2-3. International Joint Research Faculty Members

No.	Name	Project Title
2-3-1	**Takumi HIGAKI** FAST	Digital Plant Cell Biology
2-3-2	**Takahiro HOSONO** FAST	Environmental Diagnosis on Earth Surface Systems
2-3-3	**Kei ISHIDA** CWMD	Deep Learning for Hydrology
2-3-4	**Makiko KOBAYASHI** FAST	Advanced Biomedical Evaluation System
2-3-5	**Ruda LEE** IINa	Overcoming Multi-Drug Resistance Breast Cancer for Women's health and quality of life
2-3-6	**Yuta NAKASHIMA** FAST	Novel Cancer Medical Technology Using Liquid Biopsy
2-3-7	**Shinichi OHIRA** FAST	Separation, Synthesis, and Detection by Means of Ionic Solutes Handling
2-3-8	**Atsushi SAINOKI** FAST	Development of Microbially-Aided Carbon Sequestration Technology
2-3-9	**Mitsuru SASAKI** IINa	Environmentally Promising Processes for Medical and Skincare Nanomaterials
2-3-10	**Keitaro TAKAHASHI** FAST	Study of First-Generation Objects in the Universe with Radio Telescopes

FAST: Faculty of Advanced Science and Technology

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

IINa: Institute of Industrial Nanomaterials

No.3-1	Digital Plant Cell Biology			
Name	Takumi HIGAKI	Title	Professor	
Affiliation	Faculty of Advanced Science and Technology（FAST） Email: thigaki@kumamoto-u.ac.jp			
Research Field	Environmental bioscience			
Cluster Members				
Name	Affiliation/Title			
Bo LIU Kae AKITA	Professor/ University of California at Davis U.S.A. Assistant Professor/ Japan Women's University			

[Details of Activities]

With the recent advances in bioimaging equipment such as microscopes, information processing of bioimages is attracting attention as a new research field in bioinformatics. In this project, we will develop and validate microscopic image analysis techniques to quantitatively evaluate the dynamics of intracellular structures in plant cells. In particular, we will develop biological image analysis frameworks that quantitatively assess the multidimensional biological features of cytoskeleton, and utilize machine learning to make biological discoveries.

In this fiscal year, we published two papers in which members were co-authors. In a paper published in *Front Cell Dev Biol*, we quantitatively evaluated the shape of plant cell spindles and the degree of enrichment of specific proteins by image analysis (Hotta et al. 2022) (Figs. 1, 2).

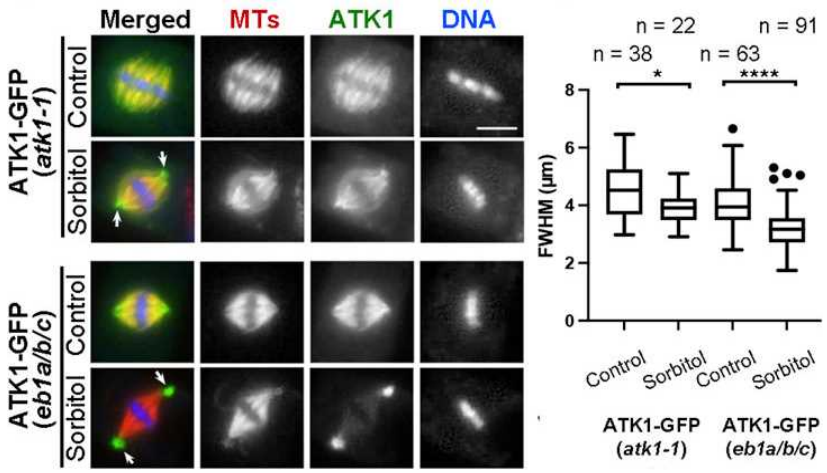


Fig. 1 Quantitative evaluation of shape of plant mitotic spindle (From Hotta et al. 2022 *Front Cell Dev Biol*)

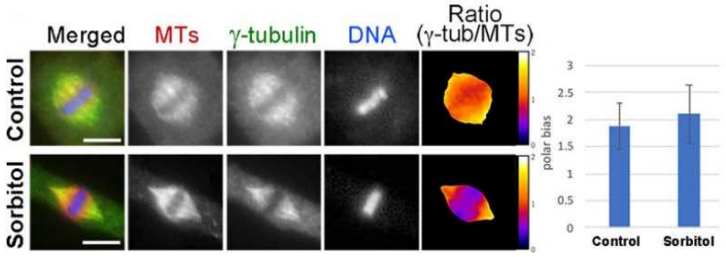


Fig. 2 Quantitative evaluation of polar-biased localization of γ-tubulin in plant mitotic spindle (From Hotta et al. 2022 *Front Cell Dev Biol*)

On the other hand, in a paper published in *Protoplasma* (category: New Methods in Cell Biology), we developed a system that automatically classifies cytoskeletal patterns by machine learning based on a multidimensional and quantitative evaluation of the cytoskeleton organization (Yoshida et al. 2022) (Fig. 3). This work has been published in a press release on this University's website (https://www.kumamoto-u.ac.jp/whatsnew/sizen/20221020). In addition, I contributed to resolving cell biological issues with the aid of image analysis techniques and published papers in high-impact journals such as *Nature Plants*, *Current Biology*, and *Communications Biology*.

In the next fiscal year, we will continue to contribute to solving cell biological problems through the development of image analysis methods. Although the name of this project is Digital Plant Biology, we plan to actively work on image analysis of animal cells as well as plant cells.

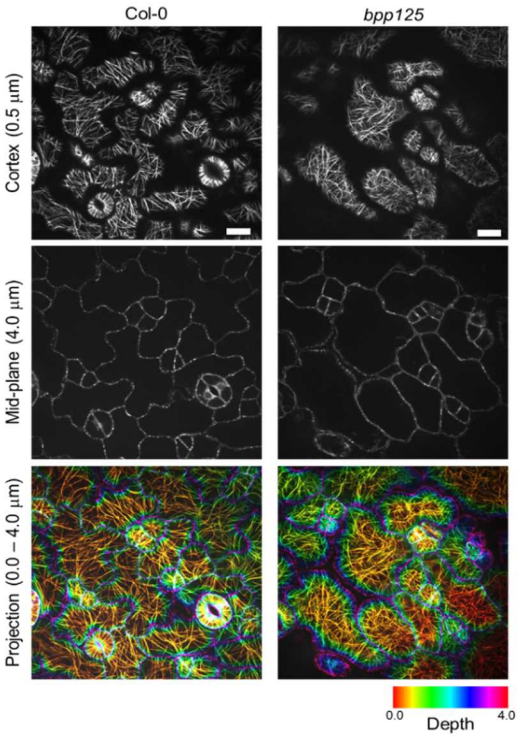


Fig. 3 Cortical microtubule patterns in wild type (Col-0) and microtubule mutant (*bpp125* triple mutant) that were automatically and accurately classified by machine learning

Publications

Takatsuka H, Higaki T, Ito M (2023) At the nexus between cytoskeleton and vacuole: How plant cytoskeletons govern the dynamics of large vacuoles. ***Int J Mol Sci*** 24: 4143.

Morotomi-Yano K, Hiromoto Y, Higaki T, Yano KI (2022) Disease-associated H58Y mutation affects the nuclear dynamics of human DNA topoisomerase IIβ. Sci Rep 12: 20627.

Yoshida D, Akita K, Higaki T (2022) Machine learning and feature analysis of the cortical microtubule organization of Arabidopsis cotyledon pavement cells. ***Protoplasma*** in press.

Hotta T, McAlear TS, Yue Y, Higaki T, Haynes SE, Nesvizhskii AI, Sept D, Verhey KJ, Bechstedt S, Ohi R (2022) EML2-S constitutes a new class of proteins that recognizes and regulates the dynamics of tyrosinated microtubules. ***Curr Biol*** 32: 3898-3910.

Takihara Y, Higaki T, Yokomizo T, Umemoto T, Ariyoshi K, Hashimoto M, Sezaki M, Takizawa H, Inoue T, Suda T, Mizuno H (2022) Bone marrow imaging reveals the migration dynamics of neonatal hematopoietic stem cells. ***Commun Biol*** 5: 776.

Sakamoto T, Sakamoto Y, Grob S, Slane D, Yamashita T, Ito N, Oko Y, Sugiyama T, Higaki T, Hasezawa S, Tanaka M, Matsui A, Seki M, Suzuki T, Grossniklaus U, Matsunaga S (2022) Two-step regulation of centromere distribution by condensin II and the nuclear envelope proteins. ***Nat Plants*** 8: 940–953.

Hotta T, Lee YR, Higaki T, Hashimoto T, Liu B (2022) Two Kinesin-14A motors oligomerize to drive poleward microtubule convergence for acentrosomal spindle morphogenesis in Arabidopsis thaliana. ***Front Cell Dev Biol.*** 10:949345.

Presentations

The International Symposium on "Plant-Structure-Optimization" in Nara (Nov 19-20, 2022)

No. 3-2	Environmental Diagnosis on Earth Surface Systems			
Name	Takahiro HOSONO	Title	Professor	
Affiliation	Faculty of Advanced Science and Technology(FAST) Email: hosono@kumamoto-u.ac.jp			
Research Field	Environment-friendly technology / Strengthening resilience / Data science and AI			

Cluster Members

Name	Affiliation/Title
Jens HARTMANN	Institute for Geology, University of Hamburg, Germany / Professor
Gibran Romero MUJALLI	Institute for Geology, University of Hamburg, Germany / Postdoc
Marino Domenico BARBERIO	National Institute of Geophysics and Volcanology, Italy / Researcher
Kimpei ICHIYANAGI	Faculty of Advanced Science and Technology, Kumamoto Univesity, Japan / Associate Professor

[Details of Activities]

1. Research outline and its perspective

1) From June 5th to October 3rd, 2022, I conducted an overseas research stay in Dipartimento di Scienze della Terra, Università di Roma La Sapienza, Italy, under the framework of the JSPS Fostering Joint International Research A (19KK0291). In addition to promote field surveys (Photo 1), we have constructed a framework for joint research on earthquake-volcano-water research with a team in Università di Roma La Sapienza.
2) From February 15th to March 18th, 2023, I conducted a water sampling survey of 23 major rivers in New Zealand's South Island (Photo 2) with a financial support by IROAST.

Photo 1. Sampling of spring water in Italy

Photo 2. River water sampling in New Zealand

2. Research progress and results in the fiscal year

Based on the analysis of samples obtained from the nationwide precipitation sampling project, we succeeded in characterizing the spatio-temporal distribution of transboundary metal pollution in Japan in flux units throughout a year. I devoted myself to writing as a first author, and the results were published in Scientific Reports of Nature Research, Springer Nature. IROAST provided financial support (US$2409 ≒JPY327,624) for publication fees. I would like to express my gratitude for the great support.

