Japan-India Global Education and Research Center (JIGER)
Kick–off Symposium
Kunibiki Messe, February 27-28, 2026

Inaugural Program

Day 1 – February 27, 2026 (Friday)

**** Simultaneous interpretation is available for the 'Inaugural Program' only. All 'Scientific Program' sessions (27 PM; 28 AM & PM) will be conducted in English ****

Time	Program
08:45–09:30	Registration
09:30–09:40	Opening & Lamp Lighting
09:40–09:50	Address by the President, Shimane University
09:50–09:55	Address by Ministry of Education, Culture, Sports, Science and Technology (MEXT) Representative
09:55–10:00	Address by the Mayor of Matsue City
10:00–10:05	Address by the Consul General of India, Osaka-Kobe, Japan
10:05–10:15	Address by the Director, Indian Institute of Technology Hyderabad (IITH)
10:15–10:20	Address by Japan Society for the Promotion of Science (JSPS) Representative
10:20–10:25	Address by Japan Science and Technology Agency (JST) Representative
10:25–10:30	Address by Japan International Cooperation Agency (JICA) Representative
10:30–10:45	Project Overview by the Vice-President for Promotion of Globalization, Shimane University
10:45–11:00	BREAK
11:00–12:00	Panel Discussion
12:00–12:10	Photo Session

Scientific Program

Day 1 – February 27, 2026 (Friday)

Time	Program
12:10–13:40	**Lunch + Posters**
Session 1 (General)	**Session Chair – Prof. Yoshimi KATAOKA / Dr. Hemanth Noothalapati**
Keynote Lecture -1 13:40–14:00	[Growth of institutions through collaborations] Prof. B.S. Murty, IIT Hyderabad, India
Invited Lecture -1 14:00–14:15	[Introduction to LOTUS by JST] Mr. Sadahito TANAKA, Japan Science and Technology Agency
Invited Lecture -2 14:15–14:30	[Associations working for India Japan collaborations in the field of science & technology] Prof. Sakthi Kumar, Toyo University
Invited Lecture -3 14:30–14:45	[From Goals to Systems: The Role of Administration in Academic Excellence] Ms. D. Chanchala, IIT Hyderabad, India
Invited Lecture -4 14:45–15:00	[The role of cultural values in the effective collaboration between India and Japan] Dr. M.P. Ganesh, IIT Hyderabad, India
Invited Lecture -5 15:00–15:15	[Circular economy and climate change with emphasis on waste recycling] Dr. P. Bineesha, International Institute of Waste Management (IIWM), India
15:15–15:25	BREAK
Session 2 (Bio/Materials 1)	**Session Chair – Prof. Tatsuyuki YAMAMOTO / Dr. Shourya Dutta Gupta**
Keynote Lecture -2 15:25–15:45	[Application of Bioresorbable Plate Systems in Maxillofacial Surgery: From Basic Research to Clinical Practice] Prof. Takahiro KANNO, Shimane University
Invited Lecture -6 15:45–16:00	[Electrospun polymeric biomaterials: Process-property relationships guiding drug carrier design] Dr. Satyavrata Samavedi, IIT Hyderabad, India
Invited Lecture -7 16:00–16:15	[Sulfobetaine polymer design toward drug delivery and biointerfacing applications] Prof. Nobuyuki MORIMOTO, Shimane University
Invited Lecture -8 16:15–16:30	[Novel pharmaceutical co-crystal forms of Temozolomide and Gefitinib to study the bioavailability] Dr. T. Vijay, IIT Gandhinagar, India
Invited Lecture -9 16:30–16:45	[Fluorescence spectroscopy and dynamics of biomolecular interactions] Dr. G. Krishna, IIT Hyderabad, India
Contributed Lecture -1 16:45–16:55	[A Synthetic Rootstock Prototype for Delivering Growth Hormones to the Leaves] Dr. Takushi HACHIYA, Shimane University
16:55–17:00	Final Announcements

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Day 2 – February 28, 2026 (Saturday)	
Time	**Program**
Session 3 (Bio/Materials 2)	**Session Chair – Prof. Nobuyuki MORIMOTO / Dr. Satyavrata Samavedi**
08:45–09:15	Registration
Keynote Lecture -3 09:15–09:35	[Dreaming Beyond Borders: Shaping IIT Jammu's Global Future] Prof. Manoj Singh Gaur, IIT Jammu, India
Invited Lecture -10 09:35–09:50	[Elucidation of the SARS-CoV-2 replication mechanism and its therapeutic applications] Prof. Hisashi IIZASA, Shimane University
Invited Lecture -11 09:50–10:05	[Tuning the Glow: Advances in the Modulation of Near-Infrared Luminescence] Prof. Satyen Saha, Banaras Hindu University (BHU), India
Invited Lecture -12 10:05-10:20	[Uracil Hybrids as antitubercular, antileishmanial, anti-HIV, antimicrobial and antimalarial agents] Prof. T. Kannan, Pondicherry University, India
Invited Lecture -13 10:20-10:35	[Real-time tunable cavity coupled plasmonic structures for SERS] Dr. Shourya Dutta-Gupta, IIT Hyderabad, India
Contributed Lecture -2 10:35–10:45	[Development of new medical technologies through Medical-engineering collaboration] Prof. Shinji IMADE, Shimane University
10:45–10:55	BREAK
Session 4 (Materials 3)	**Session Chair – Prof. Tadashi FUJIEDA / Dr. Jayaramulu Kolleboyina**
Keynote Lecture -4 10:55–11:15	[Unique TEM Capabilities for Metallic Materials Research at NEXTA, Shimane University] Prof. Kazuto ARAKAWA, Shimane University
Invited Lecture -14 11:15–11:30	[Challenges with in-situ transmission electron microscopy: examples from heating and liquid cell microscopy] Dr. M. Sairama Krishna, IIT Hyderabad, India
Invited Lecture -15 11:30–11:45	[Reaction induced microstructural patterns in alloy thin films] Dr. Subhradeep Chatterjee, IIT Hyderabad, India
Invited Lecture -16 11:45–12:00	[Novel Inorganic Anion-Exchanger with Selectivity and Detection Abilities for Nitrate] Prof. Ryo SASAI, Shimane University
Invited Lecture -17 12:00–12:15	[Modelling and experimental approaches for additive manufacturing processes] Prof. Junji SHINJO, Shimane University
12:15–13:45	Lunch + Posters
Session 5 (Data Science / Engineering)	**Session Chair – Prof. Fumihiko ITO / Prof. Satyen Saha**
Keynote Lecture -5 13:45–14:05	[From Data to Action: Environmental Sustainability through Inclusive Research] Prof. V.S. Kanchana Bhaaskaran, Vellore Institute of Technology (VIT), India
Invited Lecture -18 14:05–14:20	[Interdisciplinary Approaches for Intensification of Thermal Energy Storage Systems] Prof. R.K.Sekar, Sastra University, India
Invited Lecture -19 14:20–14:35	[Robotics in Action – Trends & Beyond] Prof. Arockia Selvakumar, Vellore Institute of Technology (VIT), India
Invited Lecture -20 14:35–14:50	[Quantum Technologies and Sustainability Imperatives] Prof. Srikanth Itapu, Alliance University, India
14:50–15:00	BREAK
Invited Lecture -21 15:00–15:15	[Research in Sustainable Materials and Infrastructure: IIT Jammu] Prof. Anurag Misra, IIT Jammu, India
Contributed Lecture -3 15:15–15:25	[Single-shot Depth-resolved Fluorescence Microscopy] Dr. Varun Kumar, Shimane University
Contributed Lecture -4 15:25–15:35	[Changes in lagoonal carbon burial flux associated with Anthropogenic activity] Prof. Kota KATSUKI, Shimane University
Contributed Lecture -5 15:35–15:45	[Role of Mantle Dynamics in the Opening of the Japan Sea] Dr. Silpa A Sasidharan, Shimane University
15:45–16:00	Poster Presentation Awards, Closing Remarks & Final Announcements

Growth of Institutions through Collaborations

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While individuals and institutions grow to greater heights with their individual strengths, collaborations play a significant role in this growth path. Collaborations bring a lot of synergy between individuals and institutions and leads to multiplying effect and makes 1+1 significantly greater than 2. The speaker will bring examples of such influence of collaboration based on examples from his own professional experience and institution building experience.

From Goals to Systems: The Role of Administration in Academic Excellence

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How can university administration enhance productivity, foster inclusivity, and build a community, quite a large one, while achieving academic excellence, in its infancy? The Indian Institutes of Technology (IITs) are a network of reputed public engineering and technology colleges, created to support India's industrialization and national development post-independence. Indian Institute of Technology Hyderabad (IITH), where I come from, is a second-generation IIT created less than two decades ago. Unlike the first-generation IITs, which are endowed with extensive resources, experienced talent, and established procedures, IIT Hyderabad had to build everything from the ground up while drawing inspiration from and engaging with long-established institutions. And today, going by national or global rankings, as well as academic reputation, we are one among them. How did we pull this off?

