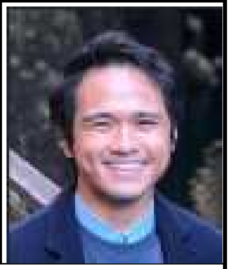
2-2. IROAST Postdoctoral Researchers

No.	Name	Project Title
2-2-1	**Jonas Karl Christopher Nuevas AGUTAYA**	Elucidation of the gas sensing mechanism of semiconductor metal oxides
2-2-2	**Prafulla Bahadur MALLA**	Seismic Performance of RRC shear walls under MRC loading
2-2-3	**Reetu Rani**	Enviromnmental applications of Metal Organic Frameworks
2-2-4	**Mizuki YAMADA** (-June, 2022)	Analysis of auxin signaling regulation in the apical region development of the plant embryo

No.2-1	Elucidation of the gas sensing mechanism of semiconductor metal oxides			
Name	Jonas Karl Christopher Nuevas AGUTAYA	Title	Postdoctoral Researcher	
Affiliation	IROAST Email: jnagutaya@chem.kumamoto-u.ac.jp			
Research Field	Advanced materials			

[Details of activities]

1. Research outline and its perspective

This research aims to elucidate the gas sensing mechanism of semiconductor metal oxides using solid-state calculations. In particular, the materials under investigation are ZnO and SnO_2, as well as their derivatives (*e.g.*, platinum-loaded, palladium-doped). The computations will be performed in conjunction with experimental techniques, such as microscopy and spectroscopy. The insights and generalizations that will be derived and formulated from this study can serve as a guide in the design of more stable, sensitive, and selective gas sensors.

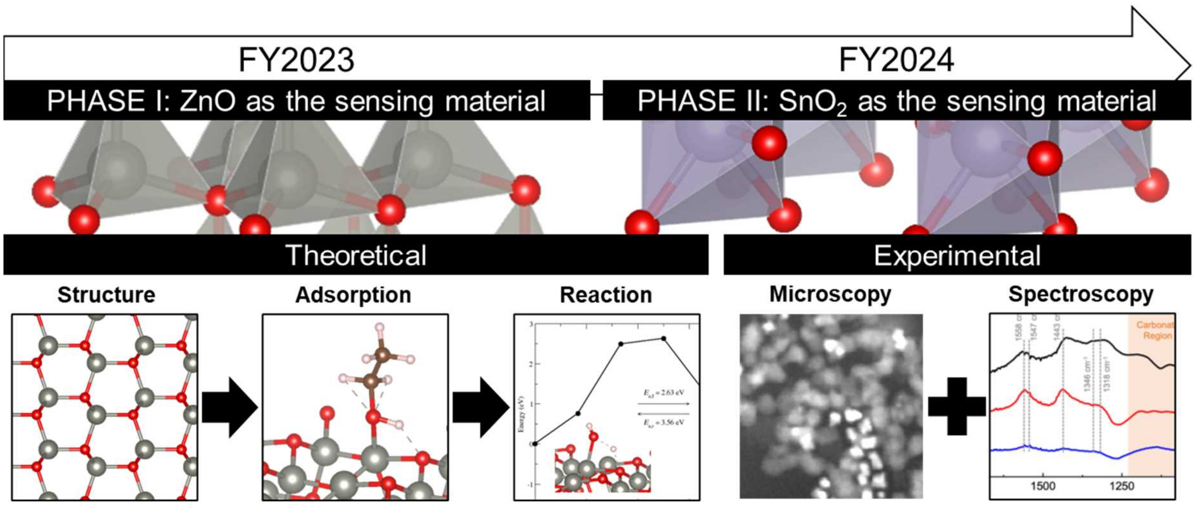


Figure 1. Timeline for study of the semiconductor metal oxides (This figure was used in the application for Grants-in-Aid for Scientific Research for FY 2023)

2. Research progress and results in FY 2022 (from September)

In light of the general objective of this study, several techniques have already been studied and implemented by the researcher in order to model the behavior of gases, such as ethanol and water, on the surface of ZnO. First, the *charge density difference* was determined to investigate how the addition of impurities in the form of doped or loaded platinum on the surface of ZnO can alter the properties of the material. Second, the *density of states* was calculated to determine the changes in the electronic properties of ZnO as a result of modification with platinum. Lastly, the pathway for the surface reaction was generated using the *nudged elastic band* method. The following is a set of representative results for each type of calculation.

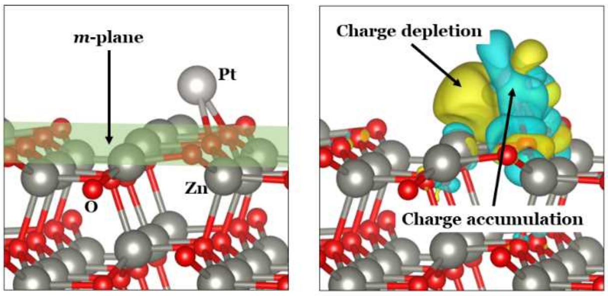


Figure 2. Charge density difference between a platinum atom and ZnO. The platinum is loaded on the *m*-plane of ZnO.

Charge density difference. As shown in Figure 2, loading a platinum on the *m*-plane of ZnO generates a charge accumulation region as a result of the bonding between platinum and the two oxygen atoms. Meanwhile, a charge depletion region exists between platinum and the adjacent zinc atoms. This region may be susceptible to a nucleophilic attack. In this study, this is a potential site for the adsorption of ethanol, which has an oxygen that bears two lone pairs of electrons.

