the talk were interested in the technique, and there might be a chance to initiate a new international collaborative project in the future.

3. Comments from the invited speaker

Since the seminar was held when the number of Omicron cases started to increase, most of the participants attended the seminar in a Zoom room. The hybrid arrangement resulted in success as the number of participants was larger than what we expected. The seminar also attracted international students successfully. The speaker enjoyed the talk partly because his new ideas were shared with students and partly because some students showed interest in the presented approaches.

4. Others

IROAST Seminar Report 4

<table>
<tr><td rowspan="2">Organizer 1</td><td>Name</td><td colspan="3">Kazuki Takashima</td></tr>
<tr><td>Affiliation</td><td>IROAST</td><td>Title</td><td>Director</td></tr>
<tr><td rowspan="2">Organizer 2</td><td>Name</td><td colspan="3">Toshio Suda</td></tr>
<tr><td>Affiliation</td><td>IRCMS</td><td>Title</td><td>Director</td></tr>
<tr><td>Seminar Title</td><td colspan="4">The 8th IRCMS-IROAST Joint Seminar
(76th IRCMS Seminar/ 83rd IROAST Seminar)
“Creation of joint researches which develops interdisciplinary research fields”</td></tr>
<tr><td>Venue</td><td colspan="4">Online seminar by Zoom</td></tr>
<tr><td>Time & Date</td><td colspan="4">13:30-15:20, March 8, 2022</td></tr>
<tr><td>Speaker’s Name/
Title/Affiliation</td><td colspan="4">1. Hidenobu Mizuno, Associate Professor, IRCMS
2. Yuichiro Arima, Associate Professor, IRCMS
3. Guojun Sheng, Professor, IRCMS
4. Kenichi Miharada, Professor, IRCMS
5. Hiroki Matsuo, Associate Professor, IROAST</td></tr>
<tr><td rowspan="5">Number of
Participants
*Including speakers</td><td rowspan="3">From KU</td><td>Faculty: 32
(Int'l participants: 7)</td><td rowspan="5">Total</td><td rowspan="5">51</td></tr>
<tr><td>Students: 12
(Int'l participants: 7)</td></tr>
<tr><td>Others: 7</td></tr>
<tr><td rowspan="2">From outside KU</td><td>Faculty: 0
(Int'l participants: 0)</td></tr>
<tr><td>Students: 0
(Int'l participants: 0)</td></tr>
</table>

1. Seminar Overview

The 8th IRCMS-IROAST Joint Seminar (76th IRCMS Seminar/ 83rd IROAST Seminar) “Creation of joint researches which develops interdisciplinary research fields” was held from 13:30 to 15:20 on March 8, 2022.

Since their establishment, both IROAST and IRCMS have been actively engaged in joint research that takes advantage of their respective strengths, and have contributed to enhancing the international presence and reputation of the University.

It goes without saying that there are many unexplored research seeds lying dormant in the boundary areas of research fields such as life science and engineering.

In order to discover such valuable research seeds, we have supported joint research groups consisting of researchers in the life sciences and natural sciences with financial support from the President and have achieved significant results to date. The results have been reported and demonstrated in seminars held seven times in the past.

In this seminar, in addition to presentations from the joint research groups, new research seeds that will lead to future collaborations were presented. The names of the researchers and their research titles are listed below in the attached flyer.

2. Seminar Outcomes and Future Plan

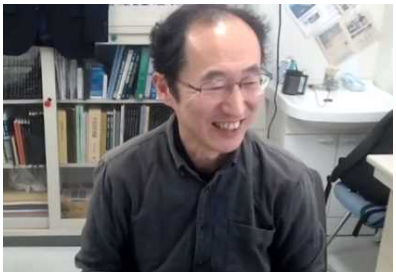
The seminar was jointly organized by Prof. Toshio Suda, Director of the International Research Center for Medical Sciences (IRCMS) and Prof. Kazuki Takashima, the director of International Research Organization for Advanced Science and Technology (IROAST). We have held eight seminars so far, but this seminar was the last. We have achieved a number of results during this period. We would like to further expand the medical-industrial collaboration based on the past cooperation.

3. Comments

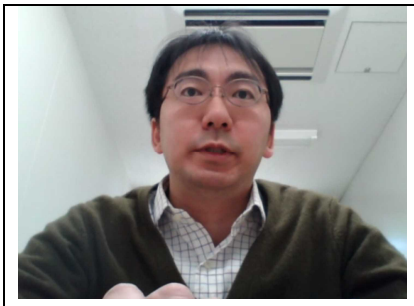
Like last year, the seminar was held online due to the expansion of COVID-19 infection, but active discussions were conducted and the advantages of online were put to good use.