At the Università di Roma La Sapienza, Dr. Barberio Marino (now moved to the National Institute of Geophysics and Volcanology, Roma, Italy), a member of this cluster, kindly acted as a facilitator and we had very enthusiastic discussion. In particular, we were able to exchange ideas for joint research plans in Kumamoto and paper writing with common topics, so future exchanges can be expected to go smoothly. Furthermore, I made a one-hour lecture at the Università di Roma La Sapienza (Photo 3), and discussion session were held after my lecture, providing an opportunity to accumulate global knowledge on earthquake-volcano-water research work. From October 14th to 16th, 2022, I met Dr. Prof. Jens Hartmann, a member of this cluster, in Kyoto during his visit to Japan, and discussed how to proceed with research on water quality characterization throughout Japan (Photo 4).

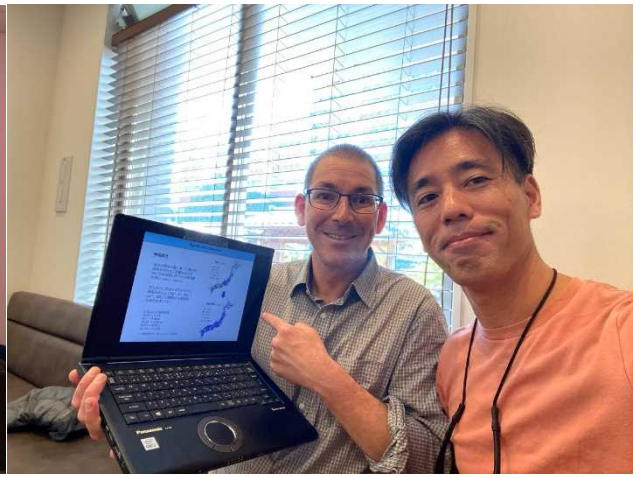


Photo 3. Lecture in Sapienza Univ. of Rome
Photo 4. Discussion with Prof. Jens Hartmann

3. Research plan for the next year

Currently, I am writing a joint paper on the chemical weathering process around the Kirishima volcano in collaboration with cluster members Gibran Romero Mujalli and Prof. Jens Hartmann, and I hope to complete the publication of this manuscript next year. My laboratory is also planning to welcome Zhi-Qiang Yu as a Postdoc Researcher from April under the support of JSPS Grant-in-Aid for Scientific Research A (22H00563). Together with him, I would like to promote data analysis related to the Kumamoto groundwater environment, as well as water cycle and water quality analysis throughout Japan. Specifically, we are planning to evaluate the impact of the water ponding project promoted Kumamoto City government on the recharge effect and the changes of the groundwater level caused by the change in permeability after the Kumamoto earthquake applying the statistical analysis of water level fluctuations in the Kumamoto region. At the same time, he hopes to advance the collection of data on river flow and river water quality throughout Japan. Dr. Zhi-Qiang Yu specializes in numerical analysis and statistical analysis of hydrological and water quality parameters, and has great expectations because it matches the theme of IROAST. Furthermore, by integrating the water quality and isotope analysis data, inspection data by the government, land use analysis, etc. accumulated in the Kumamoto region, I am planning to summarize myself the 50-year trends in nitrate nitrogen pollution in the region.

4. List of awards, grants, and patents, if any

- JSPS Grant-in-Aid for Scientific Research A (22H00563), 2022-2025, Leader: Takahiro Hosono
- JSPS Fostering Joint International Research A (19KK0291), 2020-2022 Leader: Takahiro Hosono

5. List of journal papers (with IROAST as your affiliation) published between April 2022 and March 2023.

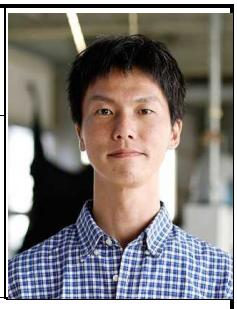
Basak, A., Rahman, A.T.M.S., Das, J., Hosono, T., Kisi, O., 2022. Drought forecasting using the Prophet model in a semi-arid climate region of western India. Hydrological Sciences Journal, 67(9), 1397-1417. https://doi.org/10.1080/02626667.2022.2082876

Hosono, T., Nakashima, S., Tanoue, M., Ichiyanagi, K., 2022. Monsoon climate controls metal loading in global hotspot region of transboundary air pollution. Scientific Reports, 12, 11096. https://doi.org/10.1038/s41598-022-15066-0

Mizota, C., Hansen, R., Hosono, T., Okumura, A., Shinjo, R., Aizawa, M., 2022. Provenancing nineteenth century saltpetre from British India using nitrogen, oxygen, and strontium isotope ratios. Collections: A Journal for Museum and Archives Professionals, 18(2), 220-235. https://doi.org/10.1177/15501906211072909

Mizota, C., Hosono, T., Okumura, A., Yamanaka, T., 2022. Nitrogen cycling in western India as revealed by nitrogen isotopes and the historic production of saltpetre. Archaeometry, 1-18. https://doi.org/10.1111/arcm.12830

Rahman, A.T.M.S., Kono, Y., Hosono, T., 2022. Self-organizing map improves understanding on the hydrochemical processes in aquifer systems. Science of the Total Environment, 846, 157281. https://doi.org/10.1016/j.scitotenv.2022.157281

No.3-3	Deep Learning for Hydrology			
Name	Kei ISHIDA	Title	Associate Professor	
Affiliation	Center for Water Cycle, Marine Environment and Disaster Management（CWMD） Email: keiishida@kumamoto-u.ac.jp			
Research Field	Environment-friendly technology / Data science and AI			

Cluster Members

Name	Affiliation/Title
Motoki AMAGASAKI	FAST・Professor
Masato KIYAMA	FAST・Assistant Professor
Ali ERCAN	Middle East Technical University, Türkiye・ Associate Professor
Tongbi TU	Sun Yat-Sen University, China・ Associate Professor

[Details of Activities]

1. Research outline and its perspective (in approx. 50-80 words and attach 1-2 relevant photographs)

Our research cluster examines the applicability of deep learning in hydrology. Deep learning is progressing rapidly, with new methods frequently developed across various research fields. We apply these novel deep-learning techniques to hydrological issues to identify the most suitable ones for each problem. Additionally, we are working to enhance and create new deep-learning methods tailored to hydrological challenges.

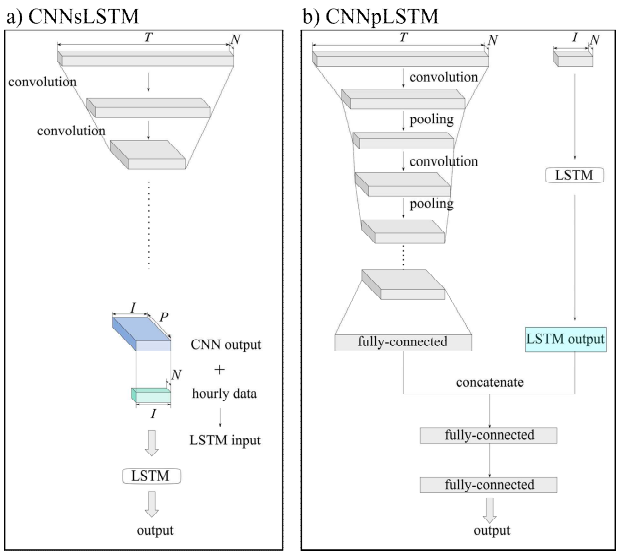


Fig 1 New architecture of deep learning suitable for hydrological issues

2. Research progress and results in the fiscal year (attach 1-2 related photos)

We have conducted this research study over the past three years. We have already applied deep learning architectures to several hydrological issues, such as rainfall-runoff modeling, precipitation downscaling, groundwater level modeling, sea surface level modeling, and sea surface temperature downscaling. We have also investigated the applicability of a recurrent neural network (RNN) architecture for rainfall-runoff modeling. Additionally, we have developed a new architecture to improve the computational requirements and accuracy of hourly-scale rainfall-runoff modeling using RNN. We have published academic papers in international and domestic journals based on these results.

This year, our research study has progressed, with our team focusing on applying deep learning methods to a wider range of hydrological issues, including snow modeling, groundwater level modeling, flood forecasting, and precipitation forecasting. While our primary approach so far has been the utilization of RNN and CNN architectures, we are now exploring the potential of other deep learning techniques, such as Transformer, Random Forest, and XGBoost, to further advance our understanding of hydrological processes. Throughout our research, we have consistently investigated the applicability of deep learning methods to various hydrological challenges, aiming to uncover the most effective techniques for each specific issue. One of our key areas of investigation has been to understand the types of relationships between hydrological variables that deep learning algorithms can identify and represent. This deeper understanding will enable us to refine our modeling approaches and improve our predictive capabilities.

In our ongoing efforts to advance the field of hydrology, we recently started exploring the potential of another deep learning method: graph neural network (GNN). GNN is specifically designed to account for relationships among nodes, a feature that may prove highly beneficial in helping models learn and understand geographical positional relationships within hydrological issues. As a result, we have begun incorporating GNNs into our work on hydrological problems, hoping to unlock new insights and improve the accuracy of hydrological simulations. Given the numerous types of GNNs available, we have undertaken a thorough investigation of these various approaches in order to better understand their differences, strengths, and limitations. Our goal is to identify the most suitable GNN architecture for each specific hydrological challenge, ensuring that our models are optimized for the unique characteristics of the problem.

A member of our research cluster, Dr. Ercan moved to Middle East Technical University Ankara in Türkiye as an associate professor. Dr. Ishida went to Middle East Technical University from March 13-22, 2023. We had discussions on our collaborative research studies.

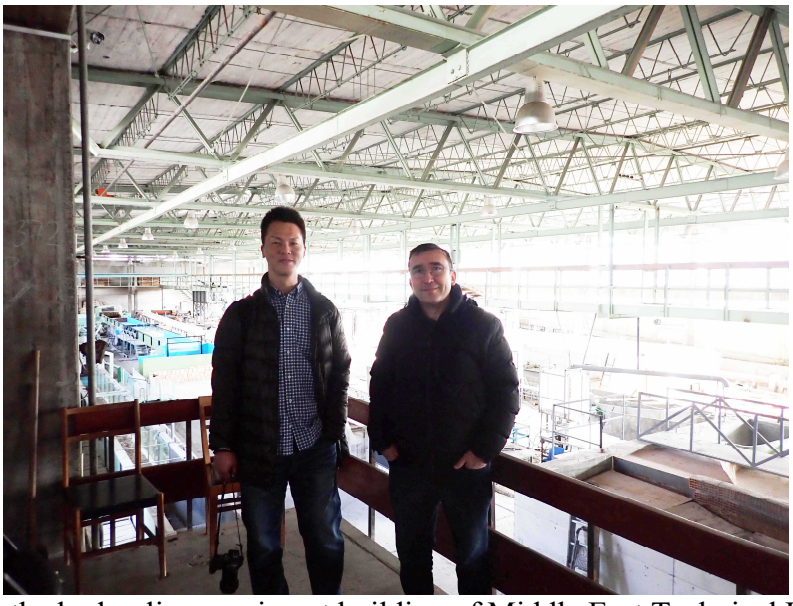


Photo 1. At the hydraulic experiment building of Middle East Technical University

3. Research plan for the next year

We will continue our research efforts, aiming to enhance model accuracy through two approaches. One involves utilizing new deep-learning architectures or refining existing ones. The other focuses on incorporating more information as input for the model. We will strive to gather as much data as possible and investigate which elements are beneficial for improving model accuracy.