Density of states. Figure 3 shows the projected density of states (PDOS) of the Pt-loaded ZnO (lower graph). The loading of Pt introduced additional energy levels within the band gap of ZnO. The proximity of these energy levels to the higher-energy conduction bands (right of the band gap) suggests that additional electrons for excitation to the conduction region are available. This leads to an improvement of the electrical conductivity of the material. Decomposition of the PDOS of Pt (upper graph) reveals that the five *d*-orbitals of Pt, corresponding to HOMO–4 to HOMO in the upper figure, comprise the energy levels in the band gap. Additional calculations, particularly the *integrated local DOS*, will be performed to fully describe the interaction between Pt and ZnO.

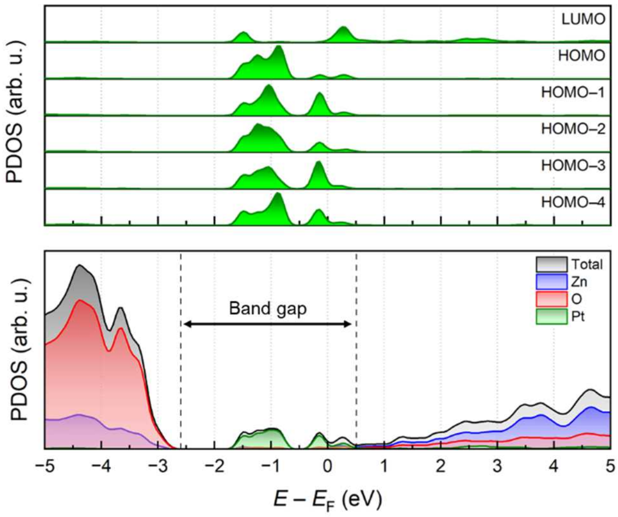


Figure 3. Projected density of states of Pt-ZnO

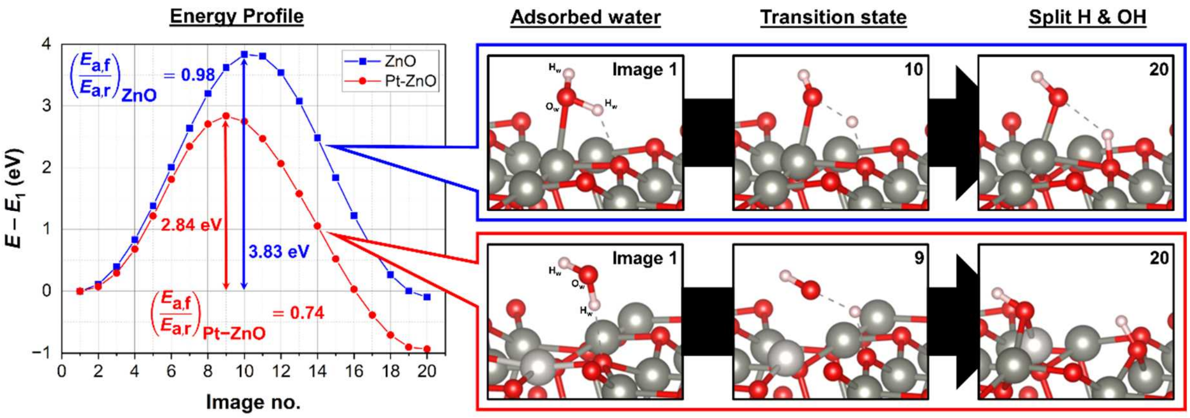


Figure 4. Formation of OH^- on the surface of ZnO and Pt-doped ZnO from the heterolysis of water (Presented at the 48th International Congress on Science, Technology and Technology-Based Innovation in Thailand)

Nudged elastic band. Aside from loading, another modification that can be performed to the ZnO surface is doping. In Figure 4, one Zn atom was replaced with Pt. In this particular investigation, the formation of OH^- on the surface of ZnO and Pt-doped ZnO was simulated using the nudged elastic band method. Based on the energy profile, the doping resulted not only in a decrease in the activation energy required for the heterolysis, but also in a reduction in the reversibility of the reaction. Platinum, therefore, is an effective catalysis in the formation of OH^- on the surface of ZnO. As one of the pre-adsorbed species detected from DRIFTS analyses of our material, OH^- is speculated to have a role in the oxidation of our target gases (e.g., ethanol, carbon monoxide) over the surface of ZnO.

3. Research plan for FY 2023

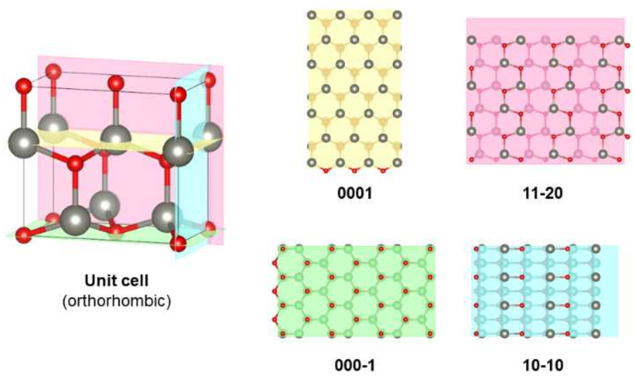


Figure 5. Unit cell of ZnO and its typical surfaces active in gas detection

The calculations so far have involved only the *m*-plane (10-10) of ZnO. As shown in Figure 5, however, other planes may also be active in gas detection. With our current shift from nanoparticles to nanorods of ZnO as our material, the *c*-plane (0001 or 000-1) has been shown to be the more dominant surface based on XRD analyses. The same pathway for calculations – geometry optimization, adsorption, and reaction, as shown in Figure 1 – will be performed to determine the mechanism of detection of our target gases such as ethanol and carbon dioxide with the surface of ZnO updated to 0001 and 000-1.

