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Nagasaki University and Jeju National University
on Science and Technology*

JSST2026

*Nagasaki University, Nagasaki, Japan
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Co-organized by



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Timetable

October 3rd, 2026 (Saturday)				
18:00 -	Welcome Reception			St. PRIÈRE
October 4th, 2026 (Sunday)				
9:00 - 10:00	Registration			Gen. Ed. & Res. Bld., 1F
10:00 - 10:05	Opening Remarks 1 [H. Murakami, NU] Prof. K. Kawamoto (Dean of Grad. Sch. Integ. Sci. & Tech., NU)			Large Auditorium, 3F
10:05 - 10:10	Opening Remarks 2 [H. Murakami, NU] Prof. Daisaku Sakaguchi (Dean of Grad. Sch. Eng., NU)			Large Auditorium, 3F
10:10 - 10:15	Opening Remarks 3 [H. Murakami, NU] Prof. Sang-Jae Kim (Dean of Sch. Eng., JNU)			Large Auditorium, 3F
10:15 - 10:30	Group Photo Session and Coffee Break			
10:30 - 11:10	Plenary Talk 1 [K. Ko, JNU] Prof. Yung-Cheol Byun (Department of Computer Eng., JNU)			Large Auditorium, 3F
11:10 - 11:50	Plenary Talk 2 [T. Okumatsu, NU] Prof. Masanari Kimura (Dean of Inst. Integ. Sci. & Tech., NU)			Large Auditorium, 3F
11:50 - 13:10	Lunch Break (Lunch Box)			Large Meeting Room, Fac. of Eng. Bld. 2F
13:10 - 14:10	Poster Session [Y. Arikawa & T. Ueda]			Multipurpose Hall, 2F
14:10 - 14:20	Coffee Break			
14:20 - 15:20	Session 1a (Large Auditorium) [K. Ko & A. Saimoto]	Session 2a (Room 209) [D.H. Kim & M. Nakano]	Session 3a (Room 31) [H.J. Im & A.T.N. Dao]	Large Auditorium, 3F Audit. Room 209, 2F Audit. Room 31, 3F
	Environmental Science & Applied Mechanics	Electric Engineering & Materials Science	Chemistry & Applied Science	
15:20 - 15:30	Coffee Break			
15:30 - 16:30 (- 16:50*) *Session 2b	Session 1b (Large Auditorium) [K. Ko & A. Saimoto]	Session 2b (Room 209) [D.H. Kim & M. Nakano]	Session 3b (Room 31) [H.J. Im & A.T.N. Dao]	Large Auditorium, 3F Audit. Room 209, 2F Audit. Room 31, 3F
	Environmental Science & Applied Mechanics	Electric Engineering & Materials Science	Chemistry & Applied Science	
17:00 - 17:30	Awards Ceremony and Closing Remarks [H. Murakami, NU]			Large Auditorium, 3F
18:30 - 20:30	Banquet (Student Banquet)			Saint Hill Nagasaki (Hasshu)
October 5th, 2026 (Monday)				
9:00 - 10:00	Labo Tour			Bunkyo Campus Bd., Nagasaki Univ.

Plenary Talk 1

**From Answers to Questions
- Redefining University Education and Research in the AI Era -**

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Abstract

Generative AI is making intelligence and knowledge easier for everyone to access and use. It can support writing, programming, data analysis, education, and research. However, AI may provide incorrect information and cannot take responsibility for its results. Therefore, in the AI era, it is important not only to find answers but also to ask meaningful questions, review the results carefully, and use AI responsibly.

These changes are creating new possibilities for university education and research. Students can use AI to prepare well-organized assignments, but they may have fewer opportunities to think independently, learn from mistakes, and develop their own ideas. Universities can help students explore real-world issues, define problems clearly, and examine AI-generated results. Professors can support this process by guiding students in learning, questioning, and discovery.

Undergraduate students can learn to use AI not only to find answers but also to develop useful ideas and create value. Helpful skills include problem definition, judgment, system design, the use of AI agents, domain understanding, and responsible decision-making. Graduate students can use AI as a research assistant for literature reviews, experimental design, data analysis, and academic writing. At the same time, researchers remain responsible for the originality, reliability, methods, and ethics of their research. Universities can also create more opportunities to connect education and research with the needs of companies and local communities. Through field-based projects and industry–university collaboration, students can gain practical experience and better prepare for employment. They may also use AI to develop new services and business ideas, explore entrepreneurship, create jobs, and contribute to society.

In the AI era, the value of university education may increasingly depend on how well it helps students ask meaningful questions. Future talent will benefit from learning how to define problems, discover opportunities, evaluate AI-generated results, and work with AI to contribute to positive changes in industry and society.

Plenary Talk 2

Science and Technology for a Sustainable Future: From Molecules to Planetary Health

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Abstract

Science and technology have contributed significantly to improving human life, while rapid industrial development has also brought increasingly complex challenges involving climate change, energy, resources, and the environment. Addressing these challenges requires not only advances within scientific disciplines but also the integration of knowledge across different scales, from molecules and materials to engineering systems, the environment, and society.

As an organic chemist, my research has focused on molecular transformation through the development of new synthetic reactions and catalytic processes. In particular, organoboron chemistry and transition-metal-catalyzed reactions provide powerful approaches for constructing functional molecules through selective bond formation.^[1,2] More recently, our research has expanded to include sustainable chemistry, particularly the utilization and chemical transformation of carbon dioxide as a renewable carbon resource. These studies illustrate how fundamental research at the molecular level can contribute to broader concepts of carbon circulation and sustainable resource utilization.