Last year, we began utilizing graph neural networks. We will continue to employ them and investigate their features. Additionally, we will persist in our efforts to identify novel deep-learning architectures that are suitable for our objectives.

4. List of awards, grants, and patents, if any

None

5. List of journal papers published between April 2022 and March 2023.

1. Izumi, T., Amagasaki, M., Ishida, K., Kiyama, M., 2022. Super-resolution of sea surface temperature with convolutional neural network- and generative adversarial network-based methods. J. Water Clim. Chang. 13, 1673–1683.
2. 永里 赳義, 石田 桂, 坂口 大珠: Out-of-Sample LSTM による高解像度積雪深分布推定, AI データサイエンス論文集, Vol3, No.J2, p889-897, 2022.
3. 坂口 大珠, 石田 桂, 永里 赳義: リサンプリングとアンサンブル学習を用いた深層学習降雨流出モデルの精度向上の試み, AI データサイエンス論文集, Vol3, No.J2, p906-945, 2022.

No.3-4	Advanced Biomedical Evaluation System			
Name	Makiko KOBAYASHI	Title	Professor	
Affiliation	Faculty of Advanced Science and Technology（FAST） Email: kobayashi@cs.kumamoto-u.ac.jp			
Research Field	Biotechnology & healthcare technology / Advanced materials / Data science and AI			

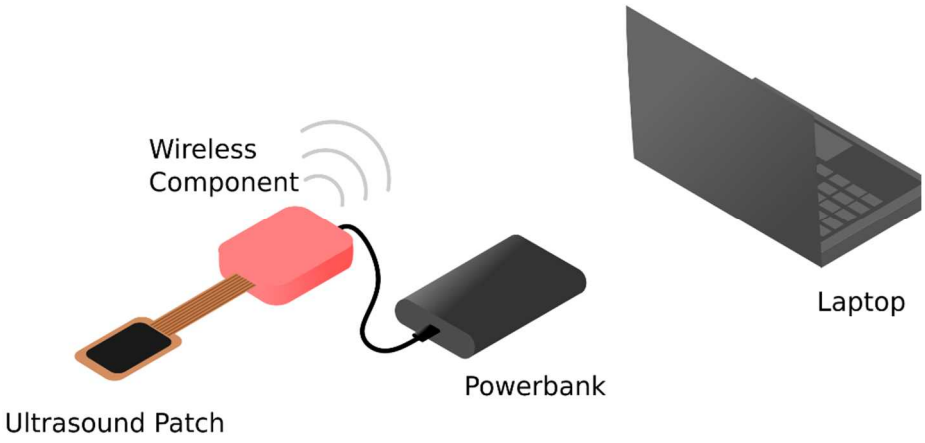
Cluster Members

Name	Affiliation/Title
Makiko KOBAYASHI	FAST, Kumamoto University/ Professor
Toshitaka YAMAKAWA	FAST, Kumamoto University/ Associate Professor →Nara Institute of Science and Technology
Masayuki TANABE	FAST, Kumamoto University/ Assistant Professor
Rajendra Udyavara ACHARYA	Ngee Ann Polytechnic/ Senior Faculty Member →Professor (Artificial Intelligence in Healthcare), University of Southern Queensland, Australia/IROAST Distinguished Professor
Shu Lih OH	Ngee Ann Polytechnic/ R&D Project Engineer
Ru san TAN	National Heart Centre/Doctor

[Details of Activities]

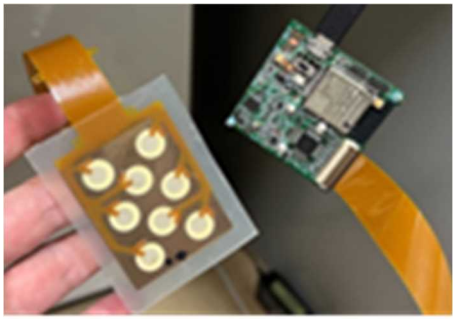
1. Research outline and its perspective (in approx. 50-80 words and attach 1-2 relevant photographs)

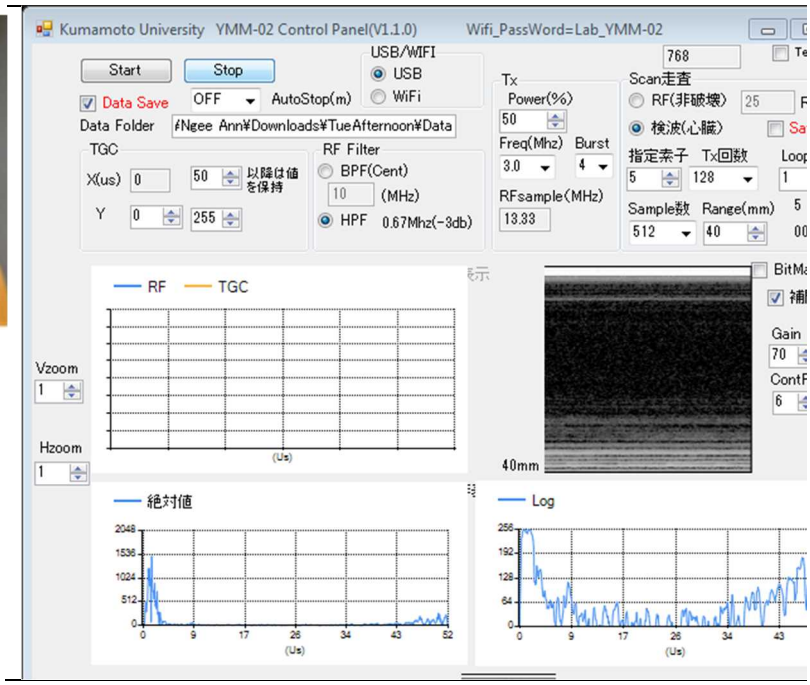
In this research cluster, our goal is to sense biomedical objects and areas that have been impossible to measure by traditional methods. To realize it, we apply our specialties, flexible ultrasonic sensors, high-performance electric circuits, visualization technology, and machine learning. In our goal, the measurement results will be automatically classified into three cardiac abnormalities by machine learning. Last year, Prototype flexible ultrasonic sensors and prototype portable pulser/receiver were successfully developed. It is better to strengthen ultrasonic echo to improve penetration depth.



2. Research progress and results in the fiscal year (attach 1-2 related photos)

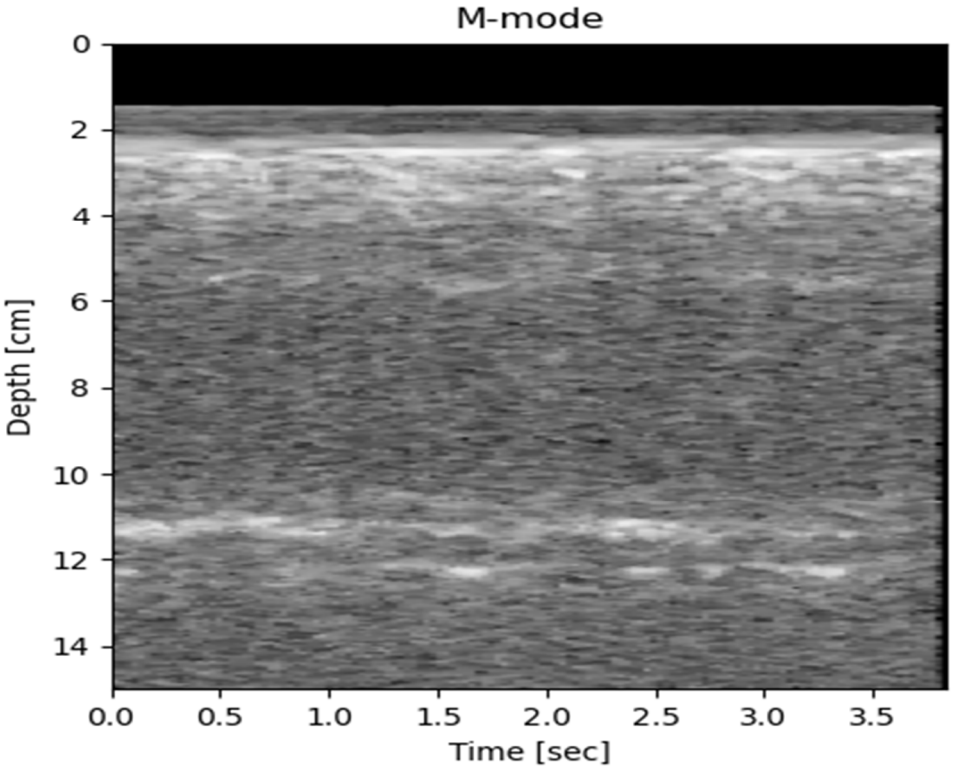
We prototyped an 8-channel ultrasonic flexible sensor, each sensor size is 12 mm diameter, are designed in a 3-2-3 row, showed higher echo strength than last year version. It was caused by process modification of lubber molding. Furthermore, based on these specifications, we designed a wireless pulser-receiver circuit with a function of driving and reading out 8-channel piezoelectric elements by time-series switching and wirelessly transmitting the received ultrasonic signal via Wi-Fi, and succeeded in downsizing the size to 4.5 cm square by conducting two circuit prototypes. Continuous measurements with specified element(s) are possible and waveforms are stored, log compression at 40dB Dynamic Range, smoothed with 3x3 Median Filter and M-mode imaging.