The second phase of the study where SnO_2 is the gas sensing material will also commence next year. Aside from platinum, our laboratory has also started exploring other impurities such palladium to improve the sensing performance of SnO_2. Aside from the typical set of calculations outlined above, a comparison between these two metals – Pt and Pd – in terms of their role in gas sensing will performed.

4. List of journals papers published between April 2022 and March 2023

a. Kam, Y. L.; **Agutaya, J. K. C. N.**; Quitain, A. T.; Ogasawara, Y.; Sasaki, M.; Lam, M. K.; Yusup, S.; Assabumrungrat, S.; Kida, T. "In-Situ Transesterification of Microalgae Using Carbon-Based Catalyst under Pulsed Microwave Irradiation". *Biomass and Bioenergy* **2023**, 168. https://doi.org/10.1016/J.BIOMBIOE.2022.106662.

5. List of awards, grants, and patents

a. **Best Poster Presentation Award** at the 48th International Congress on Science, Technology and Technology-Based Innovation (Thailand, Nov. 29–Dec. 1, 2022) for the study titled "Theoretical study of the formation of hydroxyl groups on Pt-doped ZnO(10-10) from the heterolysis of water"

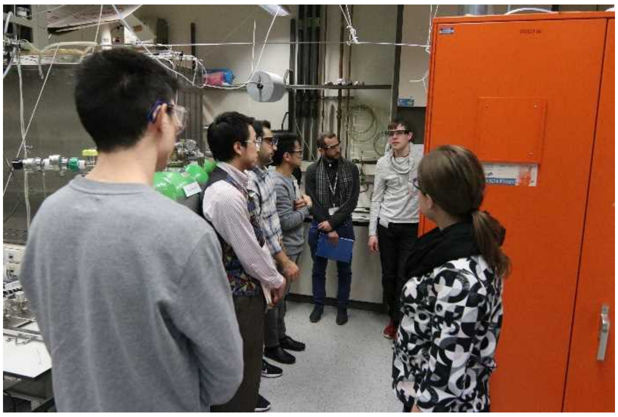
Figure 6. Awarding ceremony at the 48th STT

6. Research activities

a. [Oral presentation in a workshop] YL Kam, **JKCN Agutaya (*presenter*)**, AT Quitain, Y Ogasawara, M Sasaki, MK Lam, S Yuzup, S Assambumrungrat, T Kida. Graphene Oxide under Microwave Irradiation as an Effective Catalyst in the Production of Biodiesel from *Chlorella vulgaris*. e-ASIA Workshop and Site Visit. 2023 March 15–17. Institut Teknologi Sepuluh Nopember (ITS), Surabaya, Indonesia (online).

b. [Internship] Block course titled "Chemical Sensors – Basics, Technology and Applications" hosted by the Weimar Research Group. 2023 March 6–17. Institute of Physical and Theoretical Chemistry, University of Tübingen, Germany.

Discussion of the theory behind Kelvin probe measurements



Demonstration on the use of the Kelvin probe

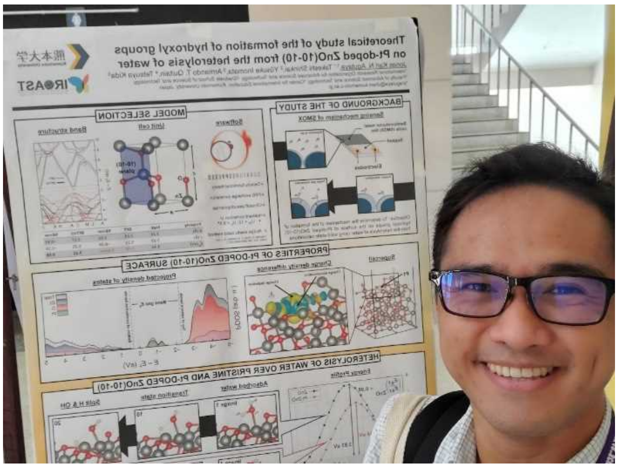
c. [Co-authorship of a paper] Nishizono, M.; Soreli, C.; Issasi, C.; **<u>Agutaya, J. K. C. N.</u>**; <u>Sasaki, M.</u>; Mizukami, H. "Production of Dried Tomato Powder with a High Concentration of Functional Components and Nutrients." *Journal of Antioxidant Activity* **2023**, 2(4), 1–21.

*Submitted and accepted to the journal while I was already in IROAST, but my affiliation was still FAST at the time of writing.
**Co-authored with Assoc. Prof. Sasaki of IROAST.

d. [Participation in a workshop] 8th JASTIP-WP2 Annual Workshop. 2023 January 9. CO113, TSP, NSTDA, Thailand (online).

e. [Conference organizer] 3rd International Symposium on Green Chemistry and Engineering as part of the Sakura Science Program hosted by the Kida Laboratory. 2023 January 18. Kumamoto University, Japan.

f. [Poster presentation in a conference] **JKCN Agutaya (*presenter*)**, T Shinkai, Y Inomata, AT Quitain, T Kida. Theoretical study of the formation of hydroxyl groups on Pt-doped ZnO(10-10) from the heterolysis of water. 48th International Congress on Science, Technology and Technology-based Innovation (STT 48). 2022 November 29 – December 1. Walailak University, Thailand.