While Japan plays a major role in our standing, our teachers exceeded expectations consistently. Younger than the average cohorts elsewhere, their energy made up for their lack of experience, their intent for procedures, and their commitment—along with Japanese cooperation—for resources. They juggled and continue to play many roles: teach, research, consult, outreach, and on top of that, administer. While they have shown the direction and set the standards, any administration is as good as its everyday performance. To paraphrase a popular insight, we do not rise to the level of our goals but fall to the level of our systems. Besides, the test of any administration is how well the institution fulfils its raison d'être, viz. if a university is created for academic excellence, in what ways can an administration facilitate?

This talk offers a few insights from an administrative (non-teaching) perspective at IIT Hyderabad, a humble attempt to pass on whatever best we could do, to Japan and to Shimane University (henceforth Shimane). For instance, how did we decentralize and digitize at a scale no other IIT has thus far, while all other universities in India continue to remain top-down and paper-heavy? While forms, dashboards, home-grown modules or the upcoming Enterprise Resource Planning (ERP) system address the routine and the everyday, emails address the exceptional. The result: productivity, flexibility, and more importantly, feedback loops that establish a virtuous cycle. Similarly, how did we create a gender-safe campus through calling out and counselling, when many universities in India do so through disciplining? And how are we building a sense of ownership and community at workplace?

These, and similar lessons, we believe hold value when shared, as we look forward to learning from Shimane equally. For instance, how does Shimane boost student intake in niche disciplines given its academic breadth? How does Shimane balance global partnerships while retaining local talent in furthering its vision? The odds of creating something new are challenging, as was told with the unfolding story of IIT Hyderabad. But with odds come opportunities, and a sense of freedom to create pathways where none exist. The Shimane University JIGER (Japan-India Global Education and Research Center) Kick-off Symposium and the platform it offers to IIT Hyderabad and other Indian universities, come with similar opportunities and a promising road ahead.

The role of cultural values in the effective collaboration between India and Japan

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The countries of Japan and India have been historically connected through various cultural and business relationships. Buddhism originated from India still thrives in Japan. Similarly, Japanese technology and products have become inherent part of Indian life in the past decades. While both these countries have been looked at as "Eastern" by studies on cultural values, they vary significantly between them in their social and cultural dynamics. As a key emerging power in terms of economic growth with a potential demographic advantage, India is one of the sought after destinations for Japan for economic investments and human capital. With this background this paper talks about the role of cultural values in facilitating collaboration between both these countries at an individual and organizational level. This paper discusses some of the potential socio-cultural challenges in establishing stronger ties between the two countries at an individual and organizational level. The paper also arrives at some specific action plan to overcome those challenges and ways to nurture the ties between Indian and Japanese individuals and organizations.

Circular Economy and Climate Change with Emphasis on Waste Recycling

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Linear material production and waste disposal systems continue to be the main source of greenhouse gas (GHG) emissions, with much of it occurring due to it being inherently energized during extraction, processing and end-of-life management. The circular economy is a systemic intervention strategy as it provides a material loop mitigation channel, with waste recycling acting as a transformational intervention. Regarding a cradle-to-cradle life-cycle analysis (LCA), recycling helps to reduce the emissions mainly due to the replacement of primary materials manufacture, as well as the prevention of disposal-related emissions. Peer-reviewed evidence indicates that recycling one tonne of aluminum avoids approximately 9–10 t CO_2-eq, steel 1.5–2.0 t CO_2-eq, paper 1.0–1.8 t CO_2-eq, plastics 1.0–3.0 t CO_2-eq, and glass 0.3–0.6 t CO_2-eq relative to virgin production, while diversion of biodegradable waste from landfilling avoids 0.2–1.0 t CO_2-eq per tonne. Conditional upon substitution efficiency, quality of secondary material, carbon intensity of the energy system, and transport demand, the achieved mitigation potential can yield losses that may cause net savings to decrease by up to 40. It is this synthesis that finds waste recycling as a technically sound and scalable climate-reduction approach in the circular economy which has direct applicability to the demand-side decarbonisation and sustainable material management.

This paper discusses how recycling of waste can help in mitigating climate change through major streams of materials that include waste that contain metal fractions, such as electronic waste, construction and demolition waste, and metal waste. The paper puts waste recycling in the context of global climate-governance policies to explain its applicability to Nationally Determined Contributions (NDCs), Scope 3 emissions reduction, and industrial sectors outlined by the Intergovernmental Panel on Climate Change (IPCC). Special attention is paid to such policy tools as Extended Producer Responsibility, technology interventions, eco-design and formalization of informal recycling systems all of which complement each other in order to improve the environment, bring about co-benefits to the society and economy.

The paper has also concluded that Net-Zero pathways cannot be achieved without high-quality, inclusive, and well-regulated recycling systems particularly in the rapidly urbanizing and resource-constrained economies, using example of E-Waste Recycling. The implementation of the circular economy in the waste-management policies (similar to SWM Rules 2026), can provide both quantifiable climate, and at the same time, sustainable development, green jobs, and resource security.

Application of Bioresorbable Plate Systems in Maxillofacial Surgery: From Basic Research to Clinical Practice

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Bioresorbable plate systems are increasingly used for bone fixation in maxillofacial surgery, including corrective facial-jaw surgery, trauma management, and reconstructive procedures. Unlike conventional titanium devices, bioresorbable systems are designed to provide temporary mechanical stability and gradually degrade in the body, eliminating the need for secondary removal surgery. However, the term "bioresorbable" encompasses a wide range of materials with markedly different physicochemical and biological properties.

Currently used systems are primarily based on synthetic polymers such as polyglycolic acid (PGA), poly-L-lactic acid (PLLA), and poly-D-lactic acid (PDLA). Their degradation kinetics, mechanical strength retention, crystallinity, inflammatory response, and replacement by host bone vary considerably depending on molecular composition and structural design. Since the early 1990s, bioresorbable fixation materials have evolved through several generations. First-generation systems established the concept of degradable osteosynthesis but were limited by prolonged degradation and inflammatory reactions. Second-generation materials were engineered to accelerate resorption. Third-generation systems incorporated improved mechanical strength, osteoconductivity through composite design, and radiopacity to allow postoperative imaging assessment. More recently, fourth-generation bioactive bioresorbable systems have been developed, aiming to balance mechanical stability, controlled degradation, and enhanced bone regeneration. Despite their expanding clinical use, systematic evidence regarding biological activity, host tissue interaction, and long-term remodeling behavior remains insufficient. Our research group has performed comprehensive investigations combining in vitro cellular and material analyses, in vivo rat mandibular defect models, and clinical outcome assessments. Particular attention has been given to comparative evaluation between third- and fourth-generation systems, focusing on bioactivity, osteoconductive potential, and resorption–replacement dynamics.

In this lecture, I will integrate material science perspectives with clinical requirements of the maxillofacial region. By clarifying how material composition and structural design influence biological response and bone healing, we aim to discuss future directions for the development of next-generation bioresorbable fixation systems.

Generation	Material Composition	Key Characteristics	Bone Regeneration & Inflammatory Response	Clinical Application Insights
1st PLLA	100% Poly-L-lactic acid	- Very slow degradation (>3.5–5 years) - High rigidity but brittle - High risk of chronic inflammation and foreign body reaction	❌ Minimal new bone formation ❌ Highest CD68+ macrophage presence ❌ Thick fibrous encapsulation up to Week 10	**❌ Not recommended for current use** **⚠ Formerly used in mandible & midface, now avoided**
2nd PLLA/PGA	85% PLLA / 15% PGA (copolymer)	- Moderate degradation (12–18 months) - Flexible but lower mechanical strength - Reduced inflammation vs. PLLA	△ Slightly better bone formation than PLLA △ Moderate CD68+ response △ Less fibrous tissue by Week 10	**▲ Non-load-bearing areas:** **• Midface trauma • Peri-Orbital regions** **• Pediatric trauma**
3rd u-HA/PLLA	40% u-HA / 60% PLLA	- Strong bioactivity and osteoconductivity - Direct bone bonding - Long degradation (4–5 years~10years)	◎ High Runx2 and OCN expression ◎ Mature lamellar bone by Week 10 ◎ Low CD68+ = minimal inflammation	**✅ Panfacial/Midface & Mandible applicability:** **• Midface, zygoma** **• Mandible, condyle** **• Orthognathic surgery (LF Ⅰ /BSSRO/Genioplasty)**
4th u-HA/PLLA/PGA	10% u-HA / 90% PLLA/PGA (88:12)	- Bioactive with accelerated resorption - Early replacement by bone - Moderate mechanical strength	◎ Highest bone volume by Week 10 ◎ Strong Runx2 and OCN ◎ Lowest CD68+ inflammation	**⚠ Midface, pediatric fractures** **⛔ Caution in mandible (risk of premature degradation)**