However, global challenges cannot be solved by chemistry alone. Sustainable energy, marine resources, advanced materials, mobility, environmental technologies, and human health are closely interconnected and require collaboration across traditional disciplinary boundaries. This perspective is closely related to the concept of Planetary Health, which recognizes that human health and well-being ultimately depend on the health and sustainability of the Earth's natural systems.^[3]

This presentation explores the connection between molecular transformations and carbon utilization and considers how science and technology can contribute to a sustainable future. It also highlights the importance of interdisciplinary approaches in connecting fundamental scientific discoveries with solutions to societal challenges.

Keywords

Molecular Transformation; Organoboron Chemistry; Carbon Dioxide Utilization; Planetary Health

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- [2] S. Toyofuku, A. Nunoda, T. Sueyoshi, G. Onodera, T. Fukuda, M. Kimura, "Copper-Catalyzed Convergent Assembly of Oxaboroles via Multicomponent Coupling for Functional Molecule Discovery", *Advanced Synthesis & Catalysis*, 368, e70597 (2026).
- [3] T. Nagayasu, N. Nishida, K. Kita, M. Hashizume, M. Kimura, Ni. Takamura, F. Yoshida, S. Kaneko, "Local Microcosm of Planetary Health: Global Challenges, Local Solutions," in *One Health and Planetary Health in Action: Lessons from Communities, Ecosystems, and Public Health*, Watanabe, S., Ed.; IntechOpen, (2026).

Invited Presentations

Technical Session 1: Environmental Science & Applied Mechanics

- S1-1 Impact of Data Recovery Rates and Terrain Complexity on the Uncertainty of Annual Energy Production Estimates
Buyankhishig Amarzaya and Kyungnam Ko (JNU)
- S1-2 Can Carbon Market Linkage Reduce the Cost of Achieving Carbon Neutrality in China, Japan, and Korea?
Sunhee Suk¹, Marton Simo², Áron Hartvig², István Heilmann² and Pim Vercoulen² (1: NU, 2: Cambridge Econometrics)
- S1-3 Enabling Higher Geometric Accuracy in Single-Point Incremental Forming: Zone-Resolved AI Modeling and Multi-Objective Optimization
Osama Salem, Ting Ai, Lin Hang Li, Karki Anisha, Osama Ali, Atif Niaz and Dongwon Jung (JNU)
- S1-4 Smart Infrastructure in Practice: Collaborative Development and Implementation of a Bridge Inspection Robot in Nagasaki
Takafumi Nishikawa (NU)
- S1-5 Thermodynamic Evaluation of PCHE Operating Strategies: From Subcooled Liquid to Superheated Vapor for Compact SMRs
Taeseok Kim (JNU)
- S1-6 Farm Layout Multi-Objective Optimization for the Sustainable Development of Tidal Stream Energy
Patxi Garcia Novo and Daisaku Sakaguchi (NU)

Technical Session 2: Electric Engineering & Materials Science

- S2-1 Prediction of a Multi-Bed Active Magnetic Refrigeration System Using a Multilayer Perceptron Artificial Neural Network Model
Jongmin Choi (JNU)
- S2-2 Wet-Process Fabrication of Magnetic Materials
Takeshi Yanai (NU)
- S2-3 Dual Optoelectronic Modulation of Percolation Paths in a Single Si Nanowire for Neuromorphic Memory
Jungkil Kim (JNU)
- S2-4 Development of Porous Metal-Oxide Gas Sensors for VOC Detection
Taro Ueda and Takeo Hyodo (NU)
- S2-5 Reinterpretation of Damage Profiles in High-Dose Helium-Irradiated Ferritic/Martensitic Steel via Density-Corrected SRIM Modeling
Seongyu Han, Myeongkyu Lee and Sangjoon Ahn (JNU)
- S2-6 Laser Induced Forward Transfer (LIFT)-made Nd-Fe-B Micromagnets
Itsuki Fukuda¹, Taiga Kitahara¹, Hiroto Ono¹, Akihiro Yamashita¹, Takeshi Yanai¹, Masaki Nakano¹, Hiroto Fukunaga¹, Kunihiro Koike² (1: NU, 2: Yamagata Univ.)
- S2-7 Hierarchical Decentralized Federated Learning Based on Anchor and Coordinator
Bibi Misbah and Do Hyeun Kim (JNU)

Technical Session 3: Chemistry & Applied Science

- S3-1 Quantitative and Qualitative Analysis of Chelating Agents Using High-Performance Liquid Chromatography and its Applications
Jin Young Yang, Chang Hyuk Kang and Hee-Jung Im (JNU)
- S3-2 Reductive Conversion of Small Molecules on Transition Metal Complexes
Yasuhiro Arikawa (NU)
- S3-3 Study on Sustainable Plastic Upcycling Process Development
Joung Sook Hong (JNU)
- S3-4 Development of an Eco-Friendly Antifouling System Based on the Light-Sensing Mechanisms of Marine Sessile Organisms
Hee-Jin Kim (NU)
- S3-5 High-Entropy Layered Double Hydroxide as a Durable Bifunctional Electrocatalyst for Chloride-Tolerant Seawater Splitting
Jyoti Prakash Das and Sang-Jae Kim (JNU)
- S3-6 Multiple Nutrient Recovery from Aquaculture Wastewater Through Membrane Separation Processes
Ying Shi Chang (NU)