Poster at the SST 48 conference in Thailand

g. [Oral presentation in a conference] YL Kam, **JKCN Agutaya (*presenter*)**, AT Quitain, Y Ogasawara, M Sasaki, MK Lam, S Yuzup, S Assambumrungrat, T Kida. Graphene Oxide under Microwave Irradiation as an Effective Catalyst in the Production of Biodiesel from *Chlorella vulgaris*. 4th International Seminar on Fundamental and Application of Chemical Engineering 2022 (ISFAChE 2022). 2022 October 26–27. Institut Teknologi Sepuluh Nopember (ITS), Surabaya, Indonesia (online).

h. [Laboratory Visit] Visit to the Ohgaki Laboratory, Katahira Laboratory, and Watanabe Laboratory of Kyoto University. 2022 September 26. Kyoto University, Japan.

*This visit to Kyoto University was upon the invitation of Prof. Hideaki Ohgaki as part of the e-ASIA Joint Research Program of Prof. Kida and Prof. Quitain.

Tour of the Katahira Laboratory, Kyoto University

Presentation of and discussion with Prof. Takashi Watanabe
about the results of his e-ASIA project on biorefinery

No.2-2	Seismic Performance of RRC shear walls under MRC loading			
Name	Prafulla Bahadur MALLA	Title	Postdoctoral Researcher	
Affiliation	IROAST Email: malla@kumamoto-u.ac.jp			
Research Field	Strengthening resilience			

[Details of activities]

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

The research work can be divided into two parts:

(1). Resilient reinforced concrete shear wall

Reinforced concrete (RC) shear wall is a cost-effective way of resisting the lateral load of the building structures. It is designed to resist the lateral force and control the inter-story drift of the building according to the building codal provisions. However, shear walls usually sustain significant damages caused by reversed lateral loads during earthquakes, especially under strong earthquakes such as the ones with long-period ground motion (LPGM) which attracted a wide concern in the research community recently. Present building codes focus on the collapse prevention of buildings for the safety of people. However, during strong earthquakes, these structures are beyond repair and result in huge economic losses, hindering disaster relief work after earthquakes. Few research on **weakly bonded ultra-high strength longitudinal bars** (UHS-WB) and **partly-debonded high strength bars (PDHS)** to develop a resilient RC (RRC) frame structure has been carried out in Japan. However, the research on the seismic safety of resilient shear wall structures with UHS-WB and PDHS under multiple reversed cyclic (MRC) loads induced by LPGM has not been reported yet.

Therefore, the main purpose of this research is to develop a RRC shear wall using ultra-high-strength-low-bond steel reinforcing rebars with fixed ends and to propose its performance evaluation and design method of the RRC walls under MRC loads. Based on the proposed research following objectives are fulfilled:

- Develop a resilient RC shear wall using weakly bonded Ultra-high strength steel rebars
- Development of Finite element model
- Simplified design model to evaluate capacity, deformation, and hysteresis curve

(2). Resilient reinforced concrete columns

Reinforced concrete column with ordinary deformed bars has been widely used in resisting vertical and lateral load simultaneously. They retain serious damage during strong earthquakes and has large residual drift which makes the repair work expensive. Thus, to improve this shortcoming UHS bar with weak bond strength has been proposed which has lower initial stiffness but greatly reduces the residual drift. Further, the UHS bars remains in elastic phase after large loading and makes repair work possible.

2. Research progress and results in the fiscal year

(1). Resilient reinforced concrete shear wall

There will be altogether 6 specimens of shear wall. The effective heigh of shear wall is 1350 mm with 150 mm thickness. Two specimens SW1 and SW2 are controlled specimens with ordinary deformed reinforcing steel bars. The remaining four specimens are ultra-high strength bars with weak bonding. The different parameters for the experiments are (a) axial load (b) type of reinforcement (c) spacing of stirrups and (d) type of horizontal loading. The parameters for the experiment are presented in Table 1. We have finalized the dimension and steel reinforcement of drawing and started purchasing materials steel reinforcement and plywood for formworks. We are currently preparing formworks and reinforcement for shear wall. The longitudinal and horizontal UHS steel bars are shown in Fig3. This fiscal year, we will be completing preparation of specimens and lab set-up.

