

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		
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Unit Members			
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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 starting 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 applicable 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 graphene 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 tetrachlorophthalimide, 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. Yagy, Z. Feng, Y. Sekine, L. F. Lindoy, J. Ohya, 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. Yagy, 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. Yagy, 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

Structural and Magnetic Characterization of Homo- and Heterometallic Trinuclear Ni(II) and Cu(II) Clusters with N₂O₆ Acyclic Polydentate Ligand, S. Kusumoto, H. Umeno, Y. Kim, Y.

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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

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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

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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),

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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

3D Porous Ni/NiOx as a bifunctional oxygen electrocatalyst derived from Freeze-dried Ni(OH)₂, Y. Shudo, M. Fukuda, Md. S. Islam, K. Kuroiwa, Y. Sekine, M. R. Karim, S. Hayami, *Nanoscale.*, 13(10), 5530-5535 (2021). DOI: 10.1039/D0NR08034A

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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

Functionalised Terpyridines and Their Metal Complexes-Solid-State Interactions, Y. H. Lee, J. Y. Kim, S. Kusumoto, H. Ohmagari, M. Hasegawa, P. Thuéry, J. Harrowfield, S. Hayami, Y. Kim, *Chemistry*, 2021, 3(1), 199-227 (2021). DOI: 10.3390/chemistry3010016

Coordinated halide and pseudo halide-dependent structures and photoluminescence of defective double cubane Zn(II) clusters, T. Kuramitsu, S. Kusumoto, H. Ohmagari, M. Hasegawa, P. Thuéry, Y. Kim, S. Hayami, M. Nakamura, *Eur. J. Inorg. Chem.*, 2021, 1160-1164 (2021). DOI: 10.1002/ejic.202001138

Elastic Crystalline Fibers Composed of a Nickel(II) Complex, S. Kusumoto, A. Sugimoto, Y. Zhang, Y. Kim, M. Nakamura, S. Hayami, *Inorg. Chem.*, 60(3), 1294-1298 (2021). DOI: 10.1021/acs.inorgchem.0c03295

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

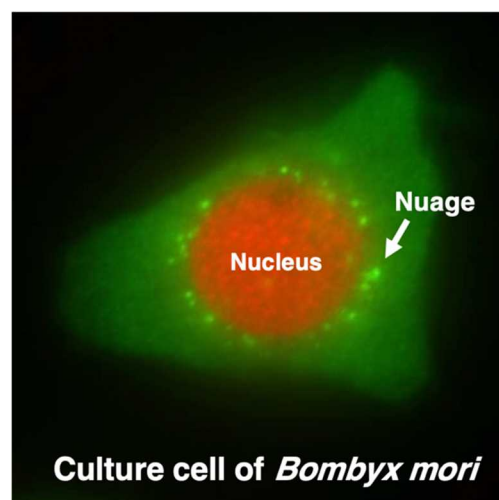
KAKENHI Grant-in-Aid for Scientific Research (A) JP17H01200 and Grant-in-Aid for Exploratory Research 20K21213.

4. Application & acquisition status of industrial property rights
non

No. 4-2	RNA Biology		
Research Field	Advanced Green Bio		
Unit Coordinator			
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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		
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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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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.

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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.

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.

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

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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.

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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		
Hiroataka 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 <i>IROAST Visiting Professor</i>		
Josep-Lluís BARONA-VILAR	Instituto de Historia de la Medicina y de la Ciencia López Piñero (IHMC), Universidad de Valencia, Spain Professor <i>IROAST Visiting Professor</i>		
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 <i>IROAST Visiting Professor</i>		
Etsuko FUJITA	Chemistry Division, Brookhaven National Laboratory, USA Senior Scientist Emeritus <i>IROAST Visiting Professor</i>		

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. Shahrzuzaman, 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. Shahrzaman, 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. Shirotsuki, 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 Bioelectronics 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-biostatic 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-L1 high 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

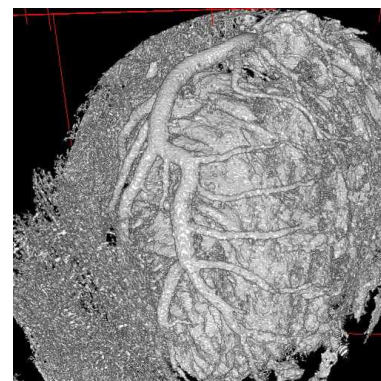
The topic of this research unit is the application of x-ray imaging to engineering, especially for geomaterials (soils, rock, and concrete). X-ray imaging plays a key role for the experimental multi-scale analysis of geomechanics, in that it helps linking the mechanisms occurring at the micro scale to 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	IRCMS, Developmental Cardiology, Associate Professor (PI) Faculty of Advanced Science and Technology (FAST), Kumamoto University Professor		
Patrice DELMAS	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 to 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).