[S1-1] Invited Presentation

Impact of Data Recovery Rates and Terrain Complexity on the Uncertainty of Annual Energy Production Estimates

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Abstract

This study investigates the impact of data-recovery rates and terrain complexity on the uncertainty of annual energy production (AEP) estimates using multiple measure-correlate-predict (MCP) approaches. Wind measurements collected over a year from met masts at four sites on Jeju Island, South Korea, were analyzed including two coastal sites, Kimnyeong and Sinchang, and two inland sites, Susan and Gashiri. The coastal sites exhibited lower terrain ruggedness values than the inland sites. To predict long-term wind climate variability, 15 years of ERA5-based WRF reanalysis data were collected. Low data-recovery scenarios were simulated by randomly sampling the measured wind data at recovery rates ranging from 10% to 90%. Long-term wind conditions were then predicted using four MCP methods: two machine learning techniques (random forest and gradient boosting regression) and two conventional approaches (regression and matrix). AEPs were estimated from the MCP predictions and compared with reference AEP values to evaluate the relative bias, from which AEP uncertainty was quantified. The results indicated that both the relative bias and uncertainty of AEP estimate generally decreased with increasing data-recovery rates. Inland sites were more sensitive to reduced data availability than coastal sites. AEP uncertainty below 2.5% was achieved at recovery rates of 40% or higher for inland sites, whereas coastal sites maintained uncertainty below this threshold across all recovery rates. These findings provide practical guidance for evaluating AEP uncertainties under limited data availability and varying terrain complexities, supporting more reliable wind resource assessments when data recovery is below the commonly recommended level of 90%.

Keywords

Data recovery rate, wind measurements, measure-correlate-predict method, annual energy production, AEP uncertainty, terrain complexity

[S1-2] Invited Presentation

Can Carbon Market Linkage Reduce the Cost of Achieving Carbon Neutrality in China, Japan, and Korea?

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Abstract

China, Japan, and Korea have all committed to achieving carbon neutrality. However, reducing greenhouse gas emissions while maintaining economic growth remains a major challenge. Carbon pricing through Emissions Trading Systems (ETSs) has become an important policy instrument in all three countries. As carbon markets continue to develop across East Asia, linking national carbon markets has attracted growing attention as a way to reduce mitigation costs while strengthening regional climate cooperation [1].

This presentation explores whether linking the carbon markets of China, Japan, and Korea can provide a more cost-effective pathway toward carbon neutrality. To examine this question, the study employs the E3ME-FTT model, an integrated economy–energy–environment simulation model used to evaluate the impacts of climate policies on greenhouse gas emissions, energy systems, economic growth, employment, industrial production, and international trade [2]. Using this model, the study compares independent national carbon markets with a linked regional carbon market, both with and without a Carbon Border Adjustment Mechanism (CBAM). The analysis evaluates changes in carbon prices, greenhouse gas emissions, GDP, employment, industrial output, and trade under different policy scenarios. Building on previous research on carbon market linkage in East Asia [3], this study incorporates updated carbon neutrality policies and evaluates their macroeconomic implications using the latest E3ME-FTT model. The results demonstrate that linking carbon markets enables emission reductions to occur where they can be achieved at lower cost, thereby reducing overall carbon abatement costs while maintaining climate targets. Although the economic impacts differ among the three countries because of differences in energy systems, industrial structures, and existing climate policies, carbon market linkage generally improves the efficiency of climate policy. The analysis also shows that complementary domestic decarbonization policies and the effective use of carbon pricing revenues play important roles in supporting economic growth and employment during the transition to carbon neutrality.

The findings suggest that regional carbon market linkage could become an effective policy option for supporting carbon neutrality in East Asia. Beyond reducing mitigation costs, enhanced regional carbon market cooperation has the potential to promote sustainable economic development and deepen regional collaboration toward a low-carbon future.

Keywords

Carbon neutrality; Carbon market linkage; Emissions Trading System (ETS); E3ME-FTT; East Asia

References

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[S1-3] Invited Presentation

Enabling Higher Geometric Accuracy in Single-Point Incremental Forming: Zone-Resolved AI Modeling and Multi-Objective Optimization

Osama Salem, Ting Ai, Lin Hang Li, Karki Anisha, Osama Ali, Atif Niaz and Dongwon Jung*

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Abstract

Geometric inaccuracy remains a major challenge in single-point incremental forming (SPIF), particularly for complex parts, where different regions can respond markedly differently under the same forming conditions. This study introduces a zone-resolved framework that combines competitive machine-learning surrogate selection with multi-objective process optimization to improve the dimensional performance of a four-lobe AA5052-H32 component. Spindle speed, feed rate, vertical step depth, and wall angle were varied using a central composite design. After forming, the unloaded parts were digitized by 3D optical scanning, registered to the nominal CAD geometry, and evaluated separately in the bent zone (BZ), inclined wall (IW), contact zone (CZ), and flat surface (FS). Seventeen regression algorithms and same-seed stacking contenders were screened independently for each regional response. Optuna-assisted leave-one-out (Q^2) guided model selection, while an independent holdout set was used to assess generalization. The selected regional surrogates achieved LOO-(Q^2) values of 0.904-0.980 and testing (R^2) values of 0.944-0.956. These models were then coupled with a SHAMODE-based search incorporating covariance-guided mutation and grid-assisted diversity preservation to resolve the trade-offs among the four regional errors. The predicted best-compromise condition reduced the mean regional MAE from 1.193 to 0.740 mm, corresponding to a 38.0% reduction. The gains were strongly region dependent, reaching 37.5% in IW, 69.6% in CZ, and 66.4% in FS, whereas BZ changed by only 0.5%. The findings show that treating geometric error region-by-region reveals process trade-offs hidden by a single global metric and provides a more balanced route toward improving the dimensional quality of complex formed parts.