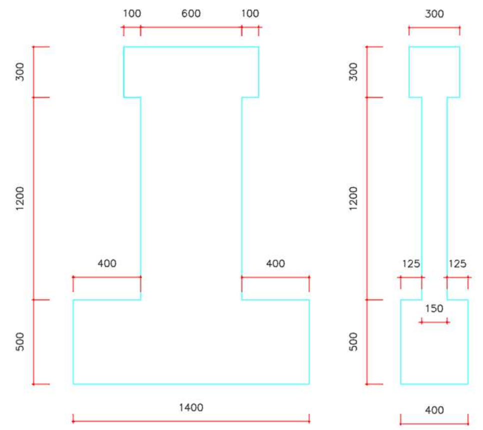


Figure 1 Dimension of shear wall

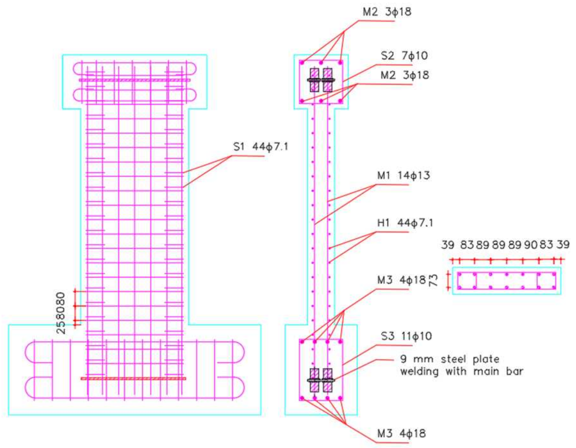


Figure 2 Detailing of steel reinforcement

Table 1 Parameters of shear wall

Shear wall experiment module

										Longitudinal steel bar	Boundary section			Vertical Shear Bar			ntal shea			Confined stirrup		Load type
	Name	b_w	l_w	h_w	l_{be}	f'c	n	N	a/D	Steel	# of bars	bar dia		Bar	bar area	pv	Steel	spacing	ph	Bar	spacing	
		mm	mm	mm	mm	N/mm²		kN			Nos.		%		mm²	%		mm	%			
1	SW1	150	600	1200	132	35	0.15	473	2.25	SD345	4	13	2.68	D13	133	0.88	U7.1	80	0.67	U7.1	80	NC
2	SW2	150	600	1200	132	35	0.15	473	2.25	SD345	4	13	2.68	D13	133	0.88	U7.1	80	0.67	U7.1	80	MRC
3	SW3	150	600	1200	132	35	0.15	473	2.25	SBPD 1275/1420	4	12.6	2.52	U12.6	125	0.83	U7.1	80	0.67	U7.1	80	NC
4	SW4	150	600	1200	132	35	0.15	473	2.25	SBPD 1275/1420	4	12.6	2.52	U12.6	125	0.83	U7.1	80	0.67	U7.1	80	MRC
5	SW5	150	600	1200	132	35	0.25	788	2.25	SBPD 1275/1421	4	12.6	2.52	U12.6	125	0.83	U7.1	80	0.67	U7.1	80	MRC
6	SW6	150	600	1200	132	35	0.15	473	2.25	SBPD 1275/1422	4	12.6	2.52	U12.6	125	0.83	U7.1	80	0.36	U7.1	150	MRC

Shear wall clea : 25 mm
Foundation clear cover 75 mm

l_w : horizontal length of entire wall or of a segment of wall considered in the direction of shear force

h_w : height of the entire wall, or segment of the wall considered

l_{be} : length of boundary zone or element

b_w : thickness of wall

Figure 3 Longitudinal and horizontal bars (UHS bar)

(2). Resilient reinforced concrete columns

This year, we also carried out test of resilient reinforced concrete column of six specimens with ultra-high strength bars to study the performance under the effect of multiple reverse cyclic loading .

Figure 4 Crack propagation of RRC columns

I have also been working on numerical model development of the RRC column considering the effect of weak bonding of ultra-high strength reinforcing steel bars. However, the results are not good as we need to consider the slip behavior of UHS-bar. More information on slip behavior can be obtained after we complete the experiment of shear wall. The current result of the simulation of RCC column is presented as in the figure below.

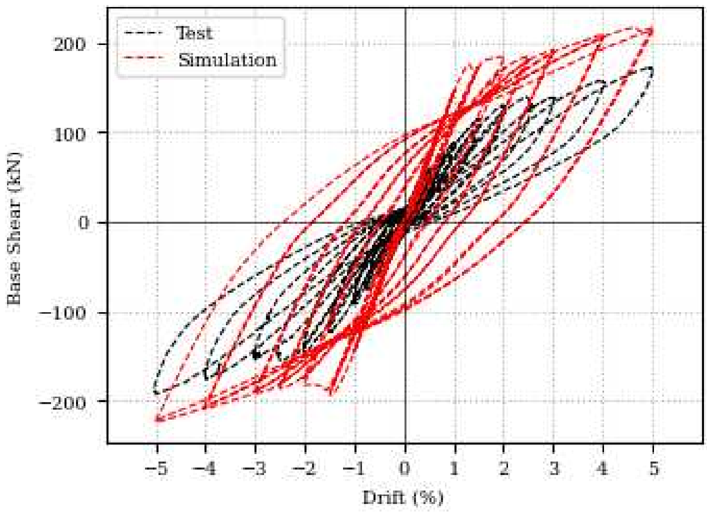


Figure 5 Comparison of numerical analysis with experiment

3. Research plan for the next year
   In the next fiscal year, experimental work on the laboratory i.e., loading on all the six specimens will be completed. More works would be done on analyzing experimental data and development of refined numerical model of RRC column and shear walls.
   AI evaluation and design modeling -In this phase, an AI model will be developed to predict the surface damage of the walls based on the images from experimental and FE results. To develop the model, a single crack pattern of a damaged component will be digitized and analyzed to obtain the corresponding singularity spectrum. Then multifractal features are extracted from the images and are fed as input into a classifier which is trained using data from experiments. Convolution Neural Network (CNN) will be adopted to create a non-linear mapping between stiffness degradation and the different parameters with multi-fractal features.