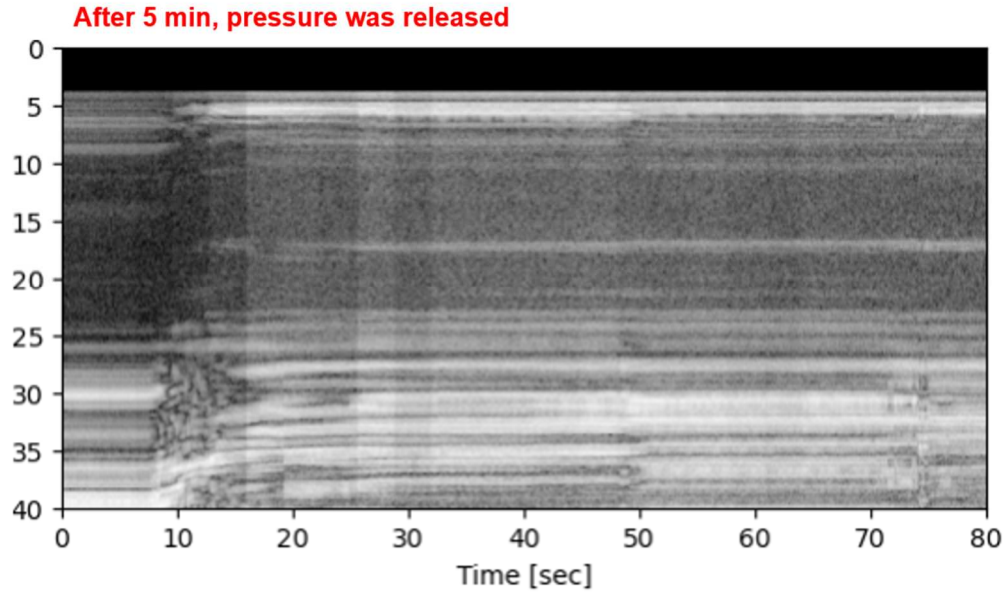




A simple test on phantoms and healthy subjects using these prototype devices showed that M-mode and pseudo-B-mode imaging were possible. Then we conducted an experiment in Singapore. Specifically, a flexible ultrasonic sensor was installed on the chest of a healthy person (Associate Professor Yamakawa) to acquire M-mode images. As a result, the movement of the

anterior and posterior walls of the heart was successfully acquired from multiple channels. Also, the radial artery expansion was successfully monitored by this developed system.





3. Research plan for the next year

In Singapore, we will start a clinical trial, which had been postponed due to the COVID19 pandemic. In the case of healthy subject measurements, since normal pattern data is only collected, a clinical trial by patients will be conducted to examine the possibility of automatic detection of diseases. In order to further improve the echo strength, Kumamoto University will develop modified materials with high dielectric constant and modified fabrication process to reduce porosity, for realization of low frequency ultrasonic sensor with smaller

electrode size. In order to improve the image quality, the sensor design including the sensor arrangement will be reviewed. In addition, the software developed at the time of current measurement is not as user-friendly, so it will be improved.

4. List of awards, grants, and patents

Makiko Kobayashi (as part of the Integrated Ultrasonic Team), the NRC's Impact Award, National Research Council of Canada, Dec. 12, 2022

5. List of journal papers (with IROAST as your affiliation) published between April 2022 and March 2023.

1. Masayuki Tanabe, Kosuke Sato, Toru Uda and Makiko Kobayashi, "Thin, flexible, and biocompatible medical ultrasound array transducer using a sol–gel composite spray technique", Jpn. J. Appl. Phys. 62 SJ1034
   * *Scheduled for publication in July 2023*

2. Ankit A. Bhurane, U. Rajendra Acharya, "An expert system for automated classification of phases in cyclic alternating patterns of sleep using optimal wavelet-based entropy features," Expert Systems, e12939, 2022.

3. Hui Wen Loh, Chui Ping Ooi, Silvia Seoni, Prabal Datta Barua, Filippo Molinari, U Rajendra Acharya, "Application of explainable artificial intelligence for healthcare: A systematic review of the last decade (2011–2022)," Computer Methods Programs in Biomedicine, 226, 2022, 107161.

4. Hui Wen Loh, Shuting Xu, Oliver Faust, Chui Ping Ooi, Prabal Datta Barua, Subrata Chakraborty, Ru-San Tan, Filippo Molinari, U Rajendra Acharya, "Application of photoplethysmography signals for healthcare systems: An in-depth review," Computer Methods Programs in Biomedicine, 216, 2022, 106677.

5. Hui Wen Loh, Chui Ping Ooi, Prabal Datta Barua, Palmer, Elizabeth Emma, Filippo Molinari, U Rajendra Acharya, "Automated detection of ADHD: Current trends and future perspective," Computers in Biology and Medicine, 146, 2022, 105525.

6. Vidya K. Sudarshan, U. Raghavendra, Anjan Gudigar, Edward J.Ciaccio, Anushya Vijayananthan, Ramesh Sahathevan, U Rajendra Acharya, "Assessment of CT for the categorization of hemorrhagic stroke (HS) and cerebral amyloid angiopathy hemorrhage (CAAH): A review," Biocybernetics and Biomedical Engineering, 42 (3), 2022, 888-901.

7. Anjan Gudigar, Raghavendra U, Jyothi Samanth, Akhila Vasudeva, Ashwal A. J., Krishnananda Nayak, Ru-San Tan, Edward J. Ciaccio, Chui Ping Ooi, Prabal Datta Barua, Filippo Molinari, U.Rajendra Acharya, "Role of Four-Chamber Heart Ultrasound Images in Automatic Assessment of Fetal Heart: A Systematic Understanding," Informatics, 2022, 9(2), 34

8. Anjan Gudigar, U Raghavendra, Jyothi Samanth, Chinmay Dharmik, Mokshagna Rohit Gangavarapu, Krishnananda Nayak, Edward J Ciaccio, Ru-San Tan, Filippo Molinari, U Rajendra Acharya, "Novel Hypertrophic Cardiomyopathy Diagnosis Index Using Deep Features and Local Directional Pattern Techniques," J Imaging, 2022 ;8(4):102.

9. Anjan Gudigar, U. Raghavendra, Tejaswi N. Rao, Jyothi Samanth, Venkatesan Rajinikanth, Suresh Chandra Satapathy, Edward J. Ciaccio, Chan Wai Yee, U. Rajendra Acharya,

"FFCAEs: An efficient feature fusion framework using cascaded autoencoders for the identification of gliomas," International Journal of Imaging Systems and Technology, 33(2), 483-494, 2023

10. V. Jahmunah, Joel En Wei Koh, Vidya K. Sudarshan, U. Raghavendra, Anjan Gudigar, Shu Lih Oh, Hui Wen Loh, Oliver Faust, Prabal Datta Barua, Edward J Ciaccio, U. Rajendra Acharya,"Endoscopy, video capsule endoscopy, and biopsy for automated celiac disease detection: A review," Biocybernetics and Biomedical Engineering, 43, 1, 2023, 82-108.
** Scheduled for publication June 2023*

No.3-5	Overcoming Multi-Drug Resistance Breast Cancer for Women's health and quality of life			
Name	Ruda LEE	Title	Associate Professor	
Affiliation	Institute of Industrial Nanomaterials (IINa) Email: aeju-lee@kumamoto-u.ac.jp			
Research Field	Biotechnology & healthcare technology			

Cluster Members	
Name	Affiliation/Title
Yong Il PARK	Chonnam National University, Korea/ Associate Professor
Jung Hoon CHOI	Kangwon National University, Korea/ Professor
Seung-Hae KWON	Korea Basic Science Institute, Korea/Principal investigator
Jungkyu KIM	University of Utah, USA/ Associate Professor

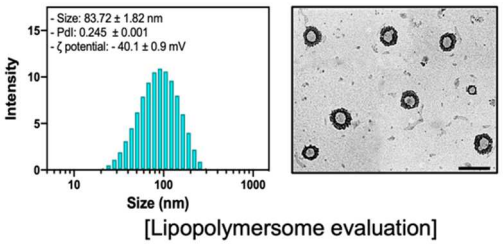
[Details of Activities]

1) Research outline and its perspective

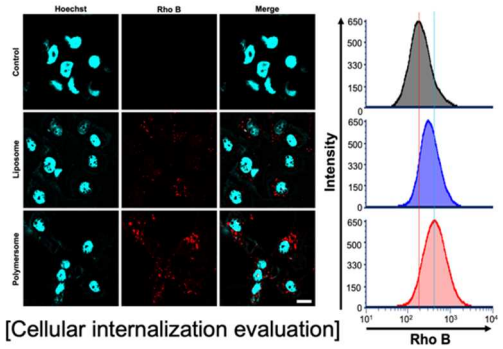
A better understanding of complex and dynamic system is essential to enable us to develop therapeutic strategies that bypass MDR, and also effective ways of inhibiting MDR components to increase the efficacy of our current extensively used chemotherapies. In this research, to get real-time MDR reactive information, we will build optimized, customizable 3D microfluidic chips, set up natural conditions, such as healthy cells and reconstructed 3D tumor microenvironments (TME) use super-resolution imaging devices from a world-class imaging cluster lab.

2) Research progress and results in the fiscal year (attach 1-2 related photos)

We aimed to analyze the MDR systemically on a 3D microfluidics chip. The customized microfluidic chip was designed and it's under production. The tumor microenvironment (TME) was designed and on the 3D cell culture dish. The ideal cell seeding number was calculated for microfluidics. Furthermore, the MDR overcoming nanoparticles was successfully developed to confirm the therapeutic mechanism.



[Lipopolymersome evaluation]



[Cellular internalization evaluation]

3) Research plan for the next year

For the materials transfer, we signed and finalized the MTA among KBSI (Korea)-University of Utah (USA)- Kumamoto University (Japan). In FY2023, the customized microchip will be delivered. The multi-drug resistance TME will represent *in vivo* animal model, and the nanoparticle's characteristics will be real-time tracking.

4) List of grants

1. FY2022 JSPS, Grant-in-Aid for Scientific Research (C)
2. 令和４年度「クロス・フロンティア研究推進事業」,熊本大学

5) Papers

1. Woojin Lee*, Leehyung Kim, Ruda Lee**. Strategic Review of Germany's LULUCF Policy Development Process: Implications for Korea. *Journal of Wetlands Research*, 24, 102-114, 2022. *Internship student (2021.09.01-2021.10.27) in IROAST Research Internship Program **Host professor at Kumamoto University

6**) Presentations**

1. Ruda Lee, Emerging Role of Nanotechnology for Water Sustainability. Korea International Water Week (KIWW) 2022. 2022/11/24, Daegu, Korea.

(At the venue)

(Group photo)

2. Ruda Lee, Nanoplatform for constructing new approaches to cancer treatment. Kangwon National University, 2022/03/30, Web.

No. 3-6	Novel Cancer Medical Technology Using Liquid Biopsy			
Name	Yuta NAKASHIMA	Title	Associate Professor	
Affiliation	Faculty of Advanced Science and Technology(FAST) Email: yuta-n@mech.kumamoto-u.ac.jp			
Research Field	Biotechnology & healthcare technology			

Cluster Members

Name	Affiliation/Title
Yoichi SAITO	Faculty of Advanced Science and Technology, Kumamoto University / Assistant Professor
Wataru IWASAKI	National Institute of Advanced Industrial Science and Technology / Chief research officer

[Details of Activities]

The objective of this project is to develop the palm-size medical diagnostic devices apply to detection of cancer and post-surgical management based on cell-based biomarker such as cell expressed protein, cell reaction, cell behavior, and so on. Through this, we aim to contribute to early detection and early treatment of cancer.