Keywords

AA5052-H32; 3D optical scanning; SHAMODE; Stacking ensemble

[S1-4] Invited Presentation

Smart Infrastructure in Practice: Collaborative Development and Implementation of a Bridge Inspection Robot in Nagasaki

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Abstract

Japan is currently promoting smart infrastructure as a key approach to creating more attractive, sustainable, and resilient cities and regions. Looking toward the future of social infrastructure, several key directions have been identified: the accumulation and integration of infrastructure data on common digital platforms; continuous linkage between physical and virtual spaces; a transition toward data-driven infrastructure management cycles; the integration of effective new technologies into operational systems; the establishment of implementation frameworks and human resource development, particularly at the local government level; and evidence-based standardization followed by nationwide and international deployment.

The Nagasaki region has been addressing these challenges through close collaboration among industry, government, and academia, developing initiatives that can be regarded as good practices both nationally and internationally. This lecture presents one such initiative as a practical example of smart infrastructure implementation: the research, development, and deployment of bridge inspection robots to address maintenance challenges and improve the efficiency and sophistication of infrastructure management. By integrating industrial robotics, one of Nagasaki University's technological strengths, with advanced computer vision technologies, a bridge inspection robot was developed through industry-academia collaboration to substantially improve the efficiency of conventional bridge inspection practices. With the active cooperation of public-sector road infrastructure managers, the technology was rapidly tested, refined, and introduced into bridge inspection operations.

This case illustrates how smart infrastructure can be realized not simply through the development of advanced technologies, but through the integration of digital technologies, field implementation, infrastructure management systems, and multi-stakeholder collaboration. It also demonstrates a practical pathway for accelerating the transition from research and development to real-world implementation and establishing scalable models that can support broader regional, national, and international deployment.

Keywords

Smart infrastructure; Infrastructure management; Bridge inspection robot; Multi-stakeholder collaboration

Reference

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[S1-5] Invited Presentation

Thermodynamic Evaluation of PCHE Operating Strategies: From Subcooled Liquid to Superheated Vapor for Compact SMRs

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Abstract

Small Modular Reactors (SMRs) demand steam generators that maximize thermal density within strict spatial constraints. While Printed Circuit Heat Exchangers (PCHEs) offer exceptionally high surface area density, conventional flash Rankine cycle concepts (e.g., I2S-LWR) strictly rely on single-phase subcooled heating to prevent flow instability and dryout risks, inherently compromising heat transfer performance and necessitating larger component volumes. Conversely, full-range boiling configurations risk critical heat flux (CHF) and post-dryout efficiency degradation. To resolve this trade-off, this study proposes a systematic design for a hybrid PCHE-Flashing Drum Rankine cycle that strategically operates the PCHE within favorable heat transfer regimes while utilizing a flash drum for phase separation.

A coupled thermodynamic simulation framework was developed by integrating an in-house microchannel PCHE sizing code with a cycle process simulator. A comprehensive performance analysis was conducted across three distinct PCHE outlet states: subcooled liquid, two-phase saturated mixture, and superheated vapor. The results reveal that exploiting partial two-phase boiling within the high-efficiency nucleate boiling regime significantly enhances the overall convective heat transfer coefficient, enabling a volume reduction of up to ~85% compared to single-phase designs, while maintaining a competitive thermal efficiency (~35%). Furthermore, operating at intermediate exit vapor qualities effectively circumvents CHF constraints and structural thermal stresses associated with dryout. This study demonstrates a robust design methodology for optimizing secondary power conversion systems in advanced compact SMR applications.

Keywords

Thermodynamics; Printed Circuit Heat Exchanger; Heat transfer; Small Modular Reactor

[S1-6] Invited Presentation

Farm Layout Multi-Objective Optimization for the Sustainable Development of Tidal Stream Energy

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Abstract

Japan aims to significantly increase electricity generation from solar PV and offshore wind energy over the coming decades. This increase will cause strong variability in power generation due to the weather dependence of these two sources. In this context, tidal stream energy can contribute to the stability of the electric grid due to its predictability and short-term periodicity.

After the successful completion of the first MW-scale demonstration project in Japan, the tidal energy sector is aiming at the reduction of the Levelized Cost of Energy (LCOE) to reach the commercialization stage. One of the innovations with a higher potential for cost reduction is the optimization of tidal energy farm layouts [1].

In this work, a multiobjective tidal farm layout optimization is introduced using as a case study an 8-turbine array in Naru Strait, Nagasaki Prefecture. Naru Strait is divided into two areas differing in the body that owns the fishery rights. It is thought that the exploitation of tidal stream energy may occur first on the eastern side and then, at a later stage of development, on the western side of Naru Strait [2].

The operation of the tidal energy farm on the eastern side (Farm A) will cause changes in the flow conditions on the western side of the channel. Thus, the two objectives of the layout optimization of Farm A are the maximization of its power generation and the maximization of the available power density on the western side of the channel.