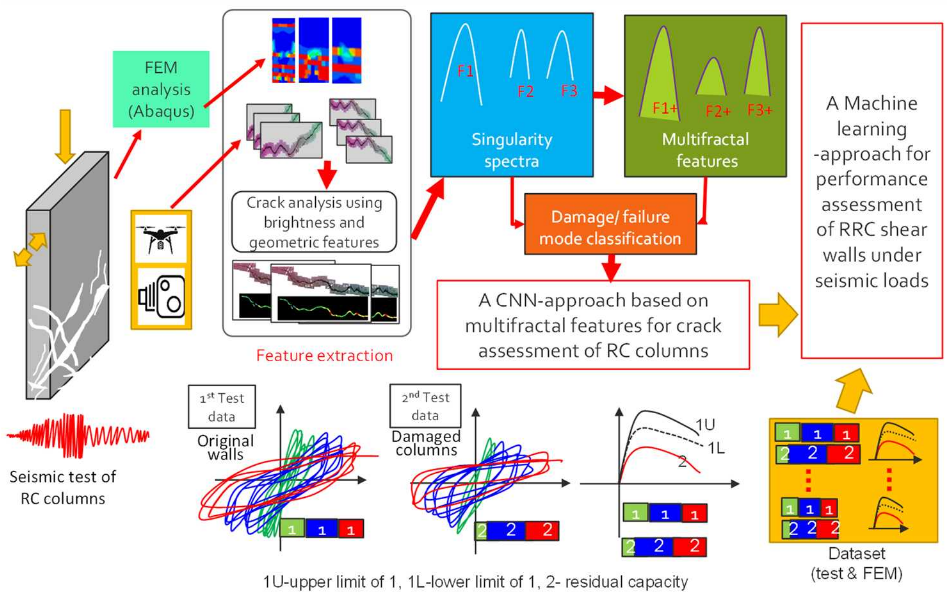


Figure 6 Research method and route

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

March 2023.
An article has been submitted on the peer-reviewed journal materials
(1) Qiwang Su, Weiming Qi, Yixi Liu, P. Malla, Amir Si Larbi and Gaochuang Cai. A Case Analysis of Cracking damage of Bridge-Railway Station RC Structures Considering Concrete Shrinkage, Creep, and Environmental Temperature. Materials. IF:3.748 (2021)

Recently a paper has been accepted.
"Cyclic behavior of RCFT columns with large D/t ratio steel tubes: effect of reinforcement arrangement", Bulletin of Earthquake Engineering.
G. C. Cai, T. Fujinaga, A. Si Larbi, Y. Wen, P. B. Malla.

I will also attend the conference

(1) Malla P. and Cai G., "Numerical analysis of precast concrete shear wall with bolted connections",1st International Symposium on Advanced Materials and Design for Structural Safety and Sustainability, 30-31 Jan, 2023, Kumamoto, Japan
(2) Yue WEN, Gaochuang Cai and Malla Prafulla, SEISMIC BEHAVIOR OF RESILIENT COLUMN WITH ULTRA HIGH STRENGTH REBARS UNDER MULTIPLE CYCLIC LOADS, Fukuoka conference.

5. List of awards, grants, and patents, if any
   (1) 2022-2023, "Seismic Performance and AI-based evaluation of RRC Shear Walls under MRC loads", FY2022 IROAST Research Funding Support for Foreign Postdoctoral Researchers.1,300,000 JPY
   (2) 2023-2024, "Development of resilient reinforced concrete shear wall with weakly and partly bonded ultra-high strength bars subjected to multiple revers cyclic loading", JSPS Early-Career Scientists
   (3) 2023-2024, "Resilient Reinforced Concrete Shear Wall with Openings", Foundation JUSOKEN (Under proposal process)

No.2-3	Environmental applications of Metal Organic Frameworks			
Name	Reetu Rani	Title	Postdoctoral Researcher	
Affiliation	IROAST Email: ranireetu@kumamoto-u.ac.jp			
Research Field	Environment-friendly technology			

[Details of activities]

1. Research outline and its perspective

Metal organic frameworks (MOFs) are porous crystalline materials made up of inorganic-organic hybrid units and have aroused interest of many researchers due to their structural diversifications, high surface area, tunable pore size and presence of various functional groups and unsaturated metal sites. MOFs have shown remarkable achievements in various fields especially in environmental remediations like storage of gases, selective separation of different analytes including ionic solutes, sensing and catalytic degradation of environmental pollutants. Among these applications, I have been working on selective separation of ionic solutes using MOF based membranes in ion transfer device (ITD). Ionic solutes in various matrices such as drinking water, sea water, and chemicals can cause problems for environment, human health, and various industrial products.

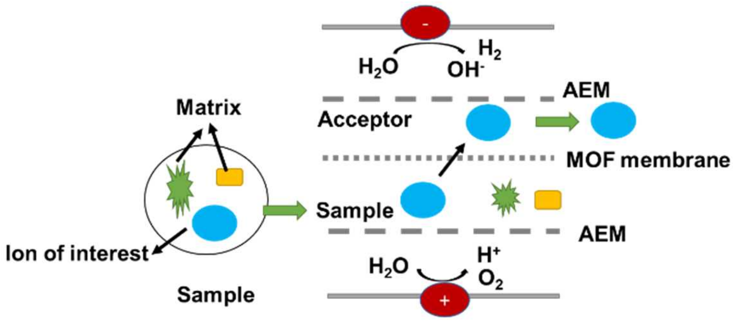


Fig. 1: Ion transfer device with MOF membrane

2. Research progress and results in the fiscal year

(a) Selective ionic solutes transfer with MOF based membranes

In this Fiscal year, I synthesized two zirconium metal organic frameworks i.e. UiO-66 and UiO-66-NH_2 (UiO: University of Oslo) using solvothermal method as shown in Fig. 2. Zirconium based MOFs have high thermal and chemical stability and adjustable pore size in sub-nanometer range. Therefore, these MOFs are promising candidates for environmental applications like selective separation of ionic solutes. In our research group, ion transfer device (ITD) is already developed and used for matrix isolation, pre-concentration, and separation of different ionic solutes for continuous analysis using different analytical techniques like atomic absorption spectroscopy (AAS) and inductively coupled plasma mass spectrometry (ICP-MS). I am developing metal organic framework modified membranes for selective separation of ionic solutes using ion transfer device. MOFs are highly porous materials that will strongly adsorb ions and strong electric field of ITDs will help in transport of these ions through MOF modified membranes. Therefore, adsorptive behavior of zirconium MOF, UiO-66-NH_2 was first checked towards metal ions namely Li^+, K^+, Ca^{2+}, and Mg^{2+}. Once selectivity of MOF towards ion will be established through adsorption studies, MOF based membranes will be tested for selective transfer of these ions.