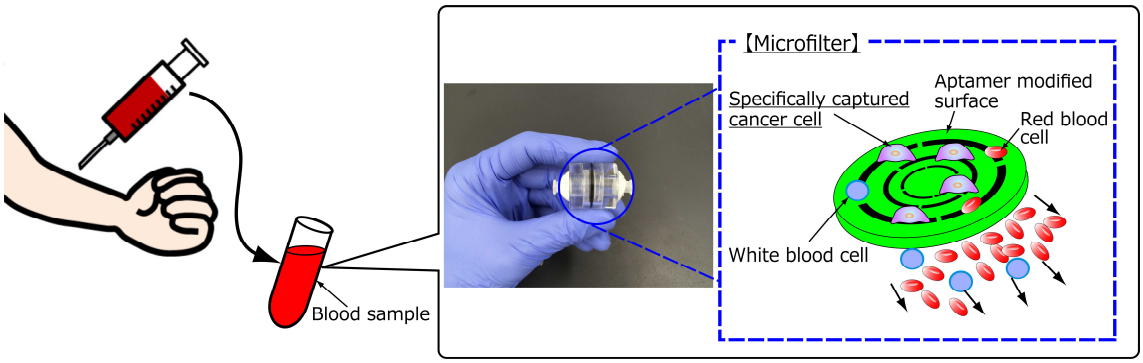


Fig. 1 Schematic of cancer diagnosis from whole blood.

In this year, we carried out the cancer cell detection experiments from patient whole blood using fabricated diagnostic device (Fig. 2). This device consists of a dynamically deformable microfilter for specifically capturing the cancer cell and housing device for grasping the microfilter. The surface of the microfilter was modified with nucleic acid aptamer that has specifically binding ability to cancer cells. When a blood sample is injected into the device, all the cell became clogging in the microfilter because the slit size of the microfilter was smaller than the cell diameter. In this case, cancer cell was specifically captured by the microfilter. Then the microfilter was deformed by fluid force, blood cells were released from the microfilter. The microfilter used in this study had the advantage of detecting target cells by repeated intentional clogging and elimination. The microfilter was fabricated by photolithography and precision electroforming. At first, photoresist was coated on the substrate by spin coating. After that,

coated photoresist was exposed and developed to make a microfilter mold. Then, the nickel structure was formed in the fabricated mold by electroforming. Finally, the nickel structure was peeled off the mold, and the entire surface was coated with gold. The microfilter device combining the microfilter and the housing device was used in the validation experiments.

The results of validation using clinical specimens from actual cancer patients by fabricated microfilter device, we successfully captured the small amount of cancer cells. This result indicates that the fabricated device can detect rare cancer cells contained in whole blood from cancer patients. Also, we monitored the cancer symptoms over time by counting the cancer cells in blood. As a result, number of detected cancer cells agreed well with the results of diagnostic imaging and tumor marker. Moreover, in a case in which recurrence was suspected but imaging and tumor markers showed a negative result, the case was determined to be positive, consistent with the physician's opinion. Although the results of the practical application were obtained, the capture efficiency of cultured cancer cells was only about 20%. The results indicate that the developed device can be achieved even more high accuracy.

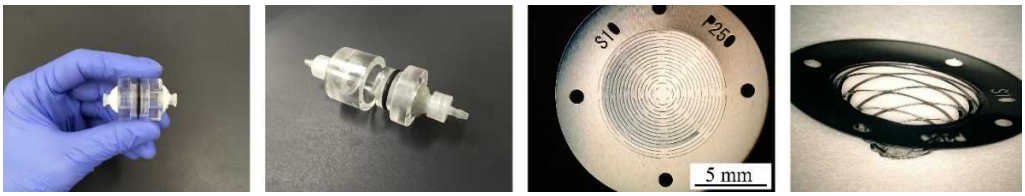


Fig. 2 The microfilter device for cancer cell detection.

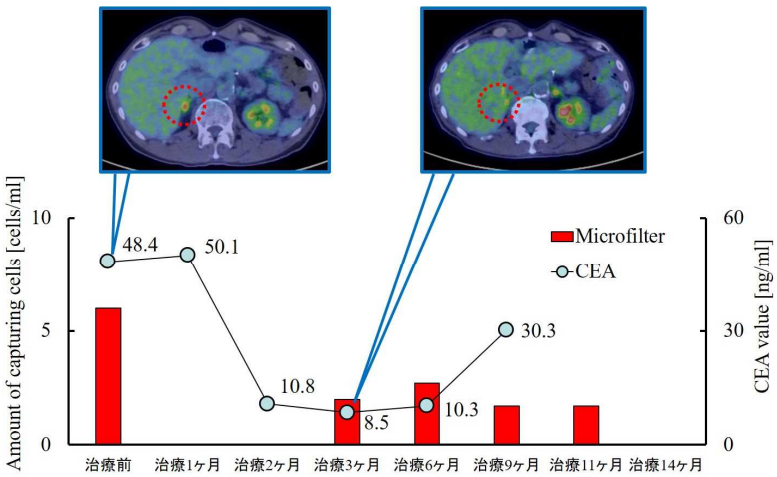


Fig. 3 Cancer continuity monitoring using the fabricated device.

In the next year, more experiments will be conducted on more clinical specimens to evaluate the reproducibility and usefulness of the developed microfilter device. In addition, cancer cell detection ratio will be increased by improving the microfilter shape and the nucleic acid aptamer. The experimental data of using specimens of cancer patients will be compared and verified with clinical findings (imaging diagnosis, CEA, etc.) for clarifying that the technique to assist the select of cancer treatment methods has clinical application. Moreover, by discussing and cooperating with researchers who are familiar with technologies related to supramolecular structure and graphene material, we will incorporate these technologies into this device to advance the device.

List of grants

[1] JST FOREST, ¥ 20,000,000-, Apr. 2022 – Mar. 2025. (Principal Investigator)

[2] Research and Development Grants, Fukuoka Financial Group, ¥ 1,500,000-, Dec. 2020 – Mar. 2022. (Principal Investigator)
[3] Gap Funding, Higo Bank, ¥ 5,000,000-, Sep. 2020 – Mar. 2023. (Principal Investigator)
[4] KAKENHI (Grant-in-Aid for Scientific Research (B)), ¥ 17,420,000-, Apr. 2019 – Mar. 2023. (Principal Investigator)
[5] KAKENHI (Grant-in-Aid for Scientific Research (C)), ¥ 900,000-, Apr. 2022 – Mar. 2025. (Co-Investigator)
[6] KAKENHI (Grant-in-Aid for Challenging Research (Exploratory)), ¥ 600,000-, Apr. 2021 – Mar. 2023. (Co-Investigator)
[7] KAKENHI (Grant-in-Aid for Scientific Research (B)), ¥ 1,800,000-, Apr. 2020 – Mar. 2023. (Co-Investigator)
[8] KAKENHI (Fund for the Promotion of Joint International Research (Fostering Joint International Research (B))), ¥ 2,500,000-, Apr. 2019 – Mar. 2025. (Co-Investigator)

List of social contributions

[1] Committee Member
Research for Innovation & Synthesis of Technology in Kumamoto
Apr. 2022 – Mar. 2023
[2] Editorial committee
39th Sensorsymposium, IEEJ (The Institute of Electrical Engineers of Japan)
Mar. 2022 – Dec. 31, 2022.
[3] Steering committee
Micro-Nano Science & Technology Division, The Japan Society of Mechanical Engineers
Apr. 2022 – Mar. 2023.
[4] Representative
Micro-Nano Science & Technology Division, The Japan Society of Mechanical Engineers
Apr. 2022 – Mar. 2023.
[5] Committee member
The 13th Symposium on Micro-Nano Science and Technology
Apr. 2022 – Mar. 2023.

List of patents

[1]発明の名称：インキュベータ装置、細胞培養環境制御システム及び細胞培養環境制御方法
登録番号：特許第 7161716
登録日：2022 年 10 月 19 日
発明者：**中島雄太**，森田金市
出願人：国立大学法人熊本大学，ウシオ電機株式会社
[2]発明の名称：標的細胞捕捉フィルター及び標的細胞捕捉方法
登録番号：特許第 7207785
登録日：2023 年 1 月 10 日
発明者：**中島雄太**，北村裕介，安田敬一郎
出願人：株式会社オジックテクノロジーズ
[3]発明の名称：光学測定器用サンプルホルダおよび光学測定器
出願番号：特願 2022-108407
登録日：2022 年 7 月 5 日
発明者：**中島雄太**，西川昌平
出願人：国立大学法人熊本大学、西川計測株式会社
[4]発明の名称：導光ユニットおよび光学測定器
出願番号：特願 2022-111672

登録日：2022 年 7 月 12 日
発明者：**中島雄太**，西川昌平
出願人：国立大学法人熊本大学、西川計測株式会社

List of journal papers

*Corresponding author

[1] Yoshitaka Nakanishi, Yukio Fujiwara, Yuta Nakashima, Yoshihiro Komohara, Kazunori Hino, Hiromasa Miura, Hidehiko Higaki, "Microchamber device for studying phagocytosis of ultra-high molecular weight polyethylene particles by human monocyte-derived macrophages," Wear, in press (Available online 15 March 2023, 204749)

[2] Yoichi Saito, Yukio Fujiwara, Yuji Miyamoto, Koji Ohnishi, Yuta Nakashima, Yasuhiko Tabata, Hideo Baba, Yoshihiro Komohara, "CD169+ sinus macrophages in regional lymph nodes do not predict mismatch-repair status of patients with colorectal cancer," Cancer Medicine, 00, 1-13, 2023. *Online Version of Record before inclusion in an issue

[3] Yoshitaka Nakanishi, Yukio Fujiwara, Yuta Nakashima, "Generation of Nano/Microplastics for Immunological Assessments," Biotribology, 33-34, 100235, 2023. *To be issued in June, 2023

[4] Seitaro Kumamoto, Souichiro Fukuyama, Seiya Nagano, Keiichiro Yasuda, Yusuke Kitamura, Masaaki Iwatsuki, Hideo Baba, Toshihiro Ihara, Yoshitaka Nakanishi, Yuta Nakashima*, "Fabrication of Three-Dimensionally Deformable Metal Structures Using Precision Electroforming," Micromachines, 13(7), 1046, 2022.

[5] Yoichi Saito, Yukio Fujiwara, Yusuke Shinchi, Remi Mito, Yuji Miura, Tomoya Yamaguchi, Koei Ikeda, Shinji Urakami, Yuta Nakashima, Takuro Sakagami, Makoto Suzuki, Yasuhiko Tabata, Yoshihiro Komohara, "Classification of PD-L1 expression in various cancers and macrophages based on immunohistocytological analysis," Cancer Science, 113(9), 3255-3266, 2022.

[6] Wataru Iwasaki, Hiroki Toda, Nobutomo Morita, Taisei Motomura, Yuki Fujio, Kenshin Takemura, Yoshitaka Nakanishi, Yuta Nakashima, "A thermoresponsive valve to control fluid flow in microfluidic paper-based devices," Microfluidics and Nanofluidics, 26, 47, 2022.

[7] Tsugumasa Toma, Hiroshi Tateishi, Kensaku Kawakami, Taha F. S. Ali, Masahiro Kamo, Kazuaki Monde, Yuta Nakashima, Mikako Fujita, and Masami Otsuka, "Novel Inhibitor for Downstream Targeting of Transforming Growth Factor-β Signaling to Suppress Epithelial to Mesenchymal Transition and Cell Migration," International Journal of Molecular Sciences, 23(9), 5047, 2022.