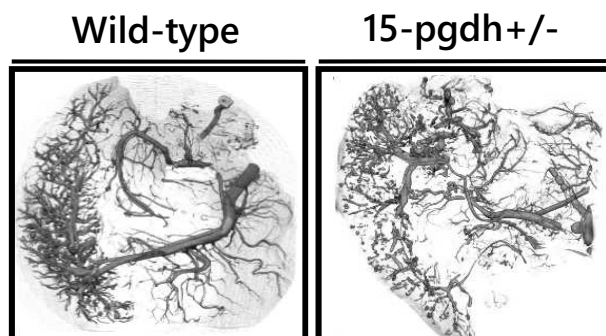


Figure 1

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 visiting 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 $\langle 10\bar{1}0 \rangle$ 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 $\langle 10\bar{1}0 \rangle$ 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 Na_{1+x}Al_xGe_{2-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 ¹H-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 Fe₂S, *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}Te₅₀ 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 Ge₂Sb₂Te₅, *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 CO₂ 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 CO₂ 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 CO₂ 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 CO₂ and SO₂ 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 Ichianagi**, 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 Ichianagi**, 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 Ichianagi, 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 Ichianagi**, 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 Ichianagi**, 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 ($\delta^{15}\text{N}$ vs. $\delta^{18}\text{O}$). *Isotopes in Environmental and Health Studies*, 58, 1-17. <https://doi.org/10.1080/10256016.2021.1990913>
- Mojtaba Heydarizad, Masoud Minaei, **Kimpei Ichianagi**, Rogert Sori (2021), The effects of local and regional parameters on the $\delta^{18}\text{O}$ and $\delta^2\text{H}$ 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		

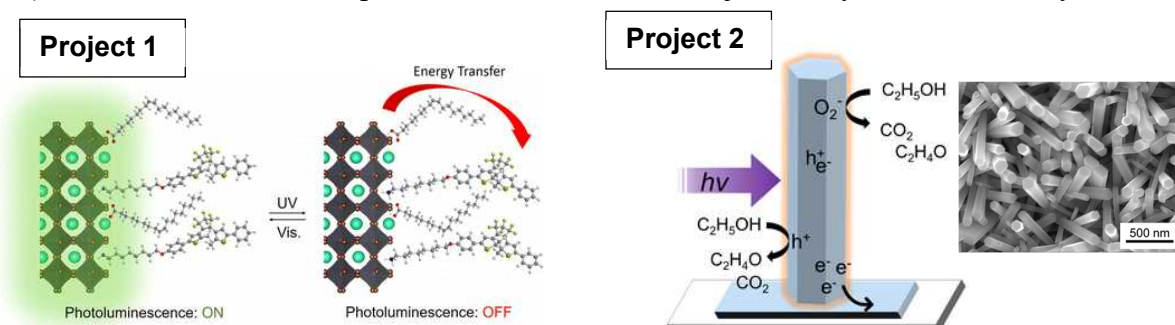
1. Overview of achievements

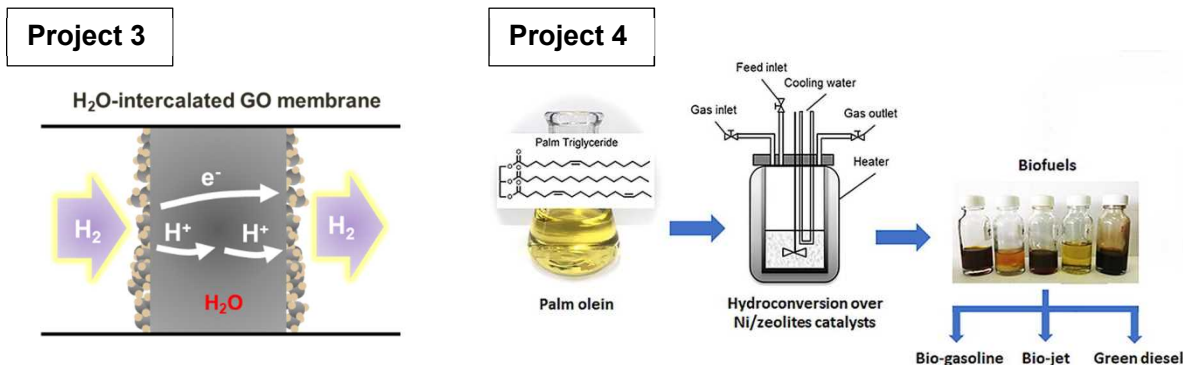
Our research projects are divided into four categories:

- 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, CsPbX₃ (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) Success 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-Ummuay, T. Kida, Enhanced Interfacial Charge Transfer Between CsPbBr₃ Quantum Dots and Surface-Modified TiO₂/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 CsPbBr₃ 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, TiO₂-Coated CsPbI₃ 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 NH₃-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 NH₃-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 H₂O-CO₂ 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 deNO_x 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	Chinese Academy of Sciences, China Postdoctoral Fellow		
Masaki SHIMONO	Michigan State University, USA Research Associate		
Kae AKITA	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 TiO₂ and Al₂O₃ 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 NaYF₄:Yb,Tm@NaYF₄/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 Na₃V₂(PO₄)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. TiO₂ 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, Biadaptability 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-2019R111A3A01061857) (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 electro-dialytic pretreatment and enrichment for Fe(II) in environment”, 57th FIA symposium (On-line), 2021/10/6. [Young poster award]
- **S. Ohira**, Electro-dialytic 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, Electro-dialytic Speciation Analysis for Chromium Species, Pacificchem 2021, on-line, 2021/12/17.
- **S. Ohira**, Y. Sato, K. Kaneda, K. Toda, Universal Detection HPLC for Sugars and Organic acids, Pacificchem 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 Cloud. 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, Subhajt 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 $\sim 13 - 17$ ”

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, Krállová 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 *CUP-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 CO₂ 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 CO₂ 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 CO₂ 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 aqueous 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 CO₂ 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 CO₂ mineralization may be enhanced by the presence of anaerobic microorganisms (Figure 2) in the form of organic matters, although the precipitation of CaCO₃ is still low. Furthermore, the metal elements required for the successful cultivation of the microorganisms that contribute to CO₂ mineralization can be identified by conducting screening with different types of media.



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

Table 1: Types of anaerobic microbes screened from andesite, limestone, and coal cores