(b) MOF based Oxygen sensor

Oxygen is one of the important contaminants in industrial gases. To continuously monitor O_2 gas in ppbv levels contained in industrial gas, I have studied MOF based gas sensor. I have synthesized a cadmium-based MOF, $[Cd_3(CPBPY)_2(BDC)_3]\cdot DMF\cdot H_2O$ using solvothermal method as shown in Fig 3. The Cd-MOF is synthesized using viologen based linker N-(3-Carboxyphenyl)-4,4'-bipyridinium chloride (HCPBPY)·Cl. Viologens exist in form of di-cation form, radical form and neutral form which show color transition from colorless to blue to yellow, respectively. Thus, N-(3-Carboxyphenyl)-4,4'-bipyridinium chloride linker is responsible for photochromism behavior of synthesized MOF in presence of oxygen. Therefore, Cd-MOF can be used for sensing and monitoring of O_2 gas.

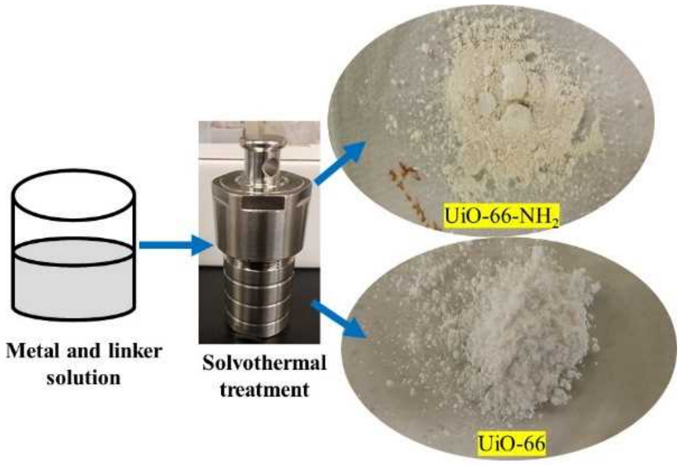


Fig. 2: Solvothermal synthesis of Zr-MOFs

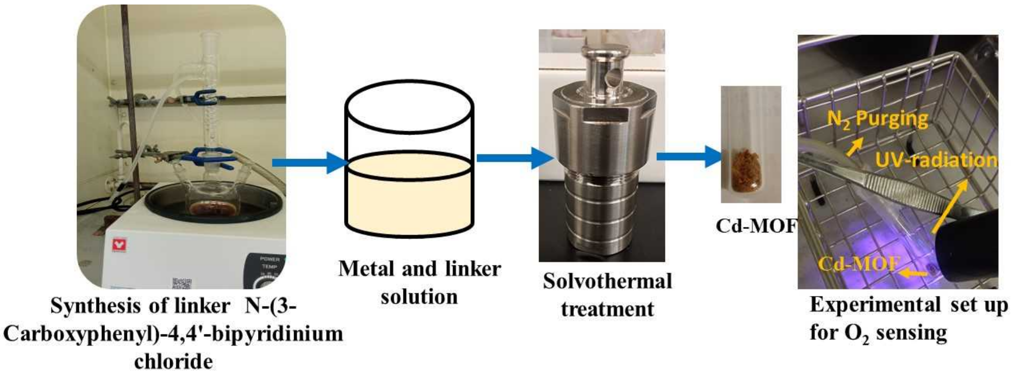


Fig. 3: Synthesis of Cd-MOF for O_2 sensing

3. Research plan for the next year
   - Characterization of synthesized MOFs will be performed using different characterization techniques.
   - Performance of ion-transfer devices (ITD) with MOF modified membranes will be tested.
   - More MOFs with sub nanometer pore size and good stability will be synthesized and explored for selective transfer of ionic solutes using ITD.
   - Real sample studies will be performed.
   - Oxygen sensing ability of synthesized Cd-MOF will be checked.
   - Manuscripts will be prepared for submission to reputed international journals.

4. List of journal papers (with IROAST as your affiliation) published between April 2022 and March 2023.
   N/A

5. List of awards, grants, and patents if any
   Grant: Grant-in-Aid for Young Scientists, applied for FY2023-2024.

No.2-4	Analysis of auxin signaling regulation in the apical region development of the plant embryo			
Name	Mizuki YAMADA	Title	Postdoctoral Researcher	
Affiliation	IROAST (-June 30, 2022) Email: myamada@kumamoto-u.ac.jp			
Research Field	Environmental bioscience			

[Details of activities]

1. Research outline and its perspective

The aerial organs (shoot) of dicotyledonous plants are generated from the center of the two cotyledons. During embryogenesis, the apical region of the embryo is separated into two cotyledons. Therefore, this cotyledon separation process is the first step of the shoot development of plants. The *CUP-SHAPED COTYLEDON* (*CUC*) genes are the key regulators of this process. Also the phytohormone auxin plays important roles in embryogenesis. I investigated the relationship between the *CUC* genes and the auxin signaling patterns.