Reference:
Shijirbold A, Kanno T, et al. PLOS ONE. 2025
Ramanathan M, Kanno T, et al. Nanomaterials. 2023
Ayasaka K, Kanno T, et al. Materials (Basel). 2023
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Electrospun polymeric biomaterials:
Process-property relationships guiding drug carrier design

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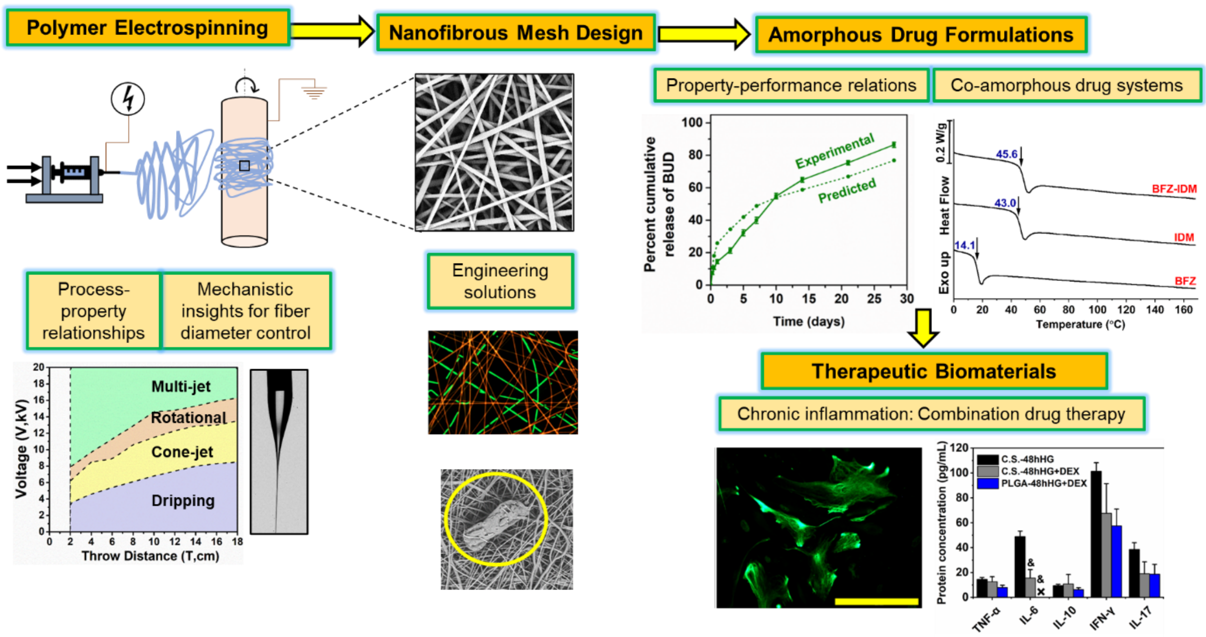
Our research group pursues problems in the domains of polymeric biomaterials and pharmaceutical soft matter. We investigate process-property-performance relationships in polymeric systems with the goal of employing them as drug carriers. Specifically, we use the industrially important processing technique of electrospinning to design fibrous meshes and powders for the regulated release of poorly soluble drugs. In this talk, I will provide a broad overview of our laboratory's research themes along these directions. I will first briefly discuss our efforts in the direct visualization of electrospinning aimed at accessing stable operational modes and gaining a deeper understanding of jet-thinning mechanisms. Physical insights that we obtain from such studies can pave the way for effective control of fiber diameter, which can significantly impact mesh performance in pharmaceutical applications. Later in the talk, I will briefly describe our efforts in the development of electrospun drug carriers. Here, I will provide snapshots from studies that improve our understanding of release mechanisms from electrospun meshes, as well as design strategies that aid the development of materials exhibiting zero-order release of small molecule drugs. I will conclude with an illustration that demonstrates the application of such materials in targeting chronic inflammation, conducted in collaboration with biologists and clinicians.



Representative publications:

- D Venugopal *et al.,* Int. J. Pharm., 651, 123768, 2024
- S Arunachalam *et al.*, Ind. Eng. Chem. Res., 63(30), pp. 13238-13251, 2024
- N Joy *et al.*, Chem. Eng. Sci., 295, 120168, 2024
- N Joy *et al.*, Eur. Polym. J., 168, 111102, 2022

Sulfobetaine polymer design toward drug delivery and biointerfacing applications

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Zwitterionic polymers consist of monomer units bearing both positively and negatively charged groups, and they are well known for their excellent biocompatibility due to their non-biofouling properties. Among them, we focus on sulfobetaine-based polymers containing sulfonate or sulfate groups, because their side chains exhibit stronger molecular interactions than other zwitterionic polymers. Although the most common sulfobetaine polymer, poly[3-[[2-(methacryloyloxy)ethyl]dimethylammonio]propane-1-sulfonate], P(SB), shows UCST-type thermoresponsiveness in pure water, this behavior disappears under physiological salt conditions. To address this issue, we have designed various sulfobetaine polymers by tuning their intra- and intermolecular interactions. In this study, a sulfobetaine copolymer, SB copolymer with a small fraction of PEG methacrylate units [P(SB-PEG)], was synthesized via RAFT polymerization. Cytotoxicity assays in HeLa cells confirmed that these polymers exhibit no detectable toxicity regardless of their molecular weight or composition. Interestingly, fluorescein labeled P(SB-PEG) showed rapid cellular internalization, reaching a maximum uptake within 5 minutes. Polymer-derived fluorescence was observed throughout the cell, and intracellular accumulation exhibited a strong linear correlation with the polymer concentration. Uptake was not suppressed by endocytosis inhibitors and was even enhanced at 4 °C, suggesting that these polymers enter cells predominantly through direct membrane permeation rather than endocytosis. Furthermore, conjugation of Rhodamine B enabled mitochondrial translocation of the polymer construct, allowing delivery into the mitochondrial matrix without affecting ATP production or other enzymatic activity. This indicates the potential of the polymer as a long-term mitochondrial imaging probe. In addition, anticancer drug–polymer conjugates demonstrated high permeation into tumor spheroids and the effective intracellular delivery, leading to significant anticancer activity within dense multicellular aggregates. In this presentation, we will also introduce the design of polymers with temperature-dependent control of intracellular distribution, as well as polymer architectures with enhanced penetration into multicellular tumor spheroids.

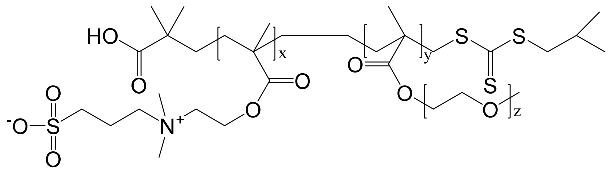

Figure 1 Chemical structure of P(SB-PEG)

Title: Novel Pharmaceutical Co-crystals forms of Temozolomide and Gefitinib to study the bioavailability

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Poor aqueous solubility and chemical instability often limit the clinical performance of anticancer drugs. This talk presents pharmaceutical co-crystallisation as an effective solid-state strategy to address these challenges using two clinically important agents: gefitinib (GEF) and temozolomide (TMZ). Gefitinib, an ATP-competitive EGFR inhibitor for non-small cell lung cancer, exhibits extremely low aqueous solubility (2.55 µg mL^{-1}). Three co-crystals of GEF were engineered with cinnamic acid, sorbic acid, and resorcinol via solvent-assisted grinding. Structural studies revealed a 1:1 GEF–cinnamic acid co-crystal and 1:1:1 co-crystal hydrates with sorbic acid and resorcinol. Among these, the GEF–cinnamic acid co-crystal showed significantly enhanced solubility while maintaining comparable anticancer potency, supported by Hirshfeld surface analysis of intermolecular interactions.

Temozolomide, a first-line prodrug for glioblastoma, rapidly hydrolyses at physiological pH, resulting in a short half-life (~1.8 h). To improve its hydrolytic stability, co-crystals were developed with pharmaceutically acceptable acids and amides. Solid-state characterisation confirmed co-crystal formation, while dissolution and stability studies demonstrated enhanced drug release and up to a 3-fold improvement in hydrolytic stability, particularly for the TMZ–salicylic acid and TMZ–4–nitrobenzoic acid hydrate systems. In vitro studies on glioblastoma cell lines further revealed improved cytotoxicity for the TMZ–4-nitrobenzoic acid hydrate.

In conclusion, pharmaceutical co-crystallisation offers a robust and versatile platform for simultaneously enhancing the solubility, stability, and biological performance of anticancer drugs without altering their molecular structure, thereby providing a promising pathway for improved therapeutic outcomes.