An optimized layout that increases the capacity factor of Farm A by 3.38% and the power density on the western side of the channel by 0.49% (relative to a baseline layout) was found.

The optimization tool presented in this work can significantly contribute to the sustainable development of tidal stream energy in Japan.

Keywords

Tidal Stream Energy; Farm Layout; Optimization

References

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- [2] P. Garcia-Novo, S. Waldman, Y. Kyojuka, D. Sakaguchi, Impacts of interactions between nearby tidal farms on their performance and operation. *Journal of Ocean Engineering and Technology*, 39(1), 47-55 (2025).

[S2-1] Invited Presentation

Prediction of a Multi-Bed Active Magnetic Refrigeration System Using a Multilayer Perceptron Artificial Neural Network Model

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Abstract

In this study, a multilayer perceptron-based artificial neural network (MLP-based ANN) model was developed using 241 steady-state experimental datasets from a magnetic refrigeration system [1]. Experiments were conducted under various operating conditions, including the inlet temperatures and flow rates of the heat transfer fluid and the secondary fluid for the heat source, as well as the reciprocating frequency of the magnetic field source. These parameters served as the input features for the MLP-based ANN model. The performance metrics of the system—comprising the temperature span between the cold and hot ends, the outlet temperature of the secondary fluid, the cooling capacity, and the coefficient of performance (COP)—were database-compiled and utilized as the output features. During the model training process, the Adaptive Moment Estimation (Adam) optimization algorithm was employed to update the weights and biases of the hidden layer perceptrons [2]. The developed MLP-based ANN model demonstrated high accuracy compared with experimental data, showing an MSE of 0.016 and an R2 of 0.988 for cooling capacity, an MSE of 0.004 and an R2 of 0.986 for COP, and a comparatively high agreement with an MSE of 0.204 and an R2 of 0.934 for the system temperature span.

Keywords

Artificial neural network; Multilayer perceptron; Magnetic refrigeration system; Magnetocaloric effect

References

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[S2-2] Invited Presentation

Wet-Process Fabrication of Magnetic Materials

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Abstract

Wet processing provides a versatile route for fabricating magnetic materials because film composition, thickness, microstructure, and magnetic properties can be controlled through relatively simple electrochemical procedures. Electroplating and related wet processes are attractive for preparing magnetic films and thick films on various substrates.

Our group has been investigating the fabrication of a wide range of magnetic materials by wet processes, including soft-magnetic Fe–Ni and Fe–Co alloys, hard-magnetic Fe–Pt-based materials, and Ni- and Co-containing films. In these studies, the relationships among electrolyte composition, additives, deposition conditions, film structure, and magnetic properties have been examined. In addition to conventional aqueous plating baths, alternative reaction environments such as gel electrolytes and deep eutectic solvents have also been explored to control ion transport and electrochemical reactions near the electrode surface.

Alongside these experimental approaches, micromagnetic simulations have been employed to understand magnetization processes and to explore possible strategies for improving magnetic performance. Such numerical approaches enable us to examine the effects of magnetic anisotropy, sample geometry, internal interactions, and other material parameters on macroscopic magnetic behavior, and therefore provide complementary information for the design of magnetic materials.

This presentation will provide an overview of our recent activities in the fabrication and design of magnetic materials. Several examples will be introduced to illustrate how wet-process conditions influence film formation and magnetic properties, as well as how numerical simulations can contribute to understanding and controlling magnetization behavior. Through these examples, the potential of combining flexible wet-processing techniques with computational approaches for the development of magnetic materials and devices will be discussed.

Keywords

Magnetic materials; Electroplating; Wet process; Micromagnetic simulation

[S2-3] Invited Presentation

Dual Optoelectronic Modulation of Percolation Paths in a Single Si Nanowire for Neuromorphic Memory

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Abstract

The physical realization of highly efficient, brain-inspired neuromorphic architectures fundamentally relies on the development of state variables that seamlessly integrate logic and memory functions. While artificial synapses effectively emulate biological plasticity for massively parallel computation, the operation of conventional, purely electrically driven devices is often strictly bottlenecked by irreversible structural degradation—such as atomic migration and dielectric breakdown—over repeated switching cycles. Exploiting photon-matter interactions to modulate charge transport offers a non-destructive alternative to circumvent these fatigue mechanisms. However, achieving deterministic, continuous analog conductance tuning and robust dynamic current suppression through simple photonic stimuli remains a formidable challenge in mesoscopic physics. In this study, we investigate the charge transport dynamics and optoelectronic modulation of percolation thresholds within a spatially modulated silicon nanowire, consisting of alternating solid-core/porous-shell and pure solid-core segments [1]. The highly defective nature of the porous nanograin shell introduces a complex energy landscape governed by localized trap states. We demonstrate that the synergistic interplay between electrical bias and targeted optical excitation dynamically alters local potential barriers, effectively reconfiguring the active charge carrier percolation paths. This spatially resolved modification of the conductive network enables the highly reversible, continuous tuning of persistent current levels and profound current suppression. Translating these microscopic physical phenomena to macroscopic synaptic dynamics, we demonstrate robust electrical potentiation and optical habituation. Specifically, localized laser illumination on the porous shell modulates local trapping/detrapping dynamics via photo-generated carriers, manifesting as a strictly linear decay in the postsynaptic conductance. Furthermore, synaptic elimination was successfully emulated through the spatial field coupling of two adjacent nodes interconnected on a single nanowire. Our results establish that the deterministic, external manipulation of localized percolation networks in mesoscopic silicon structures provides a compelling physical framework for advanced neuromorphic engineering.