[8] Hiroki Toda, Wataru Iwasaki, Nobutomo Morita, Taisei Motomura, Kenshin Takemura, Masaya Nagano, Yoshitaka Nakanishi and Yuta Nakashima*, "Reversible Thermo-Responsive Valve for Microfluidic Paper-Based Analytical Devices," Micromachines, 13(5), 690, 2022.

No. 3-7	Separation, Synthesis, and Detection by Means of Ionic Solutes Handling			
Name	Shin-Ichi OHIRA	Title	Professor	
Affiliation	Faculty of Advanced Science and Technology（FAST） Email: ohira@kumamoto-u.ac.jp			
Research Field	Biotechnology & healthcare technology / Environment-friendly technology / Advanced materials			

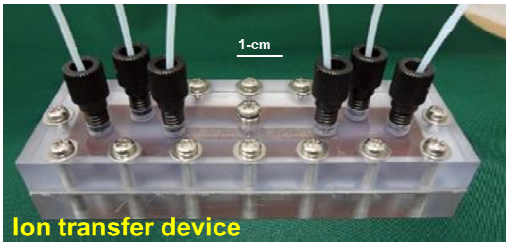
Cluster Members

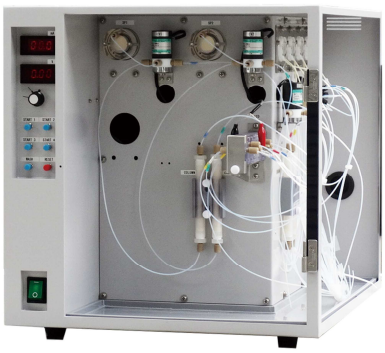
Name	Affiliation/Title
Jian MA	Professor, College of the Environment and Ecology, Xiamen University China
C. Phillip SHELOR	Assistant Research Professor, Department of Chemistry and Biochemistry, University of Texas at Arlington USA
Ganjar FADILLAH	Lecturer, Universitas Islam Indonesia Indonesia

[Details of Activities]

1. Research outline and its perspective

Ionic solutes are important chemical forms in environment, human body and industry. The analysis, handling, and purification are key process for well-being society. In our research cluster, the members are studying these processes which focus on ionic solutes. Especially, ion handling device based on electrophoretic movement and membrane transferring is the key device in our study. The device is widely applied for industrial, medical and environmental sciences.





Ion handling device and solution handling system developed by the collaboration with the company.

2. Research progress and results in the fiscal year

In the 2022FY, we have studied a) chiral separation, b) radioactive isotope separation and purification, and c) Fe(II) analysis in a river water sample.

a) Chiral separation

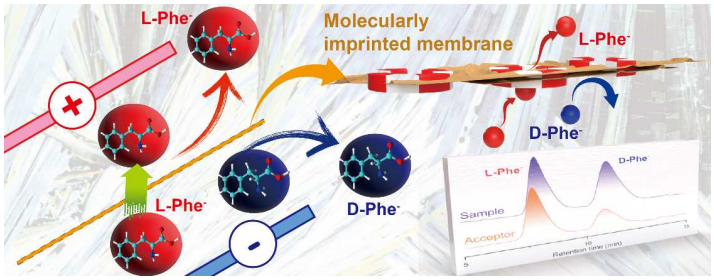
Chirality is differentiated by human body. Thus, some of the drag show different effects by the chirality. However, it is difficult to separate chiral compounds. We have approached the separation of L- and D- phenylalanine by ion handling device with molecular imprinted membranes (MIM). The MIM was prepared with the targeted molecule as template and monomer to stamp the template. The developed MIM and ion handling system achieved highest separation performance than previously reported. The results are published on *Separation and purification technology* (IF. 9.136).

b) Radioactive isotope separation and purification

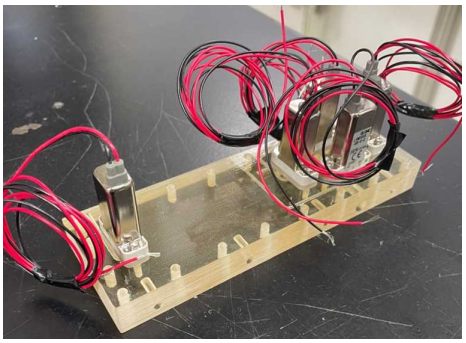
Short-life radioactive isotopes (RIs) are focused as new tracer for positron emission tomography (PET) diagnosis recently. However, it is a problem on the separation and purification of generated RI from target material. We have successfully developed a new separation method and flow-based devices which are produced with 3D printing technologies. Usually, the devices used for the RI handling is disposable. Thus, 3D printed device is effective for the purpose. The obtained results are published in *Analytical Sciences* (IF. 1.97)

c) Fe(II) analysis in a river water samples

Fe(II) plays a key role in environment. For example, Fe(II) is related to a red tides. In our study, the analysis method was newly developed with the new type of ion handling device. The analytes can be directly introduced into the color developing reagent with an enrichment. The developed device shows almost same sensitivity to the induction coupled plasma mass spectrometry (ICP-MS). Event though ICP-MS can only detect total Fe, our system can separately analyze Fe(III) and Fe(II). The developed system was applied to river water analysis and the obtained results are well matched with the results obtained with the conventional method.



Chiral separation with ion handling device


3D-printed separation/purification device

3. Research plan for the next year

In the next year, we are focusing on the following projects.

a) New analytical method for amino acid.

The previously developed chiral separation method can be applied to amino acid analysis. Amino acid is Amino acids are presently analyzed with high performance liquid chromatography (HPLC) which can simultaneously determine the many kinds of amino acids with a single injection. However, it takes long time for pretreatment and analysis. Our new method can measure an amino acid continuously.

b) Purification the solutions

The purity of the solutions is very important especially in semiconductor industries. We are going to develop purification system and evaluation methods for the impurities in the various solutions.

c) Ionic compounds synthesis system

We have previously developed the synthesis system for ionic compounds. The systems are required relatively larger scales for practical usage. Thus, large scale system will be developed.

4. List of awards, grants, and patents

Award

Shin-Ichi Ohira, JAFIA Award 2022, “Development of the key flow devices for sample pretreatment, enrichment, separation and purification on the ionic solutes analysis”, Japanese Association for Flow Injection Analysis (JAFIA), November 25, 2022

Grants

Shin-Ichi Ohira, Grant-in-Aid for Scientific Research (B) (The Japan Society for the Promotion of Science), "Developments of Lab-on-a-chip for separation/purification and synthesis of radio-active probes", April 2021 – March 2024.

Shin-Ichi Ohira, Intensive Support for Young Promising Researchers (New Energy and Industrial Technology Development Organization (NEDO)), “Development of the highly sensitive analysis system for continuous monitoring of amino acids”, March 2022 – March 2024.

Patents

Patent application 2022-193860, “Amino acid analysis method and system”
Patent application 2022-151093, “Ion transfer system”

5. List of journal papers (with IROAST as your affiliation) published between April 2022 and March 2023.

Ganjar Fadillah, Kei Toda, Shin-Ichi Ohira
One-stage chiral enrichment process by continuous flow electrodialysis with molecularly imprinted membrane
Separation and Purification Technology, 305, 122492 (2023)
https://doi.org/10.1016/j.seppur.2022.122492

Md. Aminul Haque, Kei Toda, and Shin-Ichi Ohira*
Electrodialytic Universal Synthesis of Highly Pure and Mixed Ionic Liquids
ACS Omega 2022, 7, 25, 21925–21931
https://doi.org/10.1021/acsomega.2c02209

No.3-8	Development of Microbially-Aided Carbon Sequestration Technology			
Name	Atsushi SAINOKI	Title	Associate Prof.	
Affiliation	Faculty of Advanced Science and Technology (FAST) Email: atsushi_sainoki@kumamoto-u.ac.jp			
Research Field	Environment-friendly technology			
Cluster Members				
Name	Affiliation/Title			
Murat Karakus	The University of Adelaide, Associate Prof.			
Akira Sato	Kumamoto University, Prof.			
Kazunori Nakashima	Hokkaido University, Associate Prof.			
Hiroaki Ito	Kumamoto University, Assistant Prof.			

[Details of Activities]

1. Research outline and its perspective (in approx. 50-80 words and attach 1-2 relevant photographs)

The purpose of this project is to develop a technology to cause microbially-aided carbon precipitation by injecting CO_2 into a rock in deep underground with anaerobic bacteria, elements, and nutrients. The proposed technology is deeply related to the prevention of global warming with carbon capture and sequestration generally abbreviated as CCS. CCS is one of technologies being developed around the world to reduce the amount of CO_2 released into the atmosphere by injecting carbon dioxide into deep underground with a depth of more than 2000 m. The technology is deemed necessary to achieve the Paris Agreement, but there are several concerns to be addressed, one of which is CO_2 leak-off to the ground surface through pre-existing rock mass fractures and geological structures such as faults and fractured zones. The microbially-aided carbon precipitation can contribute to mitigating the risk for CO_2 leak-off by transforming injected CO_2 into a precipitated carbonate with the help of microbes.

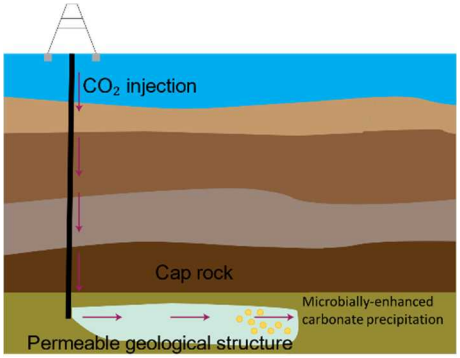


Fig.1: Mitigation of the CO_2 leak-off risk with microbially-enhanced carbon precipitation

2. Research progress and results in the fiscal year

The 2022 fiscal year was predominantly spent on contriving a long-term research plan, developing a new experimental apparatus, and obtaining an external grant for this project, as follows.

1) Long-term research plan

The result obtained from the experiment in 2021 indicated that anaerobic bacteria existing in coal may contribute to microbially-aided carbonate precipitation. To delve into the mechanism and influential factors, we decided to conduct further experiments to investigate the effect of temperature, pressure, and other minerals on the efficiency of carbon precipitation. This allows us to identify the type of minerals that could enhance the microbially-aided carbonation, hence leading to optimization of mineralization conditions. The experiments include collecting various kinds of rocks containing a variety of minerals and conducting carbonate precipitation experiments under high temperature and pressure conditions corresponding to deep underground. In addition to these experiments, we keep screening further microbes that can enhance carbon mineralization by collecting rocks from deep underground under anaerobic conditions.

The aforementioned CO_2 precipitation experiment is followed by experiments to examine the property change in rock subjected to CO_2 precipitation, the development of the constitutive model and its implementation into numerical simulations. Afterwards, a small-scale in-situ experiment will be conducted.