References:

1. Bhanu Priya, et al., Temozolomide cocrystal forms with enhanced dissolution, stability and biological activity towards Glioblastoma, Journal of Molecular Structure, 1313, 2024, 138751. https://doi.org/10.1016/j.molstruc.2024.138751.

2. A Shaik, et al., Novel pharmaceutical co-crystals of gefitinib: synthesis, dissolution, cytotoxicity, and theoretical studies, CrystEngComm, 2023, 25, 2570-2581

Fluorescence Spectroscopy and Dynamics of Biomolecular Interactions

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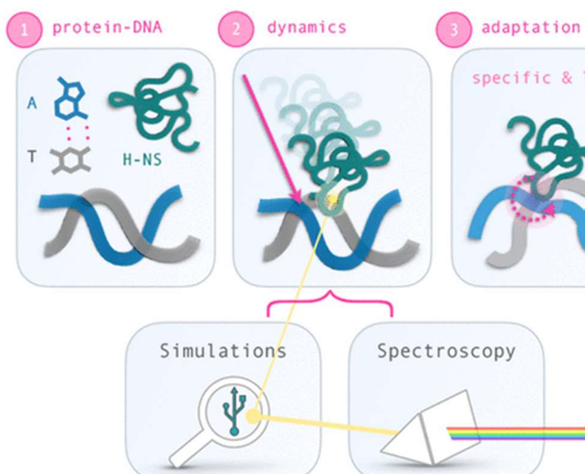
DNA demonstrates remarkable structural diversity, transitioning between conformations such as B-DNA and A-DNA under specific environmental or protein-binding conditions. These transitions are relevant for mediating cellular processes such as gene regulation, DNA organization, and stress response. In bacteria, the histone-like nucleoid structuring protein (H-NS) exemplifies the interaction between sequence-dependent DNA conformational adaptability and protein-mediated regulatory mechanisms. Despite evidence for the strong affinity of H-NS for AT-rich DNA, the specific molecular and structural interactions driving this recognition remain largely unclear. Combining fluorescence spectroscopy, circular dichroism (CD), molecular dynamics (MD) simulations, and enhanced sampling techniques, we show that H-NS exhibits a ten-fold higher affinity for ApT repeats compared to that of GpC repeats. Interestingly, selective binding of H-NS to AT-rich DNA causes a structural adaptation in the DNA, including increased bending flexibility, minor groove widening, and localized A-like DNA features, while GC-rich DNA remains closer to the canonical B-form. Our approach yielded detailed insights into how H-NS exploits the intrinsic conformational plasticity of DNA to achieve sequence-dependent binding. More broadly, this work illustrates how DNA-binding proteins can harness the structural adaptability of the DNA double helix, which may modulate regulatory outcomes, and provides insight into how the intrinsic properties of DNA shape protein-DNA interactions in diverse biological systems.



1. Dineshbabu Takkella, Javier Cerezo, Lara Martinez-Fernandez*, Krishna Gavvala*. RSC Chem. Biol., 2025, 6, 1927.
2. Thor van Heesch, Sudhanshu Sharma, Bert van Erp, Alberto Pérez de Alba Ortíz, Remus T Dame*, Jocelyne Vreede*, Krishna Gavvala*. J. Phys. Chem. B, 2025, 129, 5653.

A Synthetic Rootstock Prototype for Delivering Growth Hormones to the Leaves

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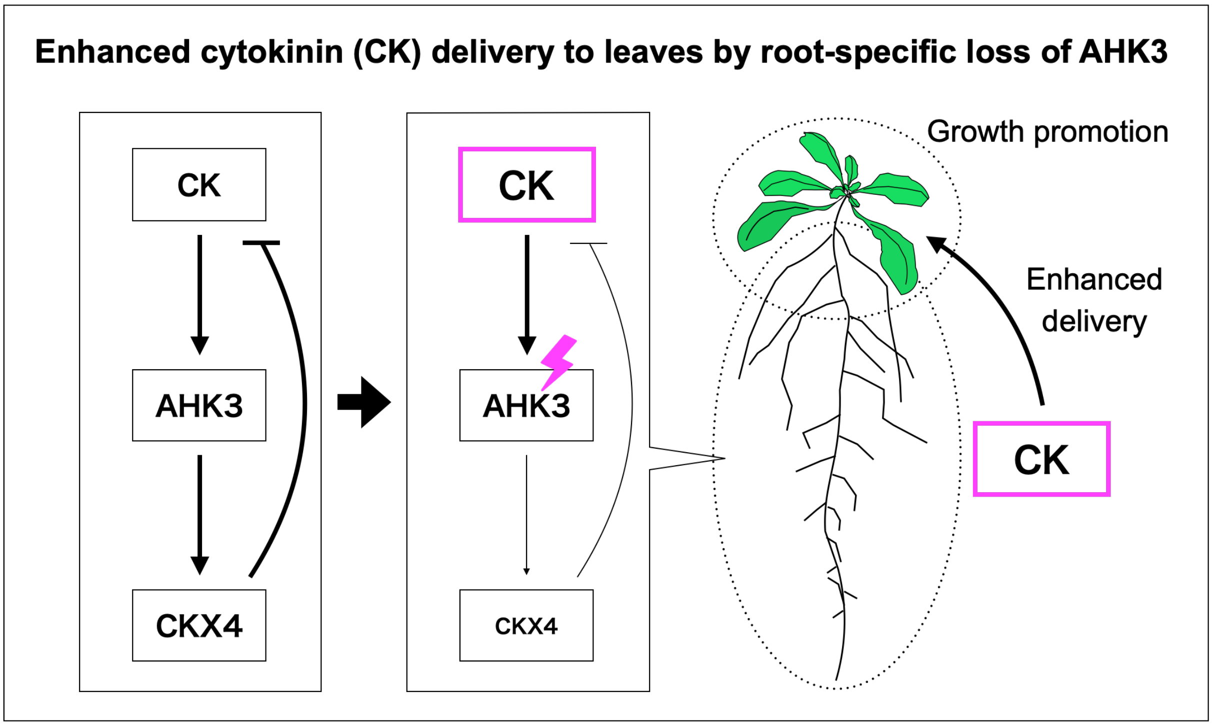
Increasing leaf area enhances light capture and can thereby boost crop productivity. Growing evidence indicates that roots regulate leaf growth through long-distance chemical signaling. Here, we propose a "hormone-pump" rootstock concept: a synthetic rootstock prototype designed to enhance the delivery of growth-promoting hormones known as cytokinins from roots to leaves, leading to increased leaf expansion. To construct this prototype, we targeted two regulatory layers of cytokinin homeostasis in roots: cytokinin signal perception mediated by Arabidopsis histidine kinases (AHKs) and cytokinin degradation by cytokinin oxidase/dehydrogenases (CKXs). Using grafting experiments, we demonstrated that root-specific loss of AHK3 systemically promotes leaf growth via a root-derived signal that is perceived by AHK3 in the leaves. To elucidate the underlying mechanism, we performed gene expression and hormone analyses, which revealed that AHK3 deficiency in roots suppresses CKX4 expression. This suppression resulted in elevated cytokinin levels in roots and xylem sap and a correspondingly enhanced cytokinin response in leaves. Together, these findings define a compact and engineerable regulatory circuit—AHK3–CKX4—that modulates cytokinin flux from roots to leaves. Because AHKs and CKXs are broadly conserved across plant species, we anticipate that root-specific manipulation of the AHK–CKX module could provide a viable strategy for improving crop productivity.



Elucidation of the SARS-CoV-2 replication mechanism and its therapeutic applications

Hisashi Iizasa[1], Aker Moushumi[1], Masami Wada[1], and Shunpei Okada[1]
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Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infects the human respiratory tract and causes symptoms ranging from the common cold to severe diseases such as pneumonia. Although the emergence of drug-resistant strains against anti-SARS-COV-2 drugs has been reported, these strains have not spread widely because they are being used preferentially on patients with underlying diseases and the elderly. However, if drugs are used on a large number of infected people, as with influenza, there is a risk that drug-resistant strains will increase. In addition, a subset of infected individuals develops long COVID, in which symptoms persist for more than three months; however, effective treatments have not yet been established. For these reasons, there is a need to develop antiviral drugs with mechanisms of action different from those of existing drugs.

Following infection, SARS-CoV-2 replicates its genomic RNA (gRNA) and transcribes subgenomic RNAs (sgRNAs) encoding structural proteins using an RNA-dependent RNA polymerase (RdRp) complex composed of nsp12 and its cofactors nsp7 and nsp8. Viral RNA synthesis is thought to involve an RNA helicase, nsp13, and recent cryo-electron microscopy studies have revealed an interaction between the RdRp complex and nsp13. However, the functional significance of this interaction in viral replication remains unclear.