Keywords

Synaptic devices; Neuromorphic; Nanowires; Memory devices

Reference

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[S2-4] Invited Presentation

Development of Porous Metal-Oxide Gas Sensors for VOC Detection

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Abstract

Microstructural control of sensing materials is important for improving the performance of semiconductor gas sensors. In particular, porous morphologies have attracted significant attention because they enable simultaneous improvements in gas diffusion and reactivity, thereby enhancing the gas-sensing performance. We have introduced ordered porous structures into metal-oxide particles by ultrasonic spray pyrolysis using polymethyl methacrylate (PMMA) microspheres as a template [1–3]. The interconnected pores facilitate the diffusion of target gases into the sensing layer and increase the number of accessible reaction sites on the oxide surface.

In this study, spherical porous metal oxides (pr-MO, MO: In_2O_3 or SnO_2), w wt% In_2O_3 -mixed pr- SnO_2 (pr- $w\text{In}_2\text{O}_3$ - SnO_2 , w : 3–95), and n wt% noble metal (M)-added pr- $33\text{In}_2\text{O}_3$ - SnO_2 ((pr- $n\text{M}$ - $33\text{In}_2\text{O}_3$ - SnO_2), M: Au or Pt, n : 0.5 or 2) powders were prepared by ultrasonic spray pyrolysis employing homemade PMMA microspheres (typical particle size: ca. 70 nm in diameter), and the VOC-sensing properties of thick-film sensors fabricated using these powders were examined at 250–500°C in air. The magnitude of the response to VOCs was defined as the ratio (R_a/R_g), where R_g and R_a are the resistances in VOCs balanced with air and in air, respectively.

The obtained powders consisted of submicron-sized spherical particles with interconnected pores, which originated from the thermal decomposition of the PMMA microspheres. The pr- $33\text{In}_2\text{O}_3$ - SnO_2 sensor showed the largest acetone response among all the pr-MO and the pr- $w\text{In}_2\text{O}_3$ - SnO_2 sensors in the temperature range examined. Figure 1 shows temperature dependences of the responses of the pr- $n\text{M}$ - $33\text{In}_2\text{O}_3$ - SnO_2 sensors to 50 ppm acetone. The addition of Au or Pt to the pr- $33\text{In}_2\text{O}_3$ - SnO_2 powders improved the acetone response of the pr- $33\text{In}_2\text{O}_3$ - SnO_2 sensor, and the pr-2Pt- $33\text{In}_2\text{O}_3$ - SnO_2 sensor showed the largest acetone response at 350°C among the sensors tested. We also confirmed that the response of the pr-2Pt- $33\text{In}_2\text{O}_3$ - SnO_2 sensor to acetone was larger than those to ethanol and toluene.

The catalytic oxidation and adsorption behavior of VOCs were also investigated. Noble-metal addition, particularly Pt, enhanced the catalytic oxidation of VOCs to understand the origin of the enhanced sensing properties. Diffuse reflectance infrared Fourier transform (DRIFT) spectroscopy indicated that acetone was strongly adsorbed on the Pt-added porous oxide and that adsorbed intermediate species remained on the surface. The details will be discussed in the presentation

Keywords

Semiconductor gas sensor; Acetone; SnO_2 ; In_2O_3 ; Noble metal; Ultrasonic spray pyrolysis; DRIFT spectroscopy

References

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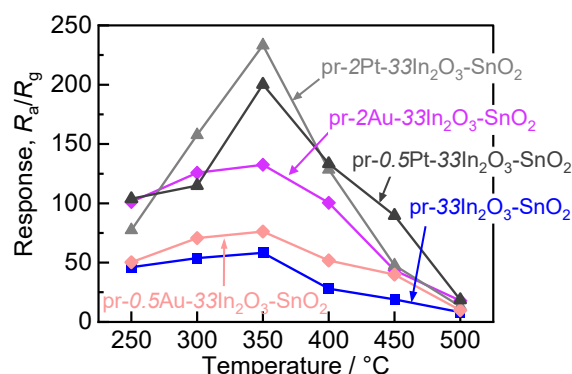


Fig. 1. Operating temperature dependences of the responses of pr- $n\text{M}$ - 33SnO_2 - In_2O_3 sensors to 50 ppm acetone.

[S2-5] Invited Presentation

Reinterpretation of Damage Profiles in High-Dose Helium-Irradiated Ferritic/Martensitic Steel via Density-Corrected SRIM Modeling

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Abstract

Helium ion irradiation is widely employed to investigate displacement damage and helium accumulation in materials for advanced nuclear systems [1–3]. However, under high-dose gaseous ion irradiation, severe cavity formation and swelling can progressively reduce the effective target density, thereby altering ion penetration and damage profiles [4–7]. In this study, 60-keV helium ion-beam irradiation up to ~200 dpa was performed on the ferritic–martensitic (F/M) steel FC92-B to investigate the influence of irradiation-induced swelling on ion transport behavior. The experimentally observed ion penetration depth reached approximately 600 nm, substantially exceeding the ~370 nm predicted by conventional SRIM-2013 calculations. Cross-sectional electron microscopy revealed a highly porous microstructure, indicating that the discrepancy originated primarily from swelling-induced reduction in effective target density. To account for this dynamic density evolution, a multi-step, multi-layer SRIM approach was developed in which the target density was successively updated according to experimentally measured depth-dependent swelling. The reliability of the proposed approach was further assessed through sensitivity analyses using different dose intervals and sublayer thicknesses. The modified calculations reproduced the experimentally observed extension of the damaged region more accurately than conventional SRIM calculations, demonstrating that dynamic density evolution becomes essential for interpreting ion irradiation damage under severe swelling conditions. This approach provides a practical framework for improving SRIM-based damage analysis of materials subjected to high-dose gaseous ion irradiation.