Opening address:
Kazuki Takashima,
Director, IROAST

MC1: Guojun Sheng,
Professor, IRCMS

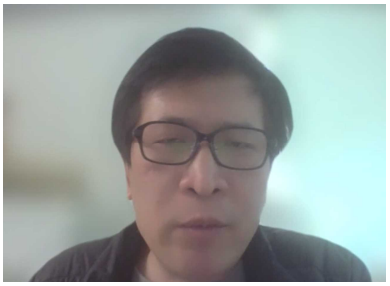


MC2: Kei Toda,
Vice Director, IROAST



Hidenobu Mizuno,
Associate Professor, IRCMS

Yuichiro Arima,
Associate Professor, IRCMS



Guojun Sheng,
Professor, IRCMS

Kenichi Miharada,
Professor, IRCMS

Hiroki Matsuo,
Associate Professor, IROAST

Closing address:
Hitoshi Takizawa,
Vice Director, IRCMS

Published Papers by IROAST Researchers

Kei Toda

K. Saeki, K. Ikari, Y. Kazuya, H. Yokoi, S. Ohira, H. Okochi, K. Toda, "Biogenic Diamines and Their Amide Derivatives Are Present in the Forest Atmosphere and May Play a Role in Particle Formation," ACS Earth and Space Chemistry, 6, 421–430, 2022.

M. Takeuchi, N. Tomiyasu, M. Namikawa, H. Tanaka, K. Toda, N. Katsumi, H. Okochi, "On-line analysis of free-tropospheric water-soluble acidic gases and particulate anions on the summit of Mt. Fuji, Japan," Atmospheric Environment, 273, 118977, 2022.

Dmitri Aleks Molodov

L.A. Barrales-Mora, Y. Tokuda, D.A. Molodov, S. Tsurekawa, "On incipient plasticity in the vicinity of grain boundaries in aluminum bicrystals: Experimental and simulation nanoindentation study," Materials Science and Engineering: A, 828, 142100, 2021.

J.E. Brandenburg, J. Seo, K. Eto, D.A. Molodov, S. Tsurekawa, "Influence of symmetrical <10$\bar{1}$0> high-angle tilt grain boundaries on the local mechanical properties of magnesium bicrystals," Materials Science and Engineering: A, 826, 141913, 2021.

László Pusztai

Temleitner, L., Pusztai, L., Cuello, G., Stunault, A., "Structural studies of ^{1}H-containing liquids by polarized neutrons: Chemical environment and wavelength dependence of the incoherent background," J. Mol. Liq., 350, 118535, 2022.

Pethes, I., Pusztai, L., Ohara, K., Temleitner, L., "Temperature-dependent structure of 1-propanol/water mixtures: X-ray diffraction experiments and computer simulations at low and high alcohol contents," J. Mol. Liq., 340, 117188, 2021.

Pothoczki, S, Pethes, I, Pusztai, L, Temleitner, L, Ohara, K, Bakó, I, "Properties of Hydrogen-Bonded Networks in Ethanol–Water Liquid Mixtures as a Function of Temperature: Diffraction Experiments and Computer Simulations," The Journal of Physical Chemistry B, 125(23), 6272-6279, 2021.

Yufeng Zheng

Kun Wang, Guo Bao, Qianqian Fan, Liquan Zhu, Lijun Yang, Tingting Liu, Zechuan Zhang, Guannan Li, Xihua Chen, Xiangbo Xu, Xiaoxue Xu, Bin He, Yufeng Zheng, "Feasibility evaluation of a Cu-38 Zn alloy for intrauterine devices: In vitro and in vivo studies," Acta Biomaterialia, 138, 561-575, 2022.

Xinhua Qu, Hongtao Yang, Bo Jia, Minqi Wang, Bing Yue, Yufeng Zheng*, Kerong Dai*, "Zinc alloy-based bone internal fixation screw with antibacterial and anti-osteolytic properties," Bioactive Materials, 6, 12, 4607-4624, 2021. (*corresponding author)

Hongtao Yang, Xinhua Qu, Minqi Wang, Houwen Cheng, Bo Jia, Jianfeng, Nie, Kerong Dai, Yufeng Zheng, "Zn-0.4Li alloy shows great potential for the fixation and healing of bone fractures at load-bearing sites," Chemical Engineering Journal, 417, 129317, 2021.

Mitsuhiro Aida

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