In this study, we converted viral gRNA to DNA and made cDNA. We generated alanine substitutions at L92, Y93, K94, and N95, which constitute the nsp13–nsp12 interaction interface (nsp13-4A mutant cDNA) and introduced it into HEK293 cells expressing ACE2 and TMPRSS2. Unlike the wild-type genome, the nsp13-4A mutant failed to produce infectious viral particles, and sgRNA expression was undetectable by RT-qPCR. Moreover, gRNA levels were markedly reduced. Biochemical analysis using recombinant nsp13-4A protein showed that its RNA helicase activity was only approximately 5% lower than that of the wild-type protein, indicating no substantial loss of enzymatic function. In contrast, while wild-type nsp13 interacted with the RdRp complex *in vitro* in the presence of RNA, this interaction was abolished in the nsp13-4A mutant.

These results demonstrate that the interaction between nsp13 and nsp12 is essential for SARS-CoV-2 RNA synthesis and viral replication. This presentation will also discuss the clinical applications of our research.

Tuning the Glow: Advances in the Modulation of Near-Infrared Luminescence

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Abstract

Near-infrared (NIR) luminescence from lanthanide-based materials is of growing importance for applications spanning bioimaging, optical sensing, photonics, and energy conversion. However, the intrinsically weak absorption of lanthanide ions necessitates precise strategies for controlling and enhancing their emission. In this presentation, we highlight recent advances in tuning NIR luminescence through rational modulation of antenna systems, metal–ligand interactions, and host environments.

A key focus is placed on the selection of 3d transition metal ions as integral components of the antenna framework, demonstrating how metal-assisted sensitization pathways can significantly improve energy transfer efficiency to NIR-emitting lanthanide centers. Strikingly, minor structural variations in the antenna ligands are shown to exert a disproportionate influence on NIR emission intensity, spectral profile, and excited-state lifetimes, revealing the delicate balance governing sensitization dynamics. The impact of multiple-antenna architectures is further explored, where cooperative light-harvesting effects enable enhanced and tunable NIR output.

Extending beyond molecular systems, we discuss Ln^{3+}-doped $NaYF_4$ nanocrystalline inorganic matrices, which provide a rigid, low-phonon host that suppresses non-radiative decay and ensures high photostability. The role of organic capping agents in surface passivation and emission modulation is critically examined, highlighting their influence on energy migration and luminescence efficiency at the nanoscale.

Collectively, these studies establish versatile design principles for the controlled modulation of NIR luminescence, offering pathways toward high-performance lanthanide materials tailored for next-generation optical and biomedical technologies.

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In-situ optical spectroscopy for monitoring dynamic processes of nanoparticle growth and assembly

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Real-time tracking of various phenomena enables us to understand the dynamics of the process like chemical reactions, nanoparticle synthesis and nanoparticle assembly. In this talk, I will discuss about two different modalities for tracking nanoscale phenomena using optical interrogation techniques. First, we study the assembly of gold nanoparticles on a charged surface and understand how real-time optical reflectivity can provide insights into the process. Furthermore, advantages and pitfalls of this approach will also be discussed. Second, using a homemade UV-Visible spectroscopy system, I will demonstrate how seeded nanoparticle growth can be tracked in real-time, especially in case of anisotropic gold nanoparticles. We will also discuss the future scope of extending the home-made platforms for measuring additional optical properties.

Title: Development of new medical technologies through Medical-engineering collaboration

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Generally, across fields, higher "precision" is advantageous for achieving objectives. Medicine is no exception to this trend. For example, high-precision reduction and fixation are advantageous for fracture healing. However, such "medical techniques" primarily involve manual work performed by surgeons, and their precision is inherently limited and variable. Pursuing precision in clinical settings may enable us to address many problems that existing techniques cannot solve. To realize this, we are working on projects to develop new medical technologies through medical-engineering collaboration. Here, we provide an overview of these studies.

1. Precisely shaping technology for grafted bone

Bone grafting is a common and widely used procedure. During surgery, surgeons manually shape the grafted bones before transplantation, making it challenging to process them into complex shapes. If surgeons can precisely shape the grafted bone into any desired form, it may enable the creation of entirely new treatment methods. We have developed a multitasking machine for bone machining that enables this. To date, we have successfully performed several clinical cases, including pseudoarthrosis surgery using autogenous bone screws and reconstructive surgery for bone defects, demonstrating the effectiveness of the machine.

2. Bone screw system designed for osteoporosis

Screws have been and will continue to be one of the primary fixation tools for fracture treatment. In osteoporosis, which increases with age, bone fragility makes screws more prone to loosening, making this a clinical challenge. We addressed this issue from both the screw and the drill bit for pre-drilling. Considering mainstream metal screws are too hard, we adopted bioabsorbable screws with physical properties approximating those of cortical bone and optimized their shape. Furthermore, we demonstrated that osteoporosis leads to excessive pre-drilled hole diameters and developed a specialized drill capable of correcting this.

Unique TEM Capabilities for Metallic Materials Research at NEXTA, Shimane University

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Dynamics of lattice defects often govern the degradation processes of metallic materials under various extreme environments. Nuclear fission and fusion structural materials degrade primarily due to the accumulation of radiation-produced lattice defects, such as point defects (self-interstitial atoms (SIAs) and vacancies) and point-defect clusters (prismatic dislocation loops and cavities). During the deformation of metals and alloys in the presence of hydrogen, large quantities of vacancies and their clusters are formed, and it has been suggested that these hydrogen-induced vacancies and vacancy clusters can be a dominant factor in hydrogen embrittlement.

We have been examining defect dynamics in metals using in situ transmission electron microscopy (TEM) [1, 2]. For these studies, we utilized high-voltage electron microscopes (HVEMs) at Research Center for Ultra-High Voltage Electron Microscopy, the University of Osaka, and at Nagoya University in Japan; ion-accelerator combined microscopes at Shimane University in Japan and the JANNuS-Orsay facility in France; and recently an atomic-resolution magnetic-field-free microscope [3] installed at Next Generation TATARA Co-Creation Centre (NEXTA), Shimane University [4], which is a powerful tool for the observation of magnetic materials such as iron and steel.

In this talk, I will demonstrate how our group's unique TEM capabilities, centered at NEXTA, can be effectively applied to the research of defect behaviors in metallic materials. The topics covered are: (1) the formation of SIA allotropic clusters as precursors for dislocation loops [5], (2) the effects of hydrogen on defect behavior, and (3) the anomalous temperature dependence of the interaction between a gliding screw dislocation and a radiation-produced dislocation loop.

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Challenges with in-situ transmission electron microscopy: examples from heating and liquid cell microscopy

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Abstract: Over the years, Transmission Electron Microscopy (TEM) has been a primary characterization tool to understand the structure-property relationship of most materials. In most studies, specimens are investigated post-mortem. There have been several successful attempts to carry out in-situ TEM experiments in which dynamic changes in a specimen are investigated while applying a stimulus, such as heating, an electrical bias, mechanical deformation, or exposure to a reactive environment. With advancements in TEMs and micro-electro-mechanical systems (MEMS), the field of in-situ TEM has advanced significantly over the last two decades. While in-situ experiments provide key insights into phenomena occurring at the nanoscale, even at the atomic scale, they pose several challenges in conducting and interpreting them. While the experimental difficulties are related to specimen preparation, experimental hardware, and issues with imaging in the microscope, the critical and more challenging aspect extends the observations from in-situ experiments to commonly observed phenomena at the bulk scale. In this talk, most of the issues related to the design, fabrication, and challenges encountered in in-situ TEM experiments using MEMS-based devices, particularly in-situ heating and liquid-cell experiments, will be highlighted.

