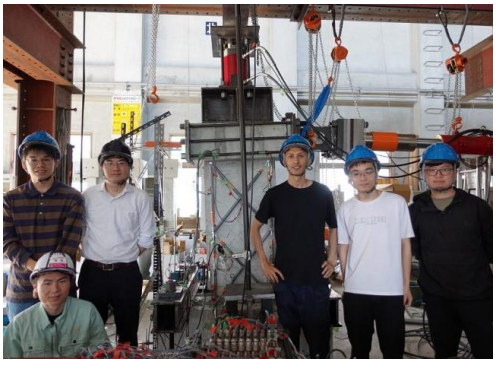
2-2. IROAST Tenure-track Professor and Associate Professors

No.	Name	Project Title
2-2-1	**Gaochuang CAI**	Design for structural safety and sustainability (DfS3)
2-2-2	**Masahiko FURUTANI**	Adaptive response of plant roots to abiotic and biotic stresses
2-2-3	**Hiroki MATSUO**	Development of polar materials for energy storage and conversion applications
2-2-4	**Zhongyue ZHANG**	Development of molecular based materials towards electronic and spintronic devices

No. 2-2-1	Design for structural safety and sustainability (DfS3)		
Name	Gaochuang CAI		
Affiliation	IROAST Email: cai@kumamoto-u.ac.jp	Title	Associate Professor
Research Field	Strengthening resilience / Advanced materials / Data science and AI		

1. Research outline and its perspective

The lab. aims to the two key research themes, i.e., (1) safety and optimization of structures under extreme loads (e.g., strong earthquake, earthquake-fire, etc.) including the application of high-performance materials (See Figure 1 a), 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 such as fiber reinforced polymer (FRP)-strengthening (See Figure 1 b). The two themes also can be shortly called *Design for Structural Safety and Sustainability* (DfS^3), which is also one of the most important parts of Design for X (DfX). Since December 2021, we have been conducted using advanced numerical methods, algebraic analysis, and experimental verification.



(a) High-performance RC walls and SRC columns under strong earthquakes

(b) FRP repaired RC columns under strong earthquakes

Figure 1 Research examples on the topic of DfS^{3}at the cluster

2. Research progress and results in the fiscal year

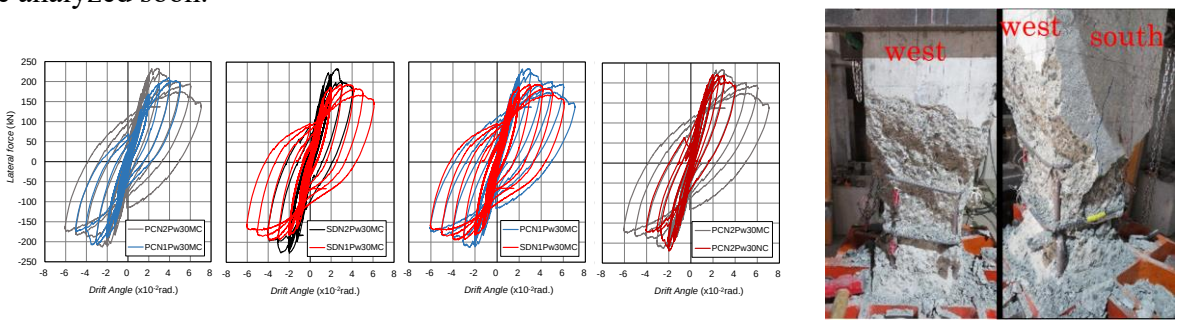
The following projects have been conducted in FY2023,

(1) Seismic performance and evaluation method of resilient RC (RRC) walls under multiple reversed cyclic loads induced by strong earthquakes (Test and numerical)
(2) Seismic performance and evaluation method of FRP repaired resilient RC (RRC) columns under multiple reversed cyclic loads induced by strong earthquakes (Test)
(3) Experimental study on seismic performance of steel-RC columns under strong earthquakes
(4) Numerical study on seismic performance of reinforced concrete-filled steel tube columns under simulated seismic loads
(5) Numerical study on flexural performance of RC beams with high-strength bars after fire
(6) Experimental and numerical study on shear performance of RC beams with high-strength bars after fire
(7) Machine learning-based evaluation of capacity and damage of RC columns

The results of three representative projects are summarized here,

(1) Seismic performance of SRC columns under strong earthquakes

Strengthening the earthquake resistance of reinforced concrete structures and developing high-precision analysis and design methods are some of the basic technologies that will be important for building a society where people can live safely and securely and an SDGs society. The purpose of this study is to conduct a series of experiments to investigate the seismic behavior of steel-reinforced concrete (SRC) columns subjected to multiple cyclic (MRC) loads due to long-period earthquake motions. Furthermore, by observing the surface damage state, we will develop an AI-based performance evaluation model and finite element analysis method, and by performing parametric analysis, we will propose an earthquake-resistant design method for SRC columns. This research allows us to quickly diagnose the safety of structures after a major earthquake and is expected to have great results from the perspective of SDGs. We have just experimentally investigated the seismic behavior of SRC columns subjected to MRC loads this year. The data will be analyzed soon.