2) Development of new experimental apparatus

The experiment mentioned above requires high temperature and pressure environment. Hence, we purchased a pressure-proof vessel (reactor) that can be used under pressure up to 20 MPa and 350 Celsius degrees, which corresponds to a hydrostatic pressure at a depth of 2000 m. Then, pressure-proof tubes and valves are connected to the vessel to inject CO_2 and monitor the pressure during an experiment. In addition to that, a new syringe pump that can accurately control fluid pressure and injection rate is going to be ordered, whereby CO_2 is injected to the vessel via the tube whilst controlling either injection pressure or rate.

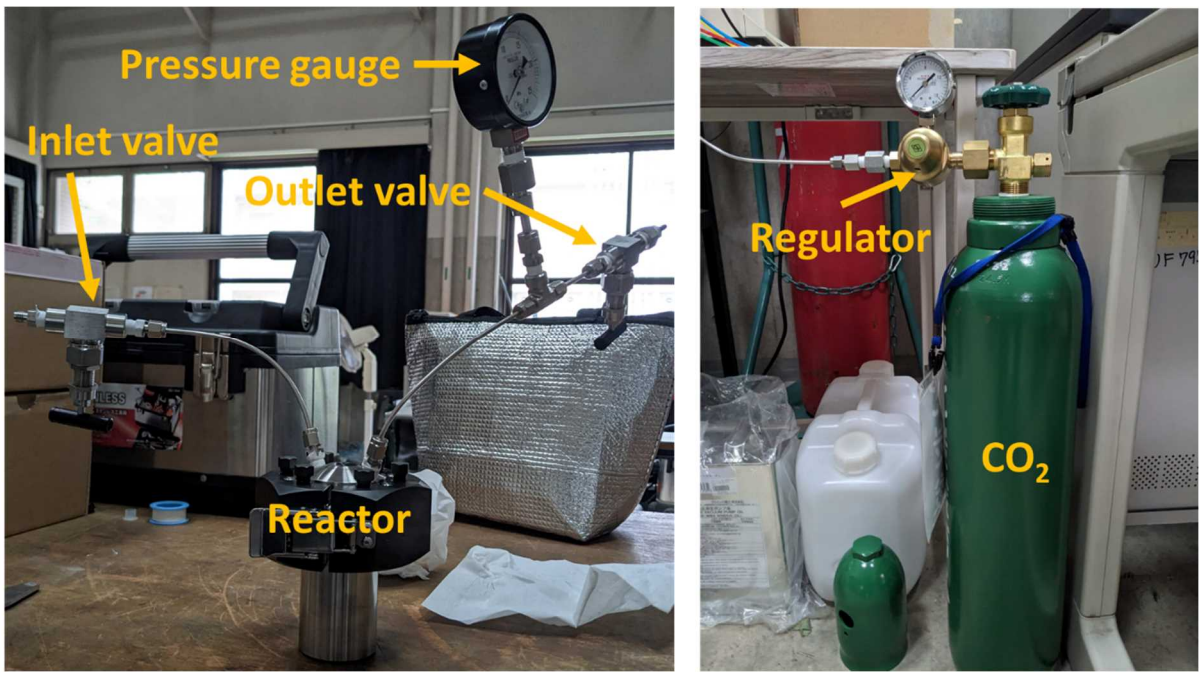


Fig. 2: Apparatus developed for the experiment under high temperature and pressure

3) Grant application

The aforementioned long-term research plan has been combined with a new idea on controlling seismicity by enhancing the stiffness of fractured rock mass with microbially-aided carbonate precipitation. That is, the new research idea can contribute to reducing CO_2 emission and mitigating the risk for seismic hazards, simultaneously. The research plan was submitted to Fusin Oriented Research for Disruptive Science and Technology (FOREST) provided by Japan Society and Technology Agency. Then, the plan was successfully accepted.

3. Research plan for the next year

The research for the next year starts with investigating the type and amount of minerals dissolved into carbonated water whilst changing the temperature and pressure. As mentioned above, various types of rocks are tested, and minerals dissolved into the carbonated water are quantitatively investigated. As of now, Kimachi sandstone, schist, serpentinite, silicified rocks, limestone, andesite, and coal have been prepared for the experiment.

In addition to the experiment, fluid flow in a fractured rock is investigated in a micro-focused X-ray CT in order to develop a method for stable CO_2 injection that does not cause damage to the rock mass in deep underground, which is crucial because damage to the rock mass could lead to seismic events. As the first step, a small-scale tri-axial compressive test machine is developed for the X-ray CT, and triaxial tests are performed for 3D printed fractured rock-like specimens. From the result, the strain distribution in a fractured rock will be investigated by performing image analyses with the digital image correlation method.

4. List of awards, grants, and patents, if any.

Title: "Control of induced seismicity with microbially-aided CO_2 mineralization"

Grant name: Fusin Oriented Research for Disruptive Science and Technology (FOREST)
provided by Japan Society and Technology Agency

Period: 2023 – 2030 (there is a midterm evaluation)

Amount: 50,000,000 JPY

5. List of journal papers published between April 2022 and March 2023

One paper has been published to international journals (SCI) as below.

- Wael R. Abdellah*,Chiaki Hirohama, Atsushi Sainoki, Ahmed Rushdy Towfeek, and Mahrous A. M. Ali, Estimating the Optimal Overall Slope Angle of Open-Pit Mines with Probabilistic Analysis, *Appl. Sci.* 2022, 12(9), 4746, https://doi.org/10.3390/app12094746

Three papers have been submitted to international journals (SCI) as below.

- A conceptual three-dimensional frictional model to predict the effect of the intermediate principal stress based on the Mohr-Coulomb and Hoek-Brown failure criteria (International Journal of Rock Mechanics and Mining Science)

- Experimental Investigation into the Mechanical Behavior of Jointed Soft Rock Using Sand Powder 3D Printing (Rock Mechanics and Rock Engineering)

- Effect of surface retaining elements on rock stability - laboratory investigation with sand powder 3D printing effect of surface retaining elements on rock stability - laboratory investigation with sand powder 3D printing (International Journal of Coal Science and Technology)

No.3-9	Environmentally Promising Processes for Medical and Skincare Nanomaterials			
Name	Mitsuru SASAKI	Title	Associate Professor	
Affiliation	Institute of Industrial Nanomaterials (IINa) Email: msasaki@kumamoto-u.ac.jp			
Research Field	Environment-friendly technology			

Cluster Members

Name	Affiliation/Title
Olivier BOUTIN	Aix Marseille University, France Professor
Bushra AL-DURI	The University of Birmingham, UK Professor
Hamid HOSANO	Institute of Industrial Nanomaterials (IINa), Kumamoto University Professor
Marleny D.A. SALDAÑA	University of Alberta, Canada Professor
M. J. COCERO	Valladolid University, Spain Professor
Elisabeth BADENS	Aix Marseille University, France Professor
Rodolfo M. IBARRA	Universidad Autonoma de Nuevo León, Mexico Associate Professor
Cinthya ISSASI	Graduate School of Science and Technology (GSST), Kumamoto University Ph.D. candidate

[Details of activities]

1. Overview of achievements

1.1. 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. Previously, we found that about 40-50% of sake lees liquefied and relatively high concentration of amino acids and minerals in subcritical water at 120ºC for 4 hours and about 50-60% by using a batch-type reactor (Yamato *et al.*, *SN Applied Sciences*, 2020). This year we also found that about 60-70% of

rice bran could liquefied and high contents of K, Mg, Ca and phosphate ions in subcritical water at 180oC for 30 min. Based on these liquefied portions obtained by subcritical water treatments, we carried out acetic acid fermentation experiments for the blended liquefied portions and found that good quality vinegar solutions could be produced (Murakami *et al.*, The Hottest Paper Award of *the 12th. International Conference on Supercritical Fluids (Supergreen 2022)*, Taipei, Oct 24-29, 2022).


Supergreen 2022

The 12th International Conference on Supercritical Fluids

THE HOTTEST PAPER AWARD

Study on the optimization of subcritical water liquefaction of vinegar residues and acetic acid fermentation conditions for new vinegar products

By

Daigo Murakami[a], Shoji Hirayama[a,b], Yuriko Hoshino[b], Kazuharu Yamato[c], Munehiro Hoshino[b,c], Mitsuru Sasaki[d,e,f*]

[a]Graduate School of Science and Technology, Kumamoto University
[b]M&A Food Technology and Biology of Technical Center (M.A.F.T)
[c]Maruboshi Vinegar Co. Ltd.
[d]Faculty of Advanced Science and Technology, Kumamoto University
[e]Institute of Industrial Nanomaterials, Kumamoto University
[f]International Research Organization for Advanced Science and Technology, Kumamoto University

October 24-29, 2022, Taipei, Taiwan
Advisory Committee & Organizing Committee of Supergreen 2022

1.2. Nanomaterials production processes for medical and industrial fields.

Traces of various pollutants such as industrial compounds, personal care products or endocrine disruptors are found in water at concentrations in the μg L^{-1} or ng L^{-1} range. Traces can also be found in drinking water, which has a direct impact on human beings. However, several studies indicate that the levels of endocrine disruptors in wastewater decrease after conventional biological treatment, mainly by simple adsorption onto activated sludge, which may then pose the problem of sludge management. Of all the compounds, this study focuses on the fate of bisphenol A. Bisphenol A (2,2-bis(4-hydroxyphenyl) propane; BPA) is used as a chemical intermediate in the manufacture of chemicals, such as polycarbonates, epoxy resins for can coating, powder coatings, adhesives, building materials and paper coatings. Bisphenol A is thus released into the environment through leaching from plastic waste and landfill leachate. It is acutely toxic at concentrations between 1 and 10 mg L^{-1} for marine species, as an endocrine disruptor causing various diseases, including cancer.

The objective of the work is to compare the treatment of BPA through wet air oxidation treatment (Prof. Olivier Boutin, AMU) and pulsed discharge treatment (Assoc. Prof. Sasaki, Kumamoto U. This year systematic experiments for BPA decomposition by the pulsed arc discharge method were carried out with Prof. Olivier and some interesting findings were obtained. For next stage, we need to calibrate and evaluate the different analysis through LC-MS, HPLC and TOC and try to compare results between pulsed discharge experiments and wet air oxidation ones.

2. Presentations & Publications (incl. submitted papers)

Publications

Masayo Nishizono, Cinthya Soreli Castro Issasi, Jonas Karl Christopher N. Agtaya, Mitsuru Sasaki*, Hiroyuki Mizukami, "Production of dried tomato powder with a high concentration of functional components and nutrients", *Journal of Antioxidant Activity*, **2**(4), 1-21 (2023). DOI: 10.14302/issn.2471-2140.jaa-23-4426

Mitsuru Sasaki*, Hiras Tumegas Manalu, Ramma Kamogawa, Cinthya Soreli Castro Issasi, Armando T. Quitain, Tetsuya Kida, "Fast and selective production of quercetin and saccharides from rutin using microwave-assisted hydrothermal treatment in the presence of graphene oxide", *Food Chemistry*, 405, 134808 (2023). DOI: 10.1016/j.foodchem.2022.134808.