Keywords

Ion irradiation; transmission electron microscopy; ferritic/martensitic steel; SRIM-2013

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[S2-6] Invited Presentation

Laser Induced Forward Transfer (LIFT)-Made Nd-Fe-B Micromagnets

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Abstract

Despite reports of sputtering-fabricated Nd–Fe–B micromagnets with outstanding magnetic properties, the films necessitate an annealing process that includes substrate heating and/or post-annealing. In this study, Nd–Fe–B micromagnets were prepared using a low-temperature process. Specifically, we used a laser-induced forward-transfer (LIFT) technique that employs Nd–Fe–B thick films fabricated using pulsed laser deposition (PLD). We succeeded in transferring the Nd₂Fe₁₄B phase from the target to the LIFT-made micromagnets, and samples with a coercivity exceeding 500 kA/m were successfully prepared without an annealing process^[1].

Keywords

PLD method; LIFT technique; Nd-Fe-B magnet; low temperature process; coercivity; Microstructure

Reference

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[S2-7] Invited Presentation

Hierarchical Decentralized Federated Learning Based on Anchor and Coordinator

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Abstract

Federated Learning (FL) enables privacy-preserving distributed intelligence across heterogeneous edge devices. Hierarchical Federated Learning (HFL) improves scalability through multi-level aggregation; however, conventional HFL relies on physically separated anchor and coordinator nodes, leading to redundant inter-layer communication and increased synchronization latency. This paper proposes a Logical Hierarchical Federated Learning (LHFL) framework that logically consolidates anchor and coordinator roles within a single high-capability device while preserving hierarchical aggregation. To further improve deployment efficiency, model pruning is incorporated to eliminate redundant model parameters and reduce computational, memory, and communication overhead while maintaining learning performance. A digital twin-based orchestration mechanism enables capability-aware node registration, clustering, and hierarchical role assignment, while a similarity-driven aggregation strategy addresses heterogeneous non-IID data distributions. Two configurations are designed to support aggregation-only and training-enabled anchor deployment for diverse edge environments. Experiments conducted using MNIST, CIFAR-10, and synthetic datasets demonstrate that LHFL maintains competitive predictive performance while reducing system-level overhead. On a heterogeneous real-device MNIST testbed, LHFL achieves up to 10% and 60% reductions in communication cost and 14% and 9% reductions in waiting time for Type-1 and Type-2 configurations, respectively, compared with conventional HFL. Furthermore, the pruning strategy reduces model complexity and resource requirements with minimal impact on predictive performance. These results demonstrate that combining logical role consolidation, model pruning, digital twin-based orchestration, and similarity-aware aggregation provides an efficient and scalable approach for hierarchical federated learning in heterogeneous edge environments.

Keywords

Hierarchical Federated Learning; Model Pruning; Digital Twin; Edge Computing.

[S3-1] Invited Presentation

Quantitative and Qualitative Analysis of Chelating Agents Using High-Performance Liquid Chromatography and its Applications

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Abstract

Chelating agents such as ethylenediaminetetraacetic acid (EDTA), diethylenetriaminepentaacetic acid (DTPA), and nitrilotriacetic acid (NTA) can be dangerous, when radionuclides form complexes with the chelating agents, increasing the mobility of the radionuclides. Therefore, a method for analyzing chelating agents in waste is needed, but existing methods for analyzing them in radioactive waste have limitations that require new methods based on liquid chromatography-quadrupole/time-of-flight mass spectrometry (LC-MS/MS). A high-performance liquid chromatography-photodiode array (HPLC-PDA) analytical method applicable to the numerous matrix samples for radioactive waste was established, and using a hydrophilic interaction chromatography column, three chelating agents, EDTA, DTPA, and NTA, were successfully separated and quantified, with recoveries ranging from 94.83 to 109.47%. All metal chelate complexes were converted exclusively to nickel chelates through the pretreatment process, and the identities of the Ni-EDTA, Ni-DTPA, and Ni-NTA peaks obtained by HPLC were confirmed using mass spectrum (LC-MS/MS) by preparing solutions for each sample.

Keywords

Chelating agents; HPLC; Quantification; Qualification

[S3-2] Invited Presentation

Reductive Conversion of Small Molecules on Transition Metal Complexes

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Abstract

Global biogeochemical cycles, including the carbon, nitrogen, and sulfur cycles, play crucial roles in sustaining life on Earth. Plants and microorganisms containing metalloenzymes are essential for catalyzing the transformations that occur within these cycles. This study aims to replicate the functions of reductases using original metal complexes.

In the carbon cycle, photocatalytic CO₂ reduction was achieved using a ruthenium-based photosensitizer, a ruthenium catalyst bearing CNC pincer and bpy ligands, and BI(OH)H as a sacrificial reagent, producing formic acid with a turnover number of 4742 over 24 hours and 80% selectivity.