(a) Comparison of load-drift ratio curves (b) Final damage

Figure 2 Load-drift ratio curves and final damage of several test specimens

(2) Machine learning-based evaluation of capacity and damage of RC columns

The objective of this study is to propose a complete seismic shear strength model of circular RC columns based on machine learning methods, via analyzing a literature database. This machine learning model is optimal compared with the other algorithms, based on real experimental data, and directly correlates the design parameters of circular RC columns with their shear strength. It overcomes the limitations of traditional methods that cannot directly compute for circular columns and eliminates the need for complex calculation formulas and norms. With only a few basic design parameters, it can quickly and easily determine the shear strength and the relationship between shear strength and the damage degree presented in Figure 3. Moreover, the predicted results exhibit a very high level of accuracy. To address the concerns of many structural engineers regarding the "black box" nature of machine learning, this study employs the SHAP (SHapley Additive exPlanations) method to visually depict the varying contributions of each parameter during the machine learning training process. The dataset training method and modeling, and the prediction results of the failure modes and load-carrying capacity of circular RC columns are presented in Figures 4 and 5.

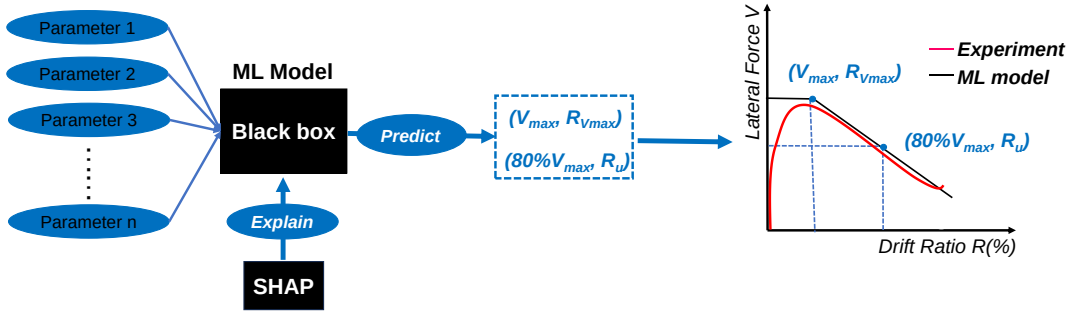


Figure 3 Framework of seismic capacity evaluation model based on the explainable ML model

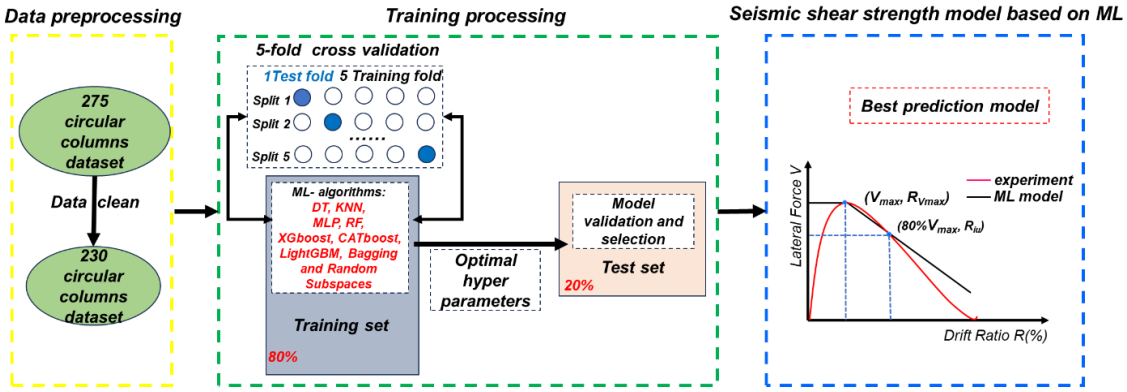


Figure 4 Dataset training method and modeling in the study

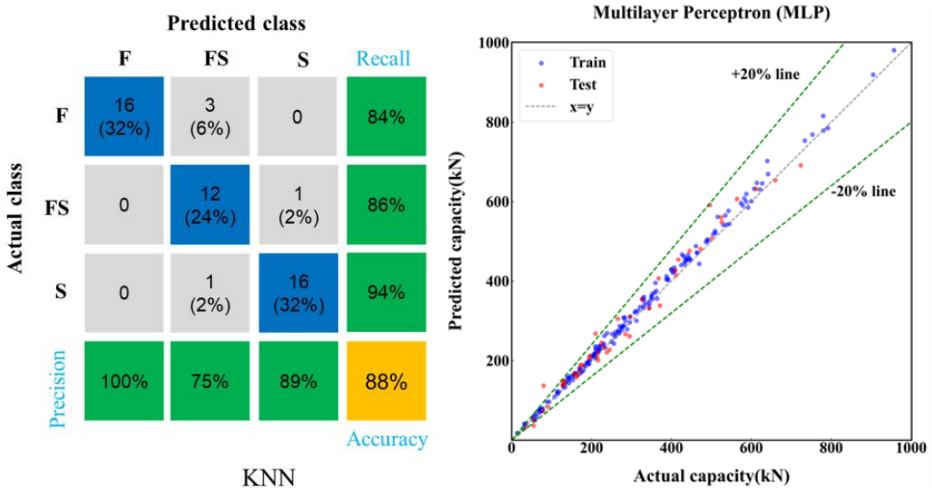


Figure 5 Prediction results of the failure modes and load-carrying capacity of circular RC columns

(3) Experimental and numerical study on shear performance of RC beams with high-strength bars after fire

This project investigates the shear performance of twenty reinforced concrete (RC) beams with high-strength longitudinal rebars and stirrups in room and high-temperature environments through experimental, numerical, and theoretical studies to understand the key factors affecting the beam shear resistance. It is understood that the mechanical properties of concrete and steel bars show a trend of first increasing and then decreasing after high temperatures. Increasing the stirrup ratio and stirrup strength can significantly improve the crack resistance and shear load-bearing capacity of the beams, and also improve the deformation performance of the beams. The residual shear capacity of the beams after high temperature was greatly affected by stirrup ratios because the load-bearing capacity of the beams after high temperature mainly depended on the mechanical properties of the steel reinforcement. The higher the strength of the steel reinforcements, the higher the shear capacity of the beams. A simplified calculation formula for the residual shear capacity of RC beams after room temperature and high temperature is proposed, which predicts well the test results. The results and simulation of some representative specimens are shown in Figures 6-8.