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

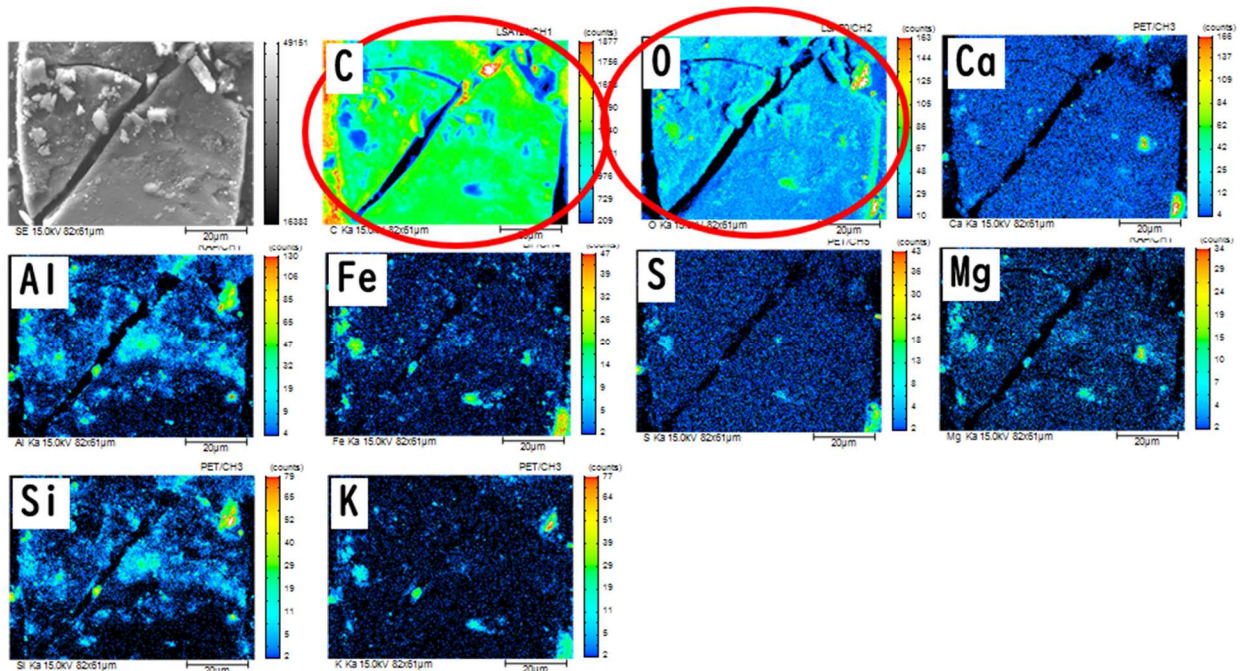


Figure 2: Carbon fixation as organic matters, but low precipitation as CaCO_3

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		
Affiliation	Faculty of Advanced Science and Technology Email: kobayashi@cs.kumamoto-u.ac.jp	Title	Professor
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.

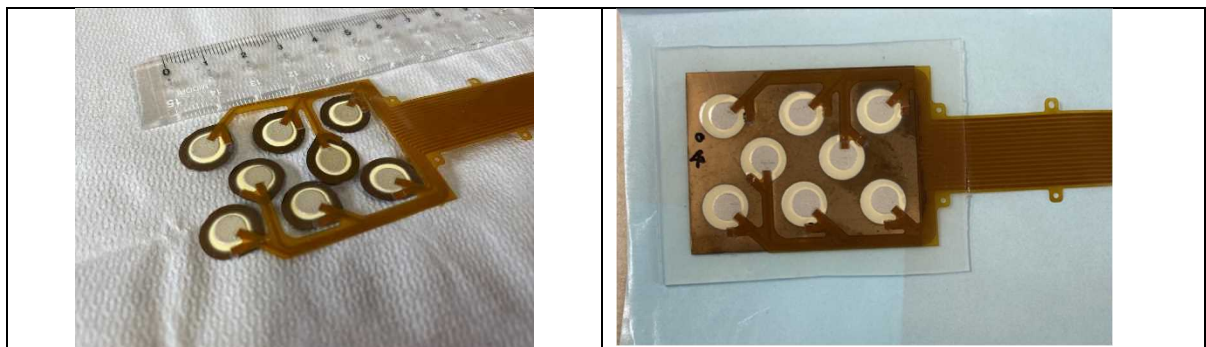


Fig. 1 Prototype 8 channel flexible ultrasonic sensors.

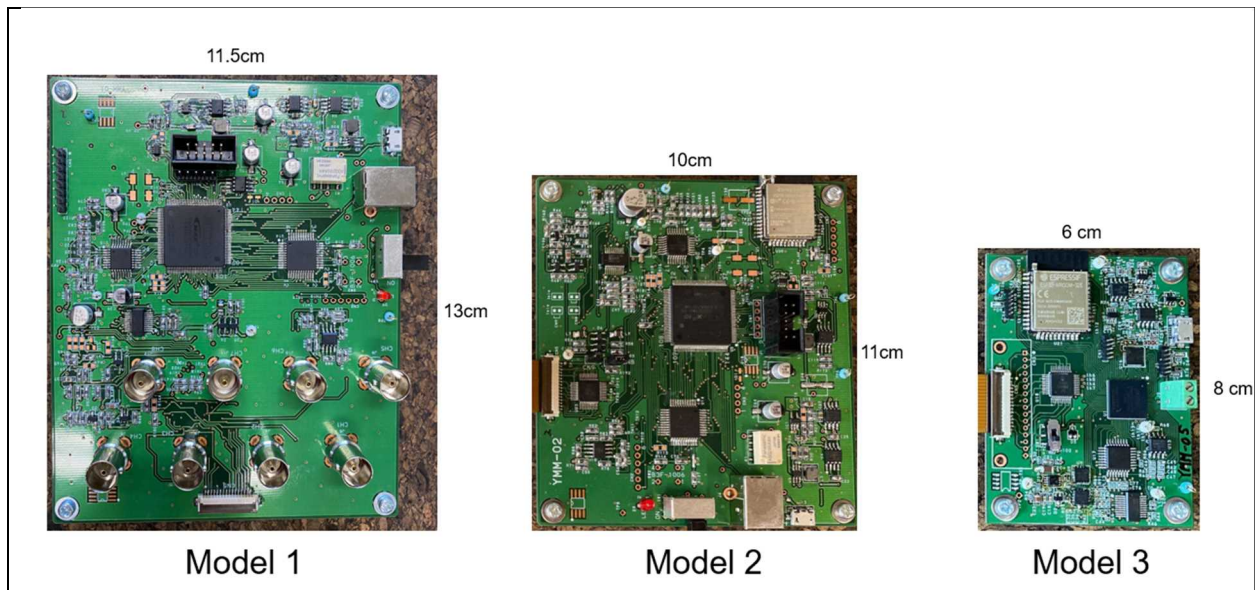


Fig. 2 Prototype 8 channel portable P/R machines.