Keywords: in-situ TEM studies, MEMS devices, nano-scale phenomena

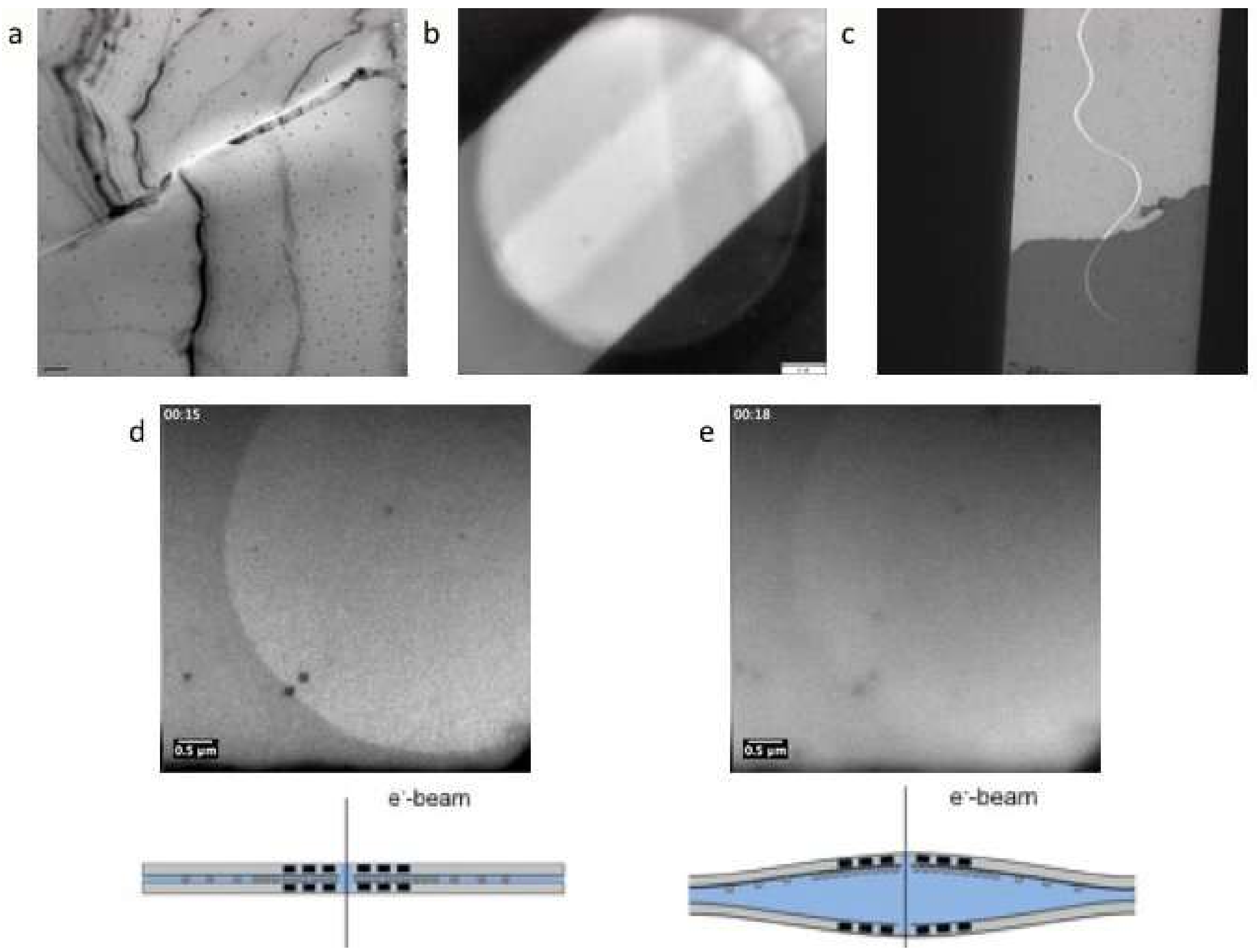

Figure 1: Examples of issues with in-situ TEM experiments: a) precipitation due to surface diffusion while heating, b) flooding of gas-nanoreactor while gluing for leak-tightness, c) cracking of a nanoreactor used for in-situ liquid cell experiments, d) beam induced precipitation of Pt nanoparticles (while the liquid thickness is nearly constant) and e) bulging of liquid cell membranes due to beam-induced diffusion.

Title: Local Microstructural Tuning of Ag-Cu Thin Films by Substrate-Film Reaction

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Local microstructural tuning of alloy thin films is of importance for functional applications such as plasmonics, electronics, sensors, catalysis, etc. We demonstrate a reaction-diffusion driven methodology to achieve this using Ag-Cu films deposited on a Si substrate. The as-deposited nominally equimolar films consist of a metastable homogeneous Ag-Cu solid solution. When the films are subjected to a post-deposition thermal exposure without any substrate interactions, phase separate produces Ag-rich and Cu-rich domains. Alternatively, we induce local film-substrate interactions by establishing an active contact between the Si layer and the film, either by pre-patterning the substrate by FIB milling or milling the as-deposited film. The chemical reaction between Cu in the film and Si substrate leads to the formation of copper silicide. In addition, an Ag-depleted halo forms around the reaction site, thus creating three distinct microstructural regions, the extents of which can be controlled by the dimension and periodicity of the pre-patterning, and temperature and time of heat treatment. We present a kinetic model for predicting the growth of the reaction-modified zones. It reveals two distinct regimes of growth that depend on the film thickness and species diffusivity. Coupling the model with an inverse optimization procedure helps us to estimate the diffusivity of copper in the film, which reveals grain boundary diffusion to be the dominant mode of solute transport during the process.

Novel Inorganic Anion-Exchanger with Selectivity and Detection Abilities for Nitrate

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Introduction: Nitrate-nitrogen is one of the toxic anion species that cause methemoglobinemia and eutrophication. Thus, there is a great need for a material that can easily qualify and/or quantify nitrate-nitrogen in wastewater and environmental water on site to control environmental pollution. We have previously reported that layered double hydroxides consisting of Mg^{2+} and Al^{3+} with Tb^{3+} partially doped at the Al^{3+} sites (Tb-LDH) show photoluminescence (PL) intensity depending on the anion species in the interlayer space and its mechanism.[1] Moreover, we previously reported that the LDHs consisting of Ni and Al with Ni/Al = 4 have relatively high nitrate selectivity.[2] In this study, we synthesized Tb-LDH with Mg/(Al + Tb) = 4, and then, investigated its nitrate-selectivity and nitrate-detection ability based on changes in PL intensity.

Experimental Procedures: The Tb-LDH with chloride anions (Tb-LDH(Cl)) was synthesized by hydrothermal aging at 140℃ for 24 h of precursor dispersion, which was obtained by adjusting the pH of a mixed aqueous solution (Mg^{2+} : Al^{3+} : Tb^{3+} = 200 : 49.5 : 0.5 mmol/L and NaCl (0.83 mmol/L)) to 10 with NaOH (3 mol/L), and then, aging it at 40℃ for 2 h. The anion-exchange experiments were conducted by dispersing 0.1 g of Tb-LDH(Cl) in $NaNO_3$ aqueous solution and shaking these dispersions at 30℃ for 24h. All obtained powder samples were characterized by XRD, FT-IR, PL spectra, and diffuse reflectance (DR) spectra. The residual concentration of nitrate anions was quantitatively determined by ion-chromatography.

Results & Discussion: The Tb-LDH(Cl) showed the typical spectra from Tb3+. The PL intensity after anion exchange experiments decreased in proportion to the initial nitrate concentration. From these results, it was found that the Tb-LDH(Cl) has nitrate detective ability. In Figure 1, the dependence of the PL intensity ratio (I/I0) and the exchange rate on the initial concentration of nitrate anions. The anion exchange reaction from chloride to nitrate proceeded quantitatively even at lower concentration. This result indicates that the Tb-LDH(Cl) has relatively high nitrate selectivity. PL intensity ratio decreased linearly and rapidly up to 100 mg/L and then decreased linearly and gradually. These results indicated that the present Tb-LDH(Cl) has potential as promising material for quantitatively detecting nitrate in water. Moreover, it was found that the PL quenching can be explained by the photoabsorption of excitation light (284 nm) by nitrate anions incorporating in the Tb-LDH.

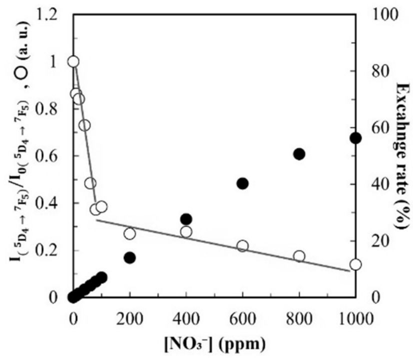

Figure 1. Dependence of PL intensity ratio (left axis) and exchange rate (right axis) on initial concentration of nitrate anions in water.