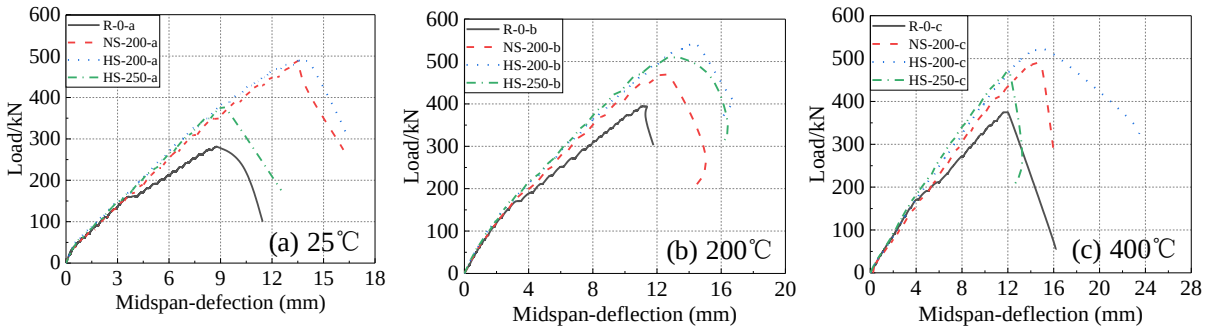


Figure 6 Load-midspan deflection of the test beams.

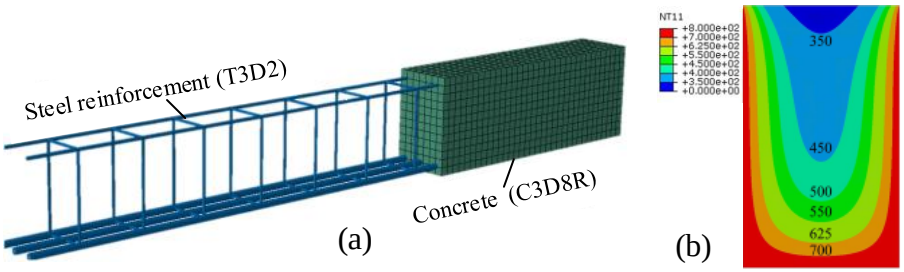
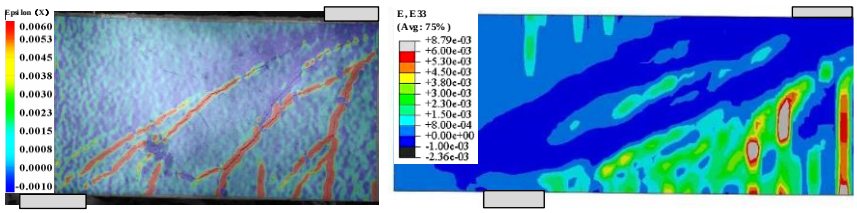
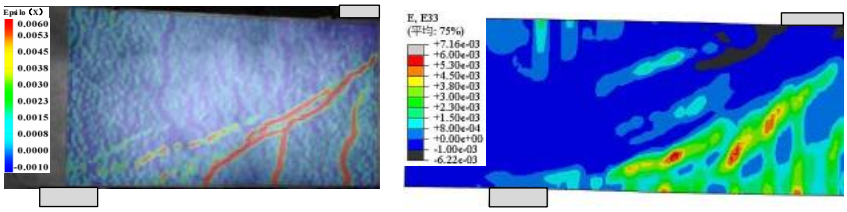


Figure 7 FEM model and cross-section temperature field simulation at 800°C.



(a) NS-200-a



(b) NS-200-b

Figure 8 Comparison of simulated and experimental strain distribution.

At this moment, the following journal papers are under review,

[1] Cai, G.*, Wen, Y.*, Malla, P., Fujinaga, T., Si Larbi, A. (2024). Effect of axial load and shear span on seismic performance of CFT columns reinforced with end-fixed ultra-high strength rebars, *Bulletin of Earthquake Engineering.*

[2] Su, Q., Qi, W., Liu, Y., Cai, G.*, Si Larbi A. (2024) Cracking Damage Analysis of Bridge-Railway Station RC Structures Considering Concrete Shrinkage, Creep, and Environmental Temperature. *Engineering, Construction and Architectural Management.*

[3] Sun, B., Huang, Y., Noguchi, T., Cai, G., Zhao W. (2024) Towards an Improved Concrete Construction Process: A Comprehensive Review of Monitoring Methods and Applications. *Journal of Building Engineering.*

[4] Khan, J.*, Si Larbi, A., Algourdin, N., Mesticou, Z., Aggelis, G., Cai, G. (2024). A holistic study on the mechanical behavior and acoustic emissions of textile reinforced mortar (TRM) strengthened reinforced concrete beams in flexure. *Construction and Building Materials.*

[5] Khan, J.*, Si Larbi, A., Algourdin, N., Mesticou, Z., Aggelis, G., Cai, G. (2024). Monitoring of acoustic emissions (AE) in TRM composites, and the use of supervised learning for bifurcation of cracking & non-cracking major damage based on AE-features. *Construction and Building Materials.*

[6] Deng, X., Zhao, J.*, Cai, G.*, Si Larbi, A. (2024) Shear behavior of reinforced concrete beams with high-strength reinforcements after high temperatures. *Construction and Building Materials.*

[7] Khan, J.*, Algourdin, N., Mesticou, Z., Cai, G., Si Larbi, A. (2024). The influence of high temperature exposure on the tensile and cracking behavior of crimped-textile reinforced mortar composites (TRMs). *Construction and Building Materials.*

3. Research plan for the next fiscal year

According to the current process and results, the following research projects will be conducted next year. These projects will be conducted by two post-doctoral researchers, four Ph.D. students, two master students, and four research students at Kumamoto University. Based on the projects, more than 8 journal articles will be published in international journals.