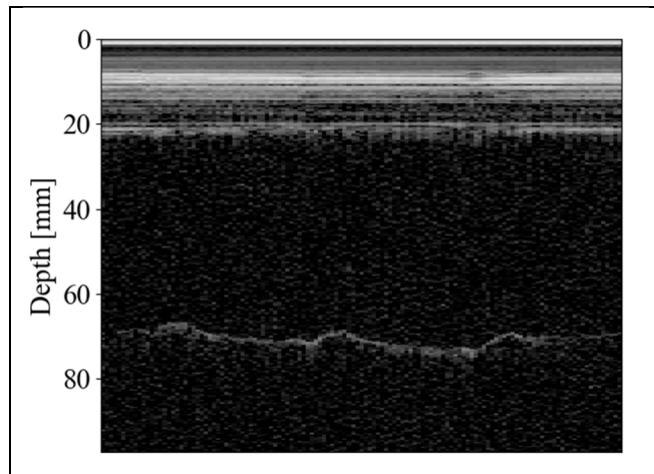


Fig. 3 M mode image by prototype sensors and P/R

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

LiNbO₃-based sol-gel composite ultrasonic transducer poled at low temperatures

Naoki Kambayashi, Naoki Zaito, Hiroaki Akatsuka, Makiko Kobayashi

Jpn. J. Appl. Phys., Feb. 2022 (accepted)

Real-Time Physiological Monitoring for Management of Normobaric Hypoxic Training Toward Wearable System Implementation

Kazuki Hisatsune, Toshitaka Yamakawa

Journal of Digital Life 1(2), Feb. 2022.

Heart Rate Variability Indices May Change Accompanying Cognitive Skills Improvement in eSports Tasks

Kazuki Hisatsune, Toshihide Otsuki, Goichi Hagiwara, Hirohisa Isogai, Toshitaka Yamakawa

Journal of Digital Life 1(4), Feb. 2022.

A Pilot Study of the Effects of Human Intervention on Canine Group Movement Behavior

Miho Nagasawa, Satomi Kuramochi, Azumi Hamamoto, Toshitaka Yamakawa, Takefumi Kikusui
Journal of Robotics and Mechatronics 33(3) 572-581, Jun. 2021.

Development of Game-Like System Using Active Behavior Input for Wakefulness-Keeping Support in Driving

Tatsuro Ibe, Koichi Fujiwara, Toshihiro Hiraoka, Erika Abe, Toshitaka Yamakawa

IEEE Transactions on Intelligent Vehicles 6(2) 323-332, Jun. 2021.

Sympathetic hyperactivity, hypertension, and tachycardia induced by stimulation of the ponto-medullary junction in humans.

Tadashi Hamasaki, Toshitaka Yamakawa, Koichi Fujiwara, Haruki Harashima, Kota Nakamura, Yoshihiro Ikuta, Tatsuo Yamamoto, Yu Hasegawa, Tatsuya Takezaki, Akitake Mukasa

Clinical neurophysiology: official journal of the International Federation of Clinical Neurophysiology 132(6) 1264-1273, Jun. 2021.

CGP17Pat: Automated Schizophrenia Detection Based on a Cyclic Group of Prime Order Patterns Using EEG Signals

E Aydemir, S Dogan, M Baygin, CP Ooi, PD Barua, T Tuncer, UR Acharya

Healthcare 10 (4), 643, Mar. 2022.

Automated Detection of Hypertension Using Continuous Wavelet Transform and a Deep Neural Network with Ballistocardiography Signals

JS Rajput, M Sharma, TS Kumar, UR Acharya

International Journal of Environmental Research and Public Health 19 (7), 4014, Mar. 2022.

Heart rate variability for medical decision support systems: A review

O Faust, W Hong, HW Loh, S Xu, RS Tan, S Chakraborty, PD Barua, F Molinari, UR Acharya

Computers in Biology and Medicine, 105407, Mar. 2022.

A Hand-Modeled Feature Extraction-Based Learning Network to Detect Grasps Using sEMG Signal

M Baygin, PD Barua, S Dogan, T Tuncer, S Key, UR Acharya, KH Cheong

Sensors 22 (5), 2007, Mar. 2022.