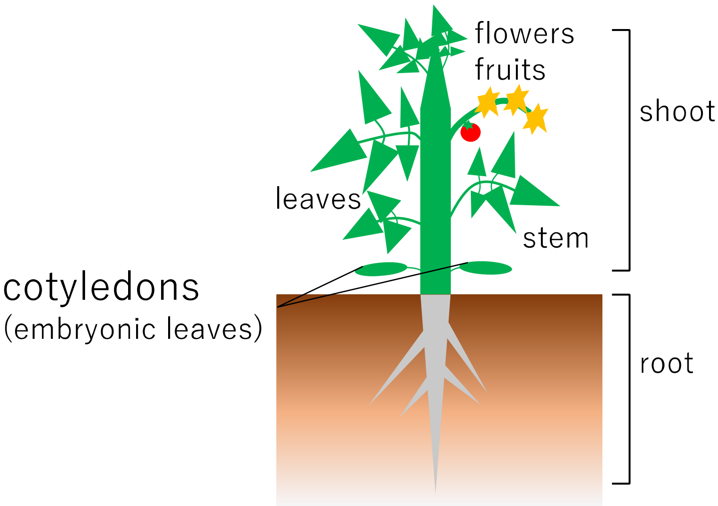


Figure1. The body plan of plants.

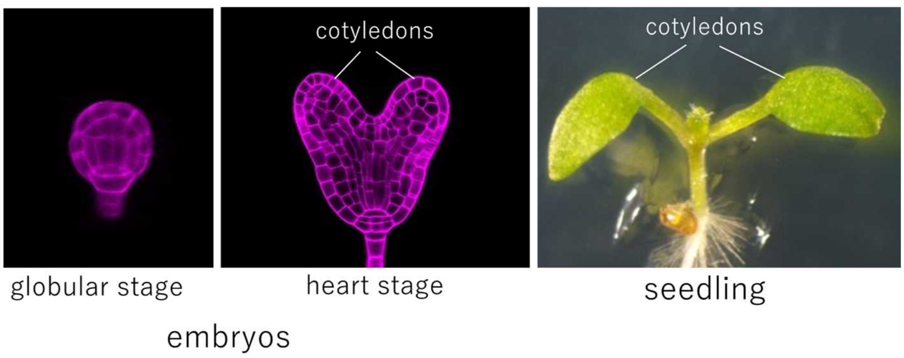


Figure 2. (Left and center) Confocal images of *Arabidopsis thaliana* embryos. Embryos before (left) and after (center) cotyledon initiation in the apical region. Stained cell walls are represented in magenta. (Right) Photo of a germinated seedling of *Arabidopsis thaliana*.

2. Research progress and results in the fiscal year

Although both of the *CUC* genes and auxin are the important regulators of plant embryogenesis, the relationship between the *CUC* genes and auxin in the development of the apical region of the embryos is not well understood. Therefore, I investigated the regulation of auxin signaling patterns by the *CUC* genes in the apical region of *Arabidopsis thaliana* embryos. By last FY, I have reported that the expression levels of several auxin biosynthetic genes, which are expressed in the cotyledon boundary region of the embryos, depend on the activity of *CUC* genes (Yamada et al., 2022). Furthermore, I found the spatial pattern of auxin response regulated by the *CUC* genes contributes to normal development in the apical region of the embryos.

(published in FY 2021)

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

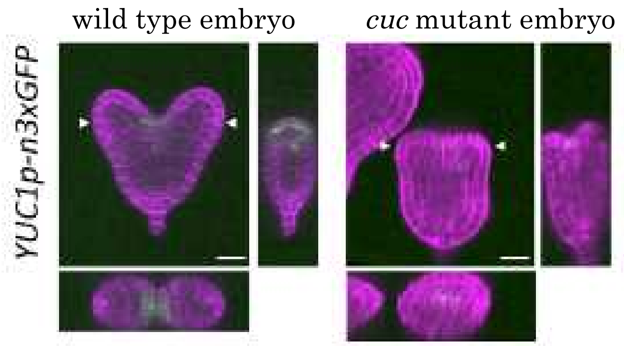


Figure 3. The expression of the auxin biosynthetic gene *YUC1* in *Arabidopsis thaliana* embryos. The cells with *YUC1* expression are represented in green (Yamada et al., 2022).

In this FY2022, I investigated more detailed and extensive analysis of the relationship between the *CUC* genes and the spatio-temporal auxin signaling patterns of the apical region of the embryos. My results suggested the genetic- and the spatial-interactions between several auxin related genes in the *CUC*-regulated developmental process of apical region of the embryos. Furthermore, I investigated the genetic interactions between the auxin signaling and other known *CUC*-regulated genes. From this result, the role of auxin signaling regulation in the development of the apical region of the embryo was suggested.

Besides the auxin signaling, I tried to find additional genes which are involved in the development of the apical region of the plant embryo. I examined the transcriptome analysis of the embryo (collaboration with Dr. Minoru Kubo, NAIST). Although the experiments were completed by last FY, I continued the analysis of obtained data in FY 2022, I listed the several new candidate genes.

This FY2022 is my last year in IROAST. Although I left Prof. Mitsuhiro Aida's lab and IROAST, some of my work in IROAST remains unpublished. Among them, the research of the relationship between the *CUC* genes and the auxin signaling will be reported soon. My works, including the auxin signaling and the transcriptome analysis, will continued to be investigated by Prof. Aida and the members of his lab.

3. Research plan for the next year

I moved to Prof. Shinichiro Sawa's lab in July 2022. Now I am working as a member of Sawa's lab and International Research Center for Agricultural and Environmental Biology (IRCAEB). IRCAEB opened in 2021, and now IRCAEB is starting various projects collaboration with various researchers. I will be making an effort in various works of IRCAEB including agronomic researches in next FY.

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

NA

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

NA