(1) Numerical analysis of resilient RC (RRC) shear walls under strong earthquake, including FEM analysis of the walls, and seismic response of the RC frames with the RRC walls.
(2) Experimental and numerical study on seismic performance of square RRC columns under strong earthquakes
(3) Experimental and numerical study on seismic performance of CFRP-confined circular RRC columns under strong earthquakes
(4) Experimental and numerical study on seismic performance of CFRP-repaired square RRC columns under strong earthquake
(5) Experimental study and numerical analysis of steel-RC (SRC) columns under strong earthquakes
(6) Experimental and numerical study on seismic performance of concrete-filled steel tube column frames with continues-beam type joints under simulated seismic loads

4. List of journal papers (with IROAST as your affiliation) published between April 2023 and March 2024

[1] Sun, Y. P., & Cai, G. C*. (2023). Seismic Behavior of Circular Concrete Columns Reinforced by Low Bond Ultrahigh Strength Rebars. *Journal of Structural Engineering*, *149*(9), 04023126. 2023.7. (IF:4.1)

[2] Zhu, H., He, Y*., Cai, G.**, Cheng, S., Zhang, Y., & Larbi, A. S***. (2023). Bond performance of carbon fiber reinforced polymer rebars in ultra-high-performance concrete. *Construction and Building Materials*, *387*, 131646.2023.7 (IF:7.3) **Internship student (2022.01.20-2022.02.25 [online]) in IROAST Research Internship Program **Host professor at Kumamoto University, **Corresponding author ***IROAST Visiting Prof.*

[3] Cai, G.*, Fujinaga, T., Si Larbi**, A., Wen, Y., & Malla, P. B. (2023). Cyclic behavior of RCFT columns with large D/t ratio steel tubes: Effect of reinforcement arrangement. *Bulletin of Earthquake Engineering*, *21*(9), 4565-4588.2023.7 (IF:4.6) ***IROAST Visiting Prof.*

[4] Wang, Y., & Cai, G.* (2023). Seismic behavior of square concrete columns confined by FRP-steel composite tube. *Journal of Building Engineering*, *65*, 105754. 2023.4 (IF:6.4)

[5] F. Zhao*, F. Xiong, G. Cai**, Q. Ge, Si Larbi, A***. (2023). Seismic behavior and simplified hysteretic model of precast concrete wall panels with bolted connections under cyclic loading. *Engineering Structures* 292, 1, 116562.2023.10 **Internship student (2022.01.20-2022.02.25 [online]) in IROAST Research Internship Program **Host professor at Kumamoto University ***IROAST Visiting Prof.*

[6] Junaid, K.*, Zyed, M., Nonna, A., Cai, G, Si Larbi, A**. (2024). Tensile and cracking behaviour of crimped textile reinforced mortar (TRM) based on digital image correlation. *Construction and Building Materials*, 417, 135321.2024.2 ***IROAST Visiting Prof.*

[7] Zhao, J., Jiang, Y., Cai, G.**, Deng, X.*, Si Larbi, A***. (2024). Flexural stiffness of RC beams with high-strength steel bars after exposure to elevated temperatures. *Structural Concrete*, *in press* (IF:3.2) https://doi.org/10.1002/suco.202300934 **Internship student (2023.11.15 ～ 2024.1.31(onsite: 2023.12.4-2024.1.31)) in IROAST Research Internship Program **Host professor at Kumamoto University ***IROAST Visiting Prof.*

5. List of awards, grants, and patents

-Grants

Seismic Performance and AI-based Evaluation Method of SRC Rectangular Columns Subjected to Multiple Repeated Cyclic Loads
Research Grant Ohata Foundation, 2,000,000JPY, 2022.10-2023.9

JST Sakura Science Exchange Program. Advanced technology and risk analysis of structures under extreme loads or environments（極端な負荷または環境下にある構造物の高度なテクノロジーとリスク分析）, 3,323,395JPY, 2024.1.22-2024.1.28

JSPS Grant-in-Aid for Scientific Research (C). 鋼コンクリート機械的ずれ止めを接合部に用いた新しい中低層 CFT 構造システムの開発, No.: 23K04120, PI: Fujinaga, T.(Kobe University), Co-Investigator: Cai, G.

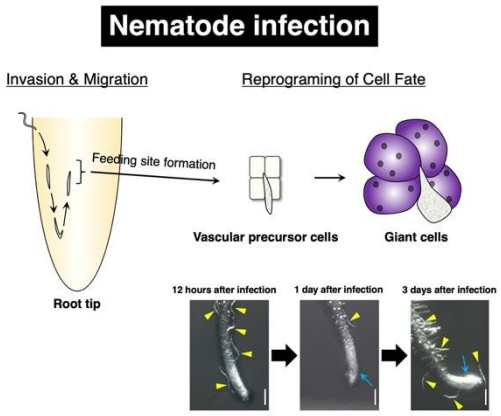
JSPS Grant-in-Aid for Scientific Research (B). Seismic performance and evaluation of resilient precast concrete columns、No.: 23K22912、PI: Sun, Y.(Kobe University), Co-Investigator: Cai, G.