Resource allocation optimization using artificial intelligence methods in various computing paradigms: A Review

Javad Hassannataj Joloudari, Roohallah Alizadehsani, Issa Nodehi, Sanaz Mojriani, Fatemeh Fazl, Sahar Khanjani Shirkharkolaie, HM Dipu Kabir, Ru-San Tan, U Rajendra Acharya

arXiv e-prints, arXiv: 2203.12315, Mar. 2022.

Automated Intracranial Hematoma Classification in Traumatic Brain Injury (TBI) Patients Using Meta-Heuristic Optimization Techniques

U Raghavendra, Anjan Gudigar, Praneet Kasula, Yashas Chakole, Ajay Hegde, Chui Ping Ooi, Edward J Ciaccio, U Rajendra Acharya

Informatics 9 (1), 4, Mar. 2022.

Detection of epileptic seizures on EEG signals using ANFIS classifier, autoencoders and fuzzy entropies

Afshin Shoeibi, Navid Ghassemi, Marjane Khodatars, Parisa Moridian, Roohallah Alizadehsani, Assef Zare, Abbas Khosravi, Abdulhamit Subasi, U Rajendra Acharya, Juan M Gorris

Biomedical Signal Processing and Control 73, 103417, Mar. 2022.

Feature-versus deep learning-based approaches for the automated detection of brain tumor with magnetic resonance images: A comparative study

U Raghavendra, Anjan Gudigar, Tejaswi N Rao, V Rajinikanth, Edward J Ciaccio, Chai Hong Yeong, Suresh Chandra Satapathy, Filippo Molinari, [U Rajendra Acharya](#)

International Journal of Imaging Systems and Technology 32 (2), 501-516, Mar. 2022.

Decision support system for major depression detection using spectrogram and convolution neural network with EEG signals

HW Loh, CP Ooi, E Aydemir, T Tuncer, S Dogan, [UR Acharya](#)

Expert Systems 39 (3), e12773, Mar. 2022.

Application of Artificial Intelligence Techniques for Automated Detection of Myocardial Infarction: a Review

Javad Hassannataj Joloudari, Sanaz Mojriani, Issa Nodehi, Amir Mashmool, Zeynab Kiani Zadegan, Sahar Khanjani Shirkharkolaie, Roohallah Alizadehsani, Tahereh Tamadon, Samiyeh Khosravi, Mitra Akbari Kohnehshari, Edris Hassannatajjeloudari, Danial Sharifrazi, Amir Mosavi, Hui Wen Loh, Ru-San Tan, [U Rajendra Acharya](#)

EasyChair, Feb. 2022.

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Computers in Biology and Medicine 136, 104697, Sep. 2021.

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Diagnostics 11 (8), 1446, Aug. 2021.

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M Sharma, [UR Acharya](#)

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D Maheshwari, SK Ghosh, RK Tripathy, M Sharma, [UR Acharya](#)

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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](#)
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Moloud Abdar, Soorena Salari, Sina Qahremani, Hak-Keung Lam, Fakhri Karray, Sadiq Hussain, Abbas Khosravi, [U Rajendra Acharya](#), Saeid Nahavandi
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SK Khare, V Bajaj, [UR Acharya](#)
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M Coskun, O Yildirim, Y Demir, [UR Acharya](#)
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DR Nayak, D Das, B Majhi, SV Bhandary, [UR Acharya](#)

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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

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SK Khare, V Bajaj, UR Acharya

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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

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Automatic identification of insomnia using optimal antisymmetric biorthogonal wavelet filter bank with ECG signals

M Sharma, HS Dhiman, UR Acharya

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U Raghavendra, Anjan Gudigar, V Vidhya, B Nageswara Rao, Sukanta Sabut, Joel Koh En Wei, Edward J Ciaccio, U Rajendra Acharya

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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.

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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 terpyridine-amine Co^{III}-H formation during catalytic H₂ 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		
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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		
Cinthyia 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 120-140°C 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, Cinthy 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 wave induced by pulsed discharge on water”, *Journal of Physics D: Applied Physics*, **55**(11), 115203 (2021).

Cinthy 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), Pacificchem 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), Pacificchem 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), Pacificchem 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), Pacificchem 2021 Congress (online), Hawaii, US, 2021.

Masayo Nishizono, Cinthy 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.

Cinthy 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 BaTiO₃ (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 BaTiO₃ 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 BiFeO₃-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* (DfS³), 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