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Modelling and experimental approaches for additive manufacturing processes

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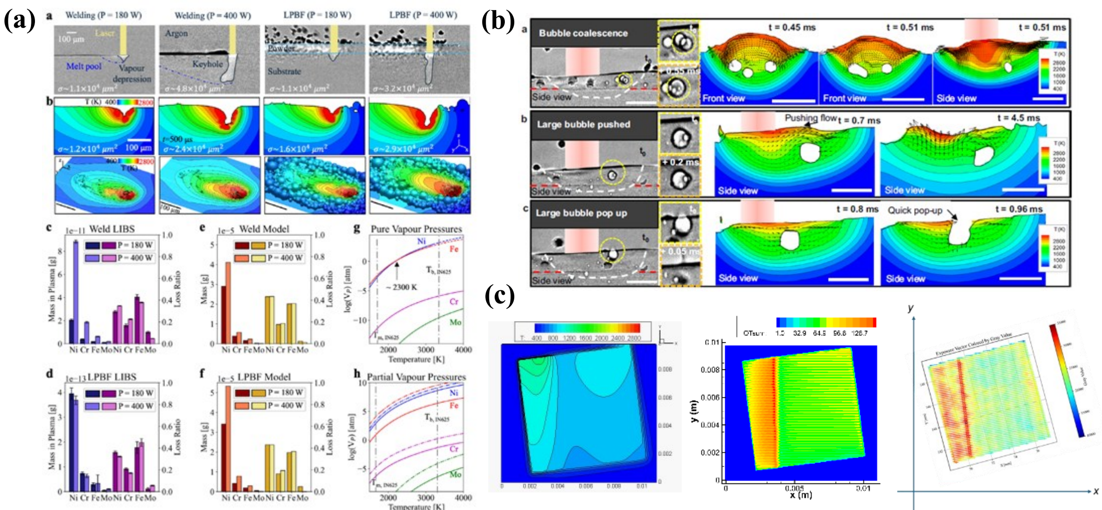
Metal additive manufacturing (AM) is an emerging metal processing technology for aerospace, automotive, energy and biomedical applications, which enables fabrication of complex shapes and control of local material properties. The fabrication process is quite complex and using both experimental and numerical approaches is effective. In this talk, some research examples are briefly introduced, in which complex physical phenomena of AM processing are investigated by detailed simulations and large part-scale thermal management is examined by a reduced order model, both with enhanced synergetic combination with experiments.

Figure 1a shows the vapour composition by laser-induced breakdown spectroscopy (LIBS) and by modelling to evaluate local mass loss during laser powder bed fusion (L-PBF) [1]. It is shown that preference in elemental mass loss exists, for example Ni and Fe are relatively more prone to vaporisation, which indicates that careful composition settings are needed for powders. Figure 1b shows the pores (bubbles) evolution in Ni-based superalloys in directed energy deposition (DED) [2]. Depending on the flow structure in the melt pool, pores may stay longer in the melt pool or may be pushed out quickly, which indicates that controlling the Marangoni flow effect is important in porosity control.

Currently, under the JAXA Space Strategy Fund scheme, AM research for real-scale rocket engine fabrication is also ongoing. Thermal management by a reduced-order scan model is conducted to identify heat and thermal stress distribution (Fig. 1c).

Combining experiments and simulations can be a powerful tool for scientific and engineering aspects of AM research, and intense research activities are being conducted at Shimane University.



(a) Simulated temperature (b) Simulated OT image (c) Experimental OT

Fig. 1 Examples of AM experiments and simulations.

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From Data to Action: Environmental Sustainability through Inclusive Research

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Environmental sustainability can be understood as an interconnected system linking climate, water, energy, materials, health, and governance. Strong and sustained research collaboration provides the structure needed to guide such integrated action. Since 2020, researchers from India and Japan have produced more than 16,819 joint publications, with a Field Weighted Citation Impact (FWCI) of 3.17 [1]. This reflects both the quality and global recognition of their work. Collaboration is particularly strong in engineering, environmental science, materials science, energy systems, and medicine disciplines that directly support climate mitigation, adaptation, and resilience. More than statistics, this partnership reflects shared commitment and complementary strengths. The expanding network highlights collective maturity and a long-term vision to translate knowledge into meaningful environmental and societal impact.

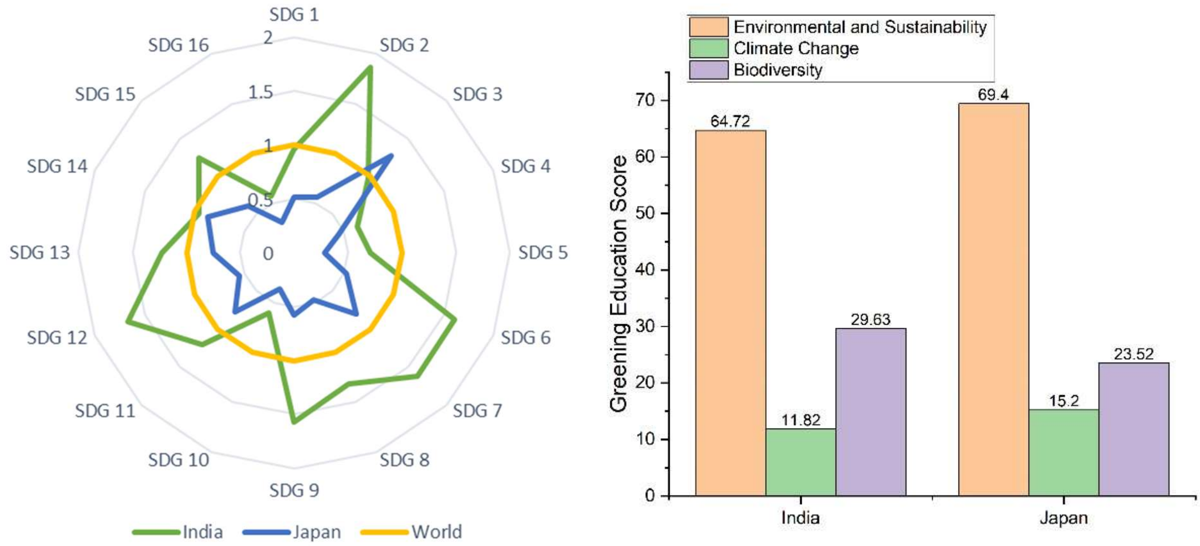

Figure 1 (a) SDG Relative Activity Index demonstrating research alignment with global sustainability priorities [1]; (b) greening education score [2].

From Figure 1(a), the SDG Relative Activity Index indicates strong engagement with SDG 6, 7, 11, and 13, demonstrating commitment to addressing climate, energy, water, and urban sustainability challenges through science and innovation [1]. Figure 1(b) further suggests that strengthening India–Japan collaboration through joint and dual degree programmes, co-supervised doctoral research, and shared sustainability curricula can establish durable academic partnerships. Integrating climate literacy and environmental stewardship into school education, supported by structured teacher training and exchange programmes, can further enhance greening education outcomes. According to UNESCO, women represented approximately 31.1% of researchers globally in 2022 [2], with both nations below the average. In line with SDG 5, improving gender participation strengthens diversity, creativity, and innovation capacity. A Living Laboratory model can connect universities, cities, industries, and communities, enabling research excellence to translate into measurable environmental resilience and scalable governance solutions.

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Intensification of Thermal Energy Storage through Nanomaterials and Flow Field Engineering

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The global energy demand for various industrial sectors and comfort applications is continuously increasing, and this has prompted increase in energy generation. The shift from fossil fuel-derived energy to renewable energy is imperative to minimize damage due to greenhouse gas emissions. Thermal energy demand in industrial sectors can be met through the utilization of storage-coupled solar thermal energy aided by an appropriate phase change material. The talk will delve into the application of materials science and thermal engineering for intensification of thermal energy storage systems, through engineered phase change materials and heat transfer fluids. The impact of the addition of nanostructures such as metal nanoparticles, metal oxide nanoparticles, carbon allotropes to medium temperature phase change materials (melting point ranging from 150 to 350°C) such as sugar alcohols, inorganic eutectics, molten salts and metallic phase change materials will be presented. Metrics for impact shall include enhancements in thermal conductivity and specific heat, reduction in solidification time, and the enhancements in heat transfer coefficients under different discharge conditions. Pertinent mechanisms driving thermophysical properties' modulation, changes in melting & freezing characteristics and the heat transfer coefficient augmentation will be discussed, enabling materials' properties – energy storage performance correlation. Progress in augmentation of properties of Therminol through nanomaterial-based interventions for application in solar collectors will be discussed. Novel plate heat exchanger geometries and channel-based heat sinks for solar thermal energy utilization and thermal management reflecting our intensification efforts through manipulation of fluid flow fields will be presented. The talk shall conclude with a roadmap for accelerated deployment of concentrated solar thermal with energy storage for meeting the industrial heating demands such as steam generation, process preheating, distillation and drying.