No. 2-2-2	Adaptive response of plant roots to abiotic and biotic stresses		
Name	Masahiko FURUTANI		
Affiliation	IROAST Email: ma-furut@kumamoto-u.ac.jp	Title	Associate Professor
Research Field	Environmental bioscience		

[Details of activities]

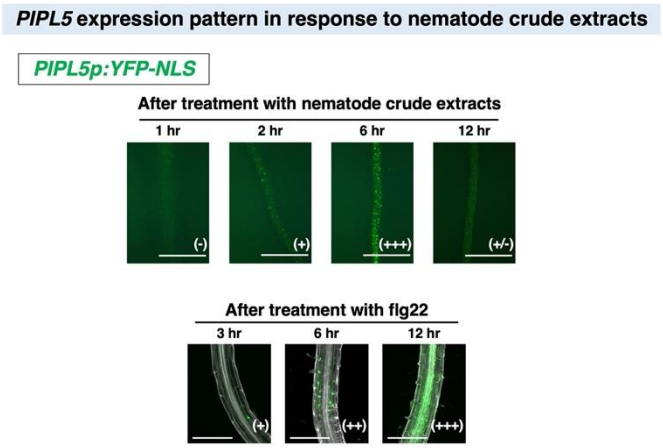
1. Research outline and its perspective

In this project, our group investigates the molecular mechanisms of adaptive response of plant roots to root-knot nematode infection using physiological, genetic, and biochemical approaches. In addition, based on the knowledge of the molecular mechanisms, we are going to establish nematode infection control methods by generating transgenic plants and developing agricultural chemicals.



2. Research progress and results in the fiscal year

At the early stage of root-knot nematode infection, nematodes invade into host roots by digesting plant cell walls and migrate to precursor vascular cells. Previously, we have identified the *PIPL5* (*PAMP-INDUCED SECRETED PEPTIDE-LIKE 5*) gene whose expression was upregulated very quickly and transiently in response to nematode infection. This year, we found that *PIPL5* expression was also upregulated when treated with crude extracts of nematodes. Upregulated *PIPL5* expression was transient in roots treated with nematode crude extracts, similar to roots infected by nematode. In addition, *PIPL5* was found to be upregulated by treatment with flg22, a peptide corresponding to the most conserved domain of bacterial elicitor flagellin. However, upregulated *PIPL5* expression was not transient but stable in roots treated with flg22. These results suggest that nematode effectors could reduce the *PIPL5* expression, whereas nematode elicitors could increase the *PIPL5* expression.



3. Research plan for the next year

Several candidate effectors from *Meloidogyne incognita* that could reduce plant defense response have been identified, for example, MiCM (Chorismate mutase) and MiCRT (Calreticulin). We already cloned these genes *MiCM1*, *MiCM2*, *MiCM3*, and *MiCRT* from *Meloidogyne incognita*. In order to confirm whether these effectors are involved in the suppression of *PIPL5* expression, we are creating transgenic plants carrying *PIPL5p:YFP-NLS*, where the expression of these

effector genes are inducible. Using these transgenic plants, PIPL5 expression will be analyzed in roots treated with nematode crude extracts after the induction of *MiCM1*, *MiCM2*, *MiCM3*, or *MiCRT* expression. In addition, to check whether these effectors are involved in nematode infection, nematode infection will be investigated after the induction of *MiCM1*, *MiCM2*, *MiCM3*, or *MiCRT* expression.

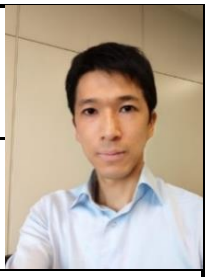
4. List of journal papers (with IROAST as your affiliation) published between April 2023 and March 2024.

Not applicable.

5. List of awards, grants, and patents

Principal Investigator (PI)

1. Kakenhi, Grant-in-Aid for Scientific Research (C) (2023-2025), Liquid-liquid phase separation in polar auxin transport.

No. 2-2-3	Development of polar materials for energy storage and conversion applications		
Name	Hiroki MATSUO		
Affiliation	IROAST Email: matsuo_h@cs.kumamoto-u.ac.jp	Title	Associate Professor
Research Field	Advanced materials		

1. Research outline and its perspective

We have developed ferroelectric materials with defect dipoles for the application to dielectric ceramic capacitors with a high energy density. The mechanism of the formation of the defect dipoles in Cu-doped $BaTiO_3$ ceramics was investigated. Moreover, the photovoltaic properties of Mn-doped $BiFeO_3$ epitaxial thin films were investigated to clarify the role of Mn under above- and below-bandgap excitation.

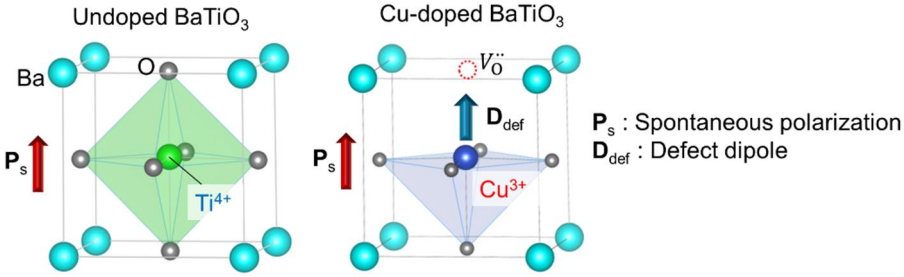


Fig. 1. Crystal structures of undoped $BaTiO_3$ and Cu-doped $BaTiO_3$ with a defect dipole ($\mathbf{D}_{def}$) comprised of Cu and oxygen vacancy ($V_O^{\bullet\bullet}$).