YikLam Kam, Jonas Karl Christopher N. Agutaya, Armando T.Quitain, Yuri Ogasawara, Mitsuru Sasaki, ManKee Lam, Suzana Yusup, Suttichai Assabumrungrat, Tetsuya Kida, "In-situ transesterification of microalgae using carbon-based catalyst under pulsed microwave irradiation," *Biomass and Bioenergy*, 168, 106662 (2023) DOI: 10.1016/j.biombioe.2022.106662

Cinthya Soreli Castro Issasi, Rodolfo Morales Ibarra, and Mitsuru Sasaki*, "In-situ Synthesis of Poly(*N*-Isopropylacrylamide) Decorated with Silver Nanoparticles Using Pulsed Electrical Discharge in Contact with Water Interface", *Nanocomposites*, 8(1), 136-141 (2022). DOI: 10.1080/20550324.2022.2086775

Presentations

Daigo Murakami, Shoji Hirayama, Yuriko Hoshino, Kazuharu Yamato, Munehiro Hoshino, Mitsuru Sasaki*, "Study on the optimization of subcritical water liquefaction of vinegar residues and acetic acid fermentation conditions for new vinegar products", #PP-21, Supergreen 2022, Taipei, Taiwan, October 24-29, 2022.

Daigo Murakami, Shoji Hirayama, Yuriko Hoshino, Munehiro Hoshino and Mitsuru Sasaki*, "Recovery of high concentration of amino acids by subcritical water treatment of residuals from vinegar production" APCChE 2022, Kuala Lumpr, Malaysia, August 9-12, 2022.

Natsuko Tashiro and Mitsuru Sasaki*, "Development of novel method for selective conversion of dibutyl phosphate into phospholic acid with the vaporphase pulsed discharges" APCChE 2022, Kuala Lumpr, Malaysia, August 9-12, 2022.

Ryo Yamada and Mitsuru Sasaki*, "Production of chain oligopeptides from diketopiperazine by pulse discharge method" APCChE 2022, Kuala Lumpr, Malaysia, August 9-12, 2022.

Shoji Hirayama, Yuriko Hoshino, Daigo Murakami, Kazuharu Yamato, Takuya Suetsugu, Munehiro Hoshino, and Mitsuru Sasaki*, "Subcritical Water Treatment of Sake Lees and Rice Bran for New Vinegar Production: Product Distribution and Reaction Pathways", ICAST2022 (online), Kumamoto 2022.

Awards

The Hottest Paper Award, Supergreen 2022 (October 24-29, 2022)
Authors: Daigo Murakami, Shoji Hirayama, Yuriko Hoshino, Kazuharu Yamato, Munehiro Hoshino, Mitsuru Sasaki*,
Title: "Study on the optimization of subcritical water liquefaction of vinegar residues and acetic acid fermentation conditions for new vinegar products" (#PP-21),
Conference name: Supergreen 2022
Date and place: October 24-29, 2022 at Taipei, Taiwan.

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) 2019-2023 (Ongoing).

Research on the aging of rice shochu using locally produced wood and its utilization, Project Research at Japan Sake and Syochu Makers Association 2022 (Ongoing).

No.3-10	Study of First-Generation Objects in the Universe with Radio Telescopes			
Name	Keitaro TAKAHASHI	Title	Professor	
Affiliation	Faculty of Advanced Science and Technology (FAST) Email: keitaro@kumamoto-u.ac.jp			
Research Field	Study of first-generation objects in the universe with radio telescopes			

Cluster Members

Name	Affiliation/Title
Rachel WEBSTER	The University of Melbourne Professor
Bart PINDOR	The University of Melbourne Professor
Takuya AKAHORI	National Astronomical Observatory of Japan Researcher
Shintaro YOSHIURA	National Astronomical Observatory of Japan JSPS Fellow
Takuya AKAHORI	Researcher, National Astronomical Observatory of Japan
Takeshi FUKUSAKO	Kumamoto University Professor
Ryo KATO	Kumamoto University Researcher

[Details of Activities]

1. Research outline and its perspective

We aim to detect the 21 cm-line radio waves from neutral hydrogen atoms in the early stage of the universe to probe the first astronomical objects. We develop algorithms and practical software for extracting information from large amounts of observational data precisely and efficiently. The developed algorithm is also applied to radio observations of other astronomical objects such as pulsars.


Radio telescope called Murchison Widefield Array in Australia

2. Research progress and results in the fiscal year

Our group continues to develop data analysis methods for detecting weak signals from observation data from radio telescopes. This year, we conducted observations of pulsars with the GMRT telescope in India, and obtained precise data of pulse arrival time collaborating with an Indian research team. We have published precise pulsar observation data through 3.5 years [5]. The accuracy of the observation reaches 1 μs, which is a big step towards the future detection of low-frequency gravitational waves [2]. Simultaneous press releases were issued in Japan and India regarding the results of this research. Furthermore, in February, a joint research workshop was held in Chennai, India, and three researchers from Japan participated.

We also carried out research to obtain three-dimensional information on magnetized astronomical objects from broadband polarization observation data of radio waves. Regarding this research method, we developed several algorithms and tested their performance. Then, by applying it to the observation data of the radio telescope called ASKAP, we studied supernova remnants and jets of active galactic nuclei. The results were published as a review paper [6].

Further, we are studying an effective method to mitigate RFI (Radio Frequency Interference), which becomes a serious obstacle to radio astronomy. We are developing an algorithm to detect RFI using non-Gaussianity of time-series data. The developed algorithm is applied to observation data from the MWA telescope and feedback is being sought.

Press Release
https://www.kumamoto-u.ac.jp/whatsnew/sizen/20221129


Group photo at a meeting in Chennai, India

3. Research plan for the next year

In 2023, we aim to complete the RFI detection analysis software currently under development. Then, by applying it to the observation data of the MWA telescope, we aim to obtain more precise results than before by removing weak RFI. This is expected to give a stronger restriction to the 21 cm-line signal, and it may be possible to detect the signal by accumulating observation data for several hundred hours.

We will continue to observe pulsars and study the statistical fluctuations of pulse waveforms and arrival time. We will also try to combine observation data from other groups around the world. In cooperation with the Indian research team, we will prepare for the detection of gravitational waves.

International cooperation is essential for the above research, and we plan to actively exchange researchers with Australia and India.

4. List of awards, grants, and patents

科学研究費補助金基盤研究 B（2021 年度～2024 年度）・代表・直接経費：13,200,000 円

5. List of journal papers

[1] “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,
Publications of the Astronomical Society of Japan, Volume 75, Issue Supplement_1, February 2023, Pages S217–S231

[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,
The Astrophysical Journal, Volume 928, Issue 2, id.161, 11 pp., 04/2022

[3] “Low-frequency wideband timing of InPTA pulsars observed with the uGMRT”
K Nobleson, Nikita Agarwal, Raghav Girgaonkar, Arul Pandian, Bhal Chandra Joshi, M A Krishnakumar, Abhimanyu Susobhanan, Shantanu Desai, T Prabu, Adarsh Bathula, Timothy T Pennucci, Sarmistha Banik, Manjari Bagchi, Neelam Dhanda Batra, Arpita Choudhary, Subhajit Dandapat, Lankeswar Dey, Yashwant Gupta, Shinnosuke Hisano, Ryo Kato, Divyansh Kharbanda, Tomonosuke Kikunaga, Neel Kolhe, Yogesh Maan, Piyush Marmat, P Arumugam, P K Manoharan, Dhruv Pathak, Jaikhomba Singha, Mayuresh P Surnis, Sai Chaitanya Susarla, Keitaro Takahashi,
Monthly Notices of the Royal Astronomical Society, Volume 512, Issue 1, pp.1234-1243, 05/2022

[4] “On the Potential of Faraday Tomography to Identify Shock Structures in Supernova Remnants”
Shinsuke Ideguchi, Tsuyoshi Inoue, Takuya Akahori and Keitaro Takahashi,
Monthly Notices of the Royal Astronomical Society, Volume 513, Issue 3, pp.3289-3301, 07/2022

[5] “Wavelets and sparsity for Faraday tomography”

Suchetha Cooray, Tsutomu T. Takeuchi, Shinsuke Ideguchi, Takuya Akahori, Yoshimitsu Miyashita, Keitaro Takahashi,
Publications of the Astronomical Society of Japan, Volume 75, Issue Supplement_1, February 2023, pp. S85-S96

[6] “The Indian Pulsar Timing Array: First data release”
Pratik Tarafdar, Nobleson K., Prerna Rana, Jaikhomba Singha, M. A. Krishnakumar, Bhal Chandra Joshi, Avinash Kumar Paladi, Neel Kolhe, Neelam Dhanda Batra, Nikita Agarwal, Adarsh Bathula, Subhajit Dandapat, Shantanu Desai, Lankeswar Dey, Shinnosuke Hisano, Prathamesh Ingale, Ryo Kato, Divyansh Kharbanda, Tomonosuke Kikunaga, Piyush Marmat, B. Arul Pandian, T. Prabu, Aman Srivastava, Mayuresh Surnis, Sai Chaitanya Susarla, Abhimanyu Susobhanan, Keitaro Takahashi, P. Arumugam, Manjari Bagchi, Sarmistha Banik, Kishalay De, Raghav Girgaonkar, A. Gopakumar, Yashwant Gupta, Yogesh Maan, P. K. Manoharan, Arun Naidu, Dhruv Pathak,
Publications of the Astronomical Society of Australia, Volume 39, article id. e053, 10/2022

[7] “Nanohertz gravitational wave astronomy during SKA era: An InPTA perspective”
Bhal Chandra Joshi, Achamveedu Gopakumar, Arul Pandian, Thiagaraj Prabu, Lankeswar Dey, Manjari Bagchi, Shantanu Desai, Pratik Tarafdar, Prerna Rana, Yogesh Maan, Neelam Dhanda BATRA, Raghav Girgaonkar, Nikita Agarwal, Paramasivan Arumugam, Avishek Basu, Adarsh Bathula, Subhajit Dandapat, Yashwant Gupta, Shinnosuke Hisano, Ryo Kato, Divyansh Kharbanda, Tomonosuke Kikunaga, Neel Kolhe, M. A. Krishnakumar, P. K. Manoharan, Piyush Marmat, Arun Naidu, Sarmistha Banik, K. Nobleson, Avinash Kumar Paladi, Dhruv Pathak, Jaikhomba Singha, Aman Srivastava, Mayuresh Surnis, Sai Chaitanya Susarla, Abhimanyu Susobhanan & Keitaro Takahashi,
Journal of Astrophysics and Astronomy, Volume 43, Article number 98 (2022).

[8] “Introduction to Faraday tomography and its future prospects”
Keitaro Takahashi,
Publications of the Astronomical Society of Japan, Volume 75, Issue Supplement_1, February 2023, Pages S50–S84