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Robotics in Action – Trends & Beyond

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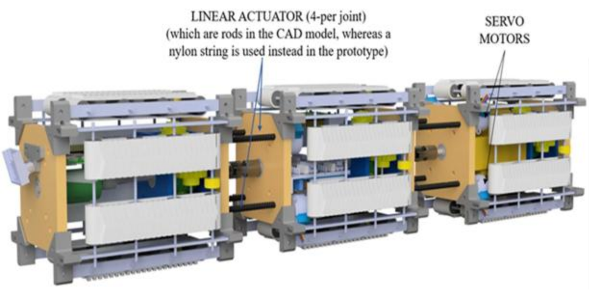
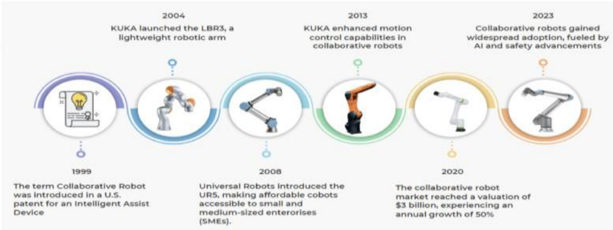
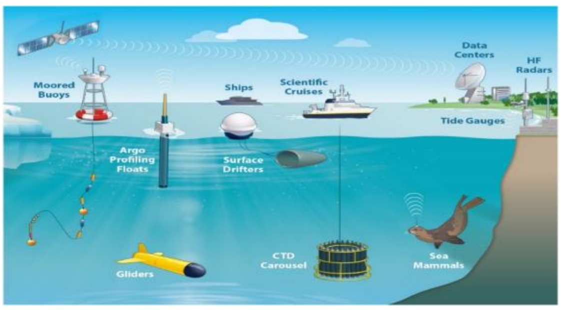
Robotic systems are increasingly required to operate autonomously, efficiently, and safely across complex and dynamic environments. This abstract presents an overview of recent advances in robotics spanning sustainable power solutions, bio-inspired mobility, collaborative automation, and intelligent control architectures. Emerging wave energy harvesting technologies for Unmanned Ocean Vehicles are examined as a means to enable long-duration, maintenance-free ocean operations, addressing challenges such as variable environmental conditions, biofouling, corrosion, and low energy density through hybrid and AI-enabled energy management approaches. Advances in search and rescue robotics are highlighted through the development of a snake-like robot capable of navigating confined and cluttered terrains, integrating robust mechanical design with deep learning-based victim detection and real-time IoT-enabled communication. In industrial settings, the evolution of collaborative robots is discussed, emphasizing the role of artificial intelligence, smart sensing, and human-centric safety mechanisms in enhancing adaptability, productivity, and safe human–robot interaction. Additionally, reinforcement learning-based control strategies for humanoid locomotion are explored, with a comparative evaluation of shared and separate Policy–Value neural network architectures demonstrating improved efficiency and real-time feasibility on embedded platforms. Collectively, these developments underscore the convergence of intelligent energy systems, adaptive mobility, collaborative autonomy, and efficient learning frameworks, shaping the next generation of resilient, sustainable, and human-aligned robotic systems.







Single-Shot Depth-Resolved Fluorescence Microscopy

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In conventional optical sectioning imaging technique such as laser scanning confocal microscopy (LSCM), a tightly focused laser spot probes the sample point by point. Two-dimensional cross-sectional images of a sample in x–y plane are reconstructed by raster scanning the sample in x and y directions. Volumetric imaging requires additional scanning along the axial (z) direction, and three-dimensional reconstruction is obtained by stacking x–y images acquired at successive z positions. Thus, LSCM requires three-dimensional (x–y–z) scanning for volumetric imaging.

In the developed system, a laser line focus of ~200 µm is created along the direction of light propagation (z-direction), with a lateral width of ~3 µm. This laser line simultaneously illuminates the fluorescent sample along the axial direction, and the emitted fluorescence is captured by a camera in a single exposure, containing depth-resolved information along z axis. The x–z cross-section image is reconstructed by scanning sample only in the x-direction in small steps. The sample is further scanned in the y-direction, and x–z cross-sections obtained at different y positions are stacked to form a three-dimensional image. Thus, our system completely eliminates the z-direction scanning of sample a, this technique reduces acquisition time and provides a faster, simpler alternative to conventional depth resolved imaging techniques like LSCM and light sheet microscopy.

The imaging capability of the system was tested by reconstructing volumetric images of fluorescent microscope of different sizes. The developed system can image depth resolved image of 200 µm along the optic axis in a single shot with lateral and axial resolution of approx. 3 µm and 3.75 µm respectively. The 3D reconstruction of an 11 µm fluorescence microsphere with x–y scanning with step size of 1 µm in both the directions is shown in Fig. 1. Fig. 2 shows the 3D image of smooth muscle actin (SMA) stained small blood vessel of a rat tissue.

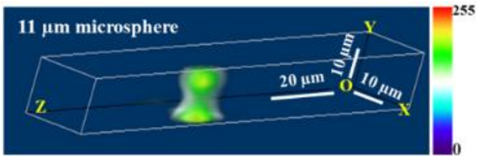

Fig. 1. 3D image of an 11 µm fluorescence microsphere.

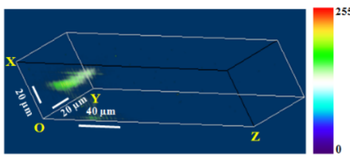

Fig. 2. Imaging of SMA-stained small blood vessels (size approx. 12 µm) of rat tissue.

The system is particularly useful for imaging of samples with multiple layers such as human skin and polymer films.

Acknowledgements: *We thank all contributors for their cooperation.*

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Changes in lagoonal carbon burial flux associated with Anthropogenic activity

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While the natural carbon dioxide absorption capacity has gained attention as a mitigation measure for global warming, lagoons have received little consideration in the global carbon cycle (GBC) due to their relatively small coverage of the Earth's surface. Lagoons are expected to exhibit higher carbon burial efficiency (CBE) than typical lakes due to their high sedimentation rates and primary productivity. However, it has been noted that CBE in estuarine environments, including lagoons, has significantly declined since the Industrial Revolution due to widespread vegetation loss. Studies on CBE in lagoons have been limited, particularly those with high temporal resolution at annual to decadal scales, making it challenging to accurately assess their role within the GBC. To address this gap, we measured the organic CBE in lagoonal sediments from 13 water bodies—12 in ten Japanese lagoons and one in a Korean lagoon—and analyzed the results by historical period and geographic region. The average CBE over the past decade in these 13 water bodies was 76.3 gC m^{-2} yr^{-1}, approximately 3.5 times the global average for lakes. In Japan, lagoons in Hokkaido exhibited particularly high CBE, likely due to elevated nutrient inputs from extensive aquaculture within the lagoons and agricultural activities, such as livestock grazing and crop cultivation, in the surrounding watershed. A historical analysis of CBE in Japanese lagoons revealed that, compared to the late 19th century - when human impact was minimal - CBE approximately doubled in the early 20th century, coinciding with intensified land use and hydrological modifications. In the late 20th century, as lagoon pollution escalated, CBE increased more than fivefold. Although a slight decline was observed in the 21st century, CBE remains approximately five times higher than in the 19th century. Since the late 20th century, the CBE of Japanese and Korean lagoons has been approximately twice that reported in previous studies on lagoonal CBE (e.g., Wilkinson et al., 2018, Sci. Rep.). However, considering that prior studies used a 200-year average for CBE, the discrepancies between this study and previous research are relatively minor. In GBC calculations, a 200-year average has traditionally been used for estimating CBE in estuaries, in contrast to assessments of atmospheric, oceanic, and lacustrine CBE. This methodological discrepancy led to a significant underestimation of estuarine CBE.

Role of Mantle Dynamics in the Opening of the Japan Sea

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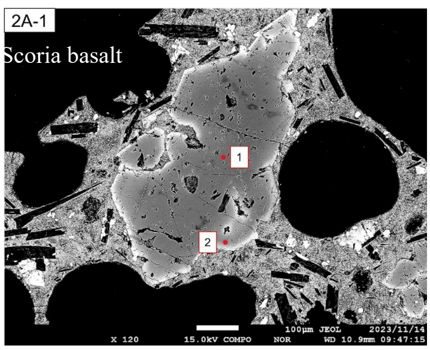
The Japan Sea is a classic example of a marginal basin formed by back-arc extension along the eastern margin of the Eurasian Plate during the Miocene (~25–15 Ma). While plate motions and crustal extension define the surface expression of this event, processes operating deep within the mantle played a fundamental role in controlling both the timing and rate of opening. Mantle dynamics, particularly upwelling, flow, and thermal structure beneath the back-arc contributed to lithospheric thinning and seafloor spreading during the opening of the Japan Sea. Asthenospheric upwelling induced by slab rollback of the subducting Pacific Plate is thought to have generated elevated mantle temperatures beneath the back-arc region. This mantle flow weakened the overlying lithosphere, promoted extensional tectonics, and supplied magma to newly forming oceanic or thinned continental crust. Variations in mantle source composition and melting conditions during this process are recorded in basaltic volcanism distributed along the Japanese margin, including the Shimane Peninsula.

Basalts from the Shimane Peninsula provide key geochemical and mineral-chemical constraints on the dynamics of Japan Sea opening. Major and trace-element compositions, together with isotopic signatures, reflect changes in mantle melting depth, temperature, and source characteristics over time. Additionally, mineral chemistry such as olivine and clinopyroxene compositions, zoning patterns, and crystallization temperatures, offers insights into melt ascent rates and magma supply. When combined with radiometric ages, these data allow estimation of magma productivity and, by extension, the rate of lithospheric extension and seafloor spreading.



Electron microscope image of olivine mineral