2. Research progress and results

a. Ceramic capacitors are considered as the leading storage components because of their robustness and extremely long lifetime. Ferroelectric $BaTiO_3$ has been widely used as a dielectric material for multi-layered ceramic capacitors because of its high dielectric permittivity. In acceptor-doped $BaTiO_3$, it has been proposed that acceptors on the Ti site trap oxygen vacancies ($V_O^{\bullet\bullet}$) to form defect dipoles. In this research, we developed an approach to improve the energy storage density and effective permittivity of $BaTiO_3$-based ceramics by utilizing defect dipoles comprised of acceptors and $V_O^{\bullet\bullet}$. Moreover, we investigate local structures around acceptors using X-ray fluorescence holography (XFH) for TM-doped $BaTiO_3$ single crystals to demonstrate the existence of defect dipoles.

We investigated the impact of annealing treatment on the polarization properties of Cu-doped $BaTiO_3$ ceramics to reveal the formation process of defect dipoles. Ceramics annealed at 400 °C showed a typical single polarization (P)-electric field (E) hysteresis loop even after an aging treatment. In contrast, samples annealed below 400 °C showed pinched P-E hysteresis loops with a high energy density because of the formation of defect dipoles. Moreover, XFH measurements for Fe-doped $BaTiO_3$ single crystals were performed using synchrotron X-ray. Atomic images around Fe atom were obtained from the holograms and indicated that Fe^{3+} substitutes Ti site as an acceptor.

b. Ferroelectric materials show a unique photovoltaic response that is not observed for photovoltaic effects in pn junctions and Schottky junctions. High photovoltages, light-polarization-dependent photocurrents, and ultrafast photoresponse are attractive features for novel optoelectronic applications. However, the weak photoresponse of typical ferroelectric oxides under visible light illumination has been one of the drawbacks for practical applications.

In our study, the photovoltaic properties of epitaxial thin films and single crystals of TM-doped ferroelectric oxides to clarify the impact of chemical doping on the photovoltaic response.

Photovoltaic properties of Mn-doped and undoped epitaxial $BiFeO_3$ thin films with a periodic multidomain structure were investigated. The films were deposited on $DyScO_3$ single-crystal substrates by the pulsed laser deposition (PLD) method. While Mn doping enhanced the photovoltaic response under below-bandgap excitation, that under above-bandgap excitation was suppressed by doping. Based on the analyses of the light polarization dependence of photocurrents, we concluded that the suppressed photovoltaic response under above-bandgap excitation is attributable to a reduced local electric field across domain-wall regions by Mn doping.

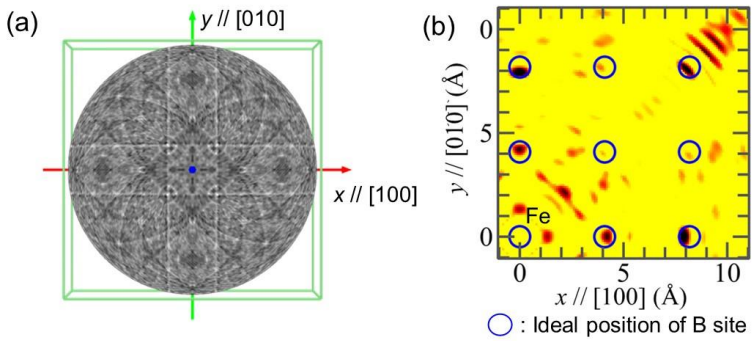


Fig. 2(a) Hologram obtained by XFH measurements for Fe-doped $BaTiO_3$ single crystals using Fe-Kα. (b) Atomic image around Fe atom reproduced from the hologram.

3. Research plan for the next year

a. As for energy-storage ceramic capacitors, we will continue the optimization of the conditions of the annealing and the aging treatment to maximize the energy storage density and effective dielectric permittivity. Moreover, XFH measurements for Cu-doped $BaTiO_3$ single crystals will be performed to demonstrate the formation of defect dipoles comprised of Cu and $V_O^{\bullet\bullet}$.

b. To obtain a larger photovoltaic response under visible light, the development of novel ferroelectric hybrid organic-inorganic perovskites (HOIP) will be started. We will prepare powders and thin films of HOIP with various chemical compositions and investigate their structural, optical, and polarization properties to find narrow-gap ferroelectrics for photovoltaic applications.

4. List of Papers

1) Seiyu Aso, Hiroki Matsuo*, Yuji Noguchi*
"Reversible electric-field-induced phase transition in Ca-modified NaNbO3 perovskites for energy storage applications"
Scientific Reports 13, 6771 (2023).
https://www.nature.com/articles/s41598-023-33975-6

2) Hiroki Matsuo*
"Domain-wall photovoltaic effect in ferroelectric perovskite oxides"
Journal of the Ceramic Society of Japan 131, 429−436 (2023).
https://doi.org/10.2109/jcersj2.23084

3) Hiroki Matsuo*, Yuji Noguchi
"Impact of Mn doping on the ferroelectric photovoltaic effect in multidomain $BiFeO_3$ thin films under above-bandgap illumination"
Japanese Journal of Applied Physics 62, SM1011 (2023).

https://iopscience.iop.org/article/10.35848/1347-4065/ace5b6

4) Julián A. Ortiz-Corrales, Hiroki Matsuo, Junichiro Otomo*
"Design and Fabrication of Protonic Ceramic Fuel Cells Based on $BaZr_{0.8}Y_{0.2}O_{3-\delta}$ |$BaZr_{0.1}Ce_{0.7}Y_{0.1}Yb_{0.1}O_{3-\delta}$ Bilayer Electrolyte"
Journal of The Electrochemical Society 170, 124520 (2023).
https://iopscience.iop.org/article/10.1149/1945-7111/ad1631

5. List of Awards and Grants

(Award)

1) The 40th Meeting on Ferroelectric Materials and Their Applications (FMA40)
Best Young Researcher Presentation Award
"Polarization Detection Properties of $BiFeO_3$-based Ferroelectric Thin Films in Visible Light Region" May. 2023

(Grants)

1) JSPS KAKENHI Grant-in-Aid for Transformative Research Areas (A)
"Control of Defect Dipoles for Designing Hyper-Ordered Structure in Ferroelectric Perovskite Oxides", April 2023-March 2025

No. 2-2-4	Development of molecular based materials towards electronic and spintronic devices		
Name	Zhongyue ZHANG		
Affiliation	IROAST Email: zhongyuezhang@kumamoto-u.ac.jp	Title	Associate Professor
Research Field	Advanced materials		

Details of activities

Research Outline and Perspectives:

Our team pursues the development of novel molecular based materials with unprecedented physical properties, such as semiconducting, metallic conductivity, magnetic properties, and spin filtration. Advanced physical measurements will be performed to unveil the mechanism of their unique physical properties, and the fabrication of molecular based devices will also be attempted to explore the potential of applications for molecular based devices.

Research progress and results in the fiscal year:

Two main research projects were conducted within this fiscal year:

(1) The preparation of new two-dimensional metal-organic frameworks with high-quality crystals and atomic scale precise structures. With rational molecular design, we successfully prepared two new 2D MOFs, $Cu_3(Trip\text{-}H)_2$ and $Cu_3(Trip\text{-}Me)_2$ (Trip-H = 2,3,6,7,12,13-hexahydroxy-triptycene, Trip-Me = 9,10-dimethyl-2,3,6,7,12,13-hexahydroxy-triptycene), and the single crystals of these two MOFs were obtained via slow diffusion method in a thin glass tube. Single crystal synchrotron diffraction measurements gave the structures of these two MOFs adapting two-dimensional honeycomb arrangement with typical $Cu(cat)_2$ (cat=catechol) building blocks. Interestingly, the interlayer stacking motif of these two MOFs are completely different: $Cu_3(Trip\text{-}H)_2$ adapts a staggered, AB stacking motif which is commonly seen in other 2D MOFs, but $Cu_3(Trip\text{-}Me)_2$ adapts an interpenetrated AB stacking motif. In both cases, the interlayer interactions that bind MOF together is the hydrogen bonding between the adjacent mono-protonated catechol units, which could be clearly observed via high-quality crystal structures. Furthermore, these hydrogen bonding led to a complicated 1D antiferromagnetic

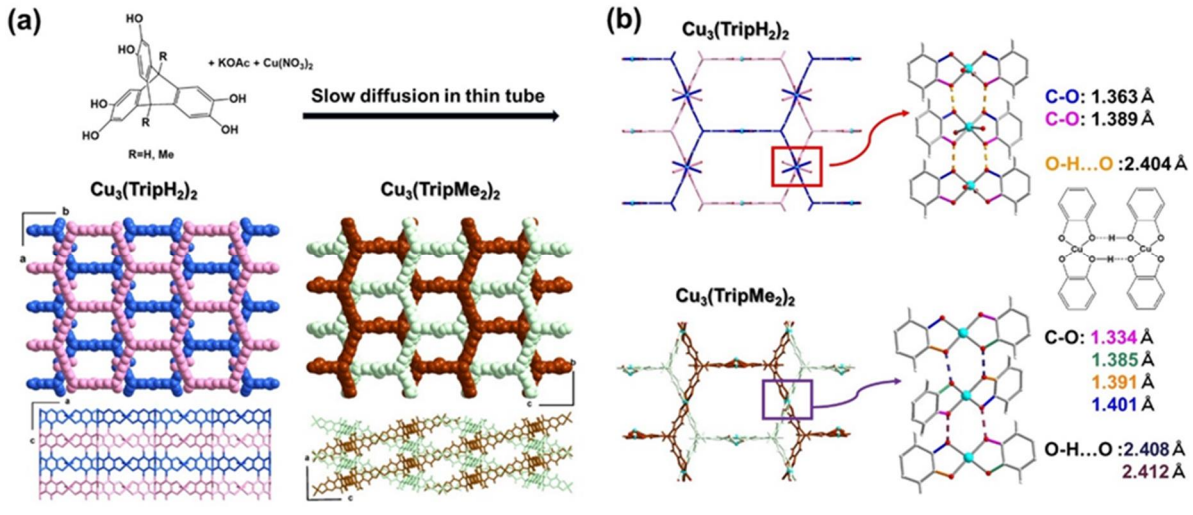


Fig.1 Structures of new 2D MOFs $Cu_3(Trip\text{-}H)_2$ and $Cu_3(Trip\text{-}Me)_2$

S=1/2 chain in both MOFs, and the signal of Cu(II) spins vanished in ESR measurements for

fresh MOF samples. The spin states and electronic properties of these MOFs were yet to be determined, but it is the first time we could make clear assertion about the detailed local coordination environments and their effects to the physical properties for 2D MOFs. (Fig.1)

(2) Chiral separation of helical extended metal wire complexes and their applications as chiral selected spin filters. The extended metal wire complex series, $M_3(dpa)_4X_2$ (M=Cu, Cr, Co, Ni, Ru, X=Cl, NCS, CN) was a well-known series of complexes that was prepared by Cotton and Peng independently, and recent results suggested these molecules being intriguing single-molecule conductors. On the other hand, these molecules are naturally helical structured, but existed as racemic complexes while as prepared and crystallized. Our strategy is to perform enantioseparation on $M_3(dpa)_4(NCS)_2$ and fabricate these molecules as self-assembled monolayer (SAM) on Au(111) surface, and characterize the single-molecule conductance via conductive AFM method with magnetized ferromagnetic tips. Simply soaking Au substrate in a high concentration CH_2Cl_2 solution of $Co_3(dpa)_4(NCS)_2$, the self-assembled monolayer was successfully observed via AFM measurement. On the other hand, by incorporating a pair of chiral anions, namely Λ/Δ-($As_2tartrate_2$), the $Co_3(dpa)_4^{2+}$ cations could be enantioseparated by forming coordination polymers [{Λ-$Co_3(dpa)_4$} Δ-($As_2tartrate_2$)]. These coordination polymers could be further digested via solvent and recombined with NCS^- anions, forming enantiopure helical extended metal wires.

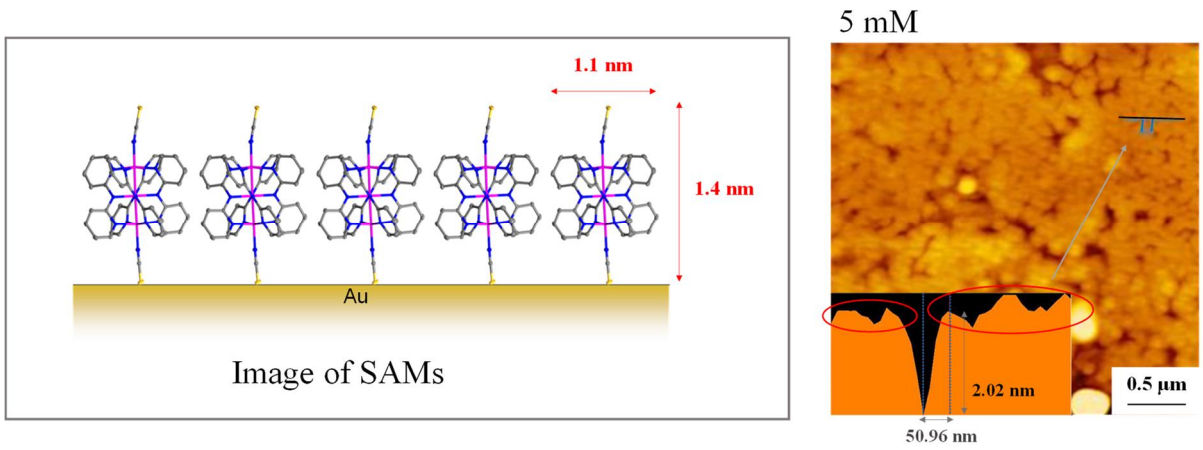


Fig.2 Self-assembled monolayer of $Co_3(dpa)_4(NCS)_2$ on Au(111).

Research plan for the next fiscal year:

At the moment, three targets will be pursued within the next fiscal year: (1), a careful characterization, including magnetic susceptibility and sophisticated ESR test of 2D MOFs, $Cu_3(Trip\text{-}H)_2$ and $Cu_3(Trip\text{-}Me)_2$ and collaborate with theoretical chemist to understand the electronic and magnetic states of them. (2) Continue and finish the enantioseparation of $M_3(dpa)_4(NCS)_2$ complexes and evaluate their chiral induced spin selectivity via polarized cAFM method. (3) Incorporating light induced spin pair or weekly coupled radical pair on two sides of $M_3(dpa)_4$ cations, and examine the effect of spin chains to the spin state distribution and evolution of radical pairs via TRESR and ODMR techniques (Collaboration with Prof. Teki, Osaka Public University)

Publications:

1. Thermally stable proton conductivity from nanodiamond oxide. L. I. Ardhayanti, Md. Saidul Islam, M. Fukuda, X. Liu, Z. Zhang, Y. Sekine and S. Hayami, *Chem. Commun.*, **2023**, *59*, 8306-8309.
2. Magnetometric Characterization of Intermediates in the Solid-State Electrochemistry of Redox-Active Metal-Organic Frameworks. Q. Chen, Z. Zhang and K. Awaga, *J. Vis. Exp.* **2023**, *196*, e65335.
3. Cu_2NiSnS_4 Nanoparticles Supported on rGO for Dual Frequency Range Electromagnetic Shielding. Z. Cai, Md Saidul Islam, M. Fukuzaki, M. A. Rahman, J. Matsuda, Z. Zhang, Y. Sekine, B. Bateer and S. Hayami, *ACS Appl. Nano Mater.* **2023**, *6*, 21980–21990.
4. Solvation/desolvation induced reversible distortion change and switching between spin crossover and single molecular magnet behaviour in a cobalt(ii) complex. H. Zenno, Y. Sekine, Z. Zhang and S. Hayami, *Dalton Trans*., **2024**, *53*, 5861-5870.

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