For the nitrogen cycle, two reduction processes were investigated: the NO reduction cycle and the NO₂⁻ reduction cycle. Unusual N–N bond formation between NO ligands on dinuclear ruthenium complexes was discovered, mimicking the mechanism of NO reductase. A synthetic nitrite reduction cycle producing NH₃ was also achieved using a dinuclear ruthenium complex. In the sulfur cycle, the transformation of SO₃²⁻ to S²⁻, a key step normally facilitated by sulfite reductases, was examined. A sulfite-bridged dinuclear ruthenium complex underwent stepwise reduction to form SO-bridged and S₂-bridged complexes, ultimately releasing H₂S upon protonation. Overall, this study demonstrates that the same dinuclear ruthenium complex can mediate the reductive conversion of NO, NO₂⁻, and SO₃²⁻, effectively replicating the functionality of their respective reductases.

Keywords

Biogeochemical cycles; Reductases; Metal complexes; Small molecules; Ruthenium

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[S3-3] Invited Presentation

Study on Sustainable Plastic Upcycling Process Development

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Abstract

Throughout its lifecycle, polyesters, such as poly(ethylene terephthalate) (PET) undergoes significant degradation during long-term ultraviolet (UV) exposure. Molecular and mechanical degradations of PET under UV aging in dry, marine, and freshwater exposure condition were characterized using rheological analysis and exhibited the degradation can be significant during mechanical recycling. To develop an effective and sustainable plastic upcycling process, an alcohol-based reaction converting waste polyethylene terephthalate (PET) into monomers (terephthalic acid) and its precursors was comprehensively evaluated from a thermodynamic perspective. Through an analysis based on Florey-Huggins interaction parameter ($\chi_{1,2}$), each process component—namely alcohol, co-solvent, Lewis acid, and reaction conditions—of solvolysis were examined. The effect of co-solvents on the depolymerization process due to reduction of thermodynamic potential, and confirmed that the solubility of the Lewis acid source is important for efficient PET deconstruction. The thermodynamic reaction design enabled sustainable reaction optimization and provides a unified avenue for optimizing and developing sustainable recycling processes for post-consumer plastic waste.

Keywords

PET; Degradation; Chemical recycling; Sustainability

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[S3-4] Invited Presentation

Development of an Eco-Friendly Antifouling System Based on the Light-Sensing Mechanisms of Marine Sessile Organisms

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Abstract

Marine sessile organisms, such as oysters and barnacles, are considered important bioresources that provide high-quality protein worldwide. Despite their benefits, they are also major biofouling organisms, as their attachment to undesired surfaces can cause substantial economic losses. This dual role highlights the need for antifouling technologies that can prevent unwanted attachment while minimizing adverse effects on these valuable resource populations. Recently, ultraviolet-C irradiation has attracted attention as an eco-friendly alternative to conventional chemical antifouling coatings because of its localized and short-range impacts. However, its application in marine environments remains challenging, particularly because of its potential effects on non-target organisms and valuable bioresources.

The light-sensing systems of marine sessile organisms vary among larval developmental stages. We therefore focused on the light-sensing characteristics of their larvae as a basis for developing an eco-friendly antifouling system. In several sessile organisms, specialized eyespots or photoreceptors develop at specific developmental stages associated with settlement. For example, oyster larvae develop an eyespot during the pediveliger stage, when they become competent for settlement and attachment. In contrast, barnacle larvae develop compound eyes from the nauplius VI stage, in addition to a naupliar eye. These photoreceptors exhibit wavelength-dependent light absorbances, with patterns that differ among species. These eyespot characteristics are reflected in larval phototactic behavior, resulting in species-specific responses in horizontal phototaxis and attachment rates under irradiation at different wavelengths [1, 2].

Based on findings from previous studies, visible-light irradiation has considerable potential as an eco-friendly antifouling approach that may reduce adverse effects on marine ecosystems. In this presentation, I will comprehensively discuss the effects of different light wavelengths on the larvae of various marine sessile organisms, focusing on the quantitative characteristics of their photoreceptors and wavelength-dependent phototactic responses.

Keywords

Biofouling; Light irradiation; Antifouling system; Eco-friendly technology

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[S3-5] Invited Presentation

High-Entropy Layered Double Hydroxide as a Durable Bifunctional Electrocatalyst for Chloride-Tolerant Seawater Splitting

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Abstract

Direct seawater electrolysis is an attractive route to scalable green hydrogen, since seawater is an abundant feedstock, but the competing chlorine evolution reaction and chloride-driven corrosion make it difficult to design catalysts that are both active and durable. Conventional binary and ternary layered double hydroxides (LDHs) offer limited active-site diversity and remain prone to chloride leaching and structural degradation in real seawater. To address this, we designed a nonnoble-metal, five-element high-entropy layered double hydroxide (HE-LDH; Ni-Co-Fe-Cr-Bi) grown directly on Ni foam as a bifunctional OER/HER electrocatalyst. Configurational-entropy engineering raises the Ni³⁺/Ni²⁺ ratio, lattice disorder, oxygen-vacancy density, and metal-oxygen covalency, generating abundant, electronically tuned active sites, while spectroscopic and DFT analyses confirm that the high entropy ($\Delta S_{\text{config}} \approx 1.6R$) stabilizes a single-phase structure that resists chloride attack. In alkaline natural seawater, HE-LDH requires only 266 mV (OER) and 160 mV (HER) at 10 mA cm⁻², a mass activity of 44.2 A g⁻¹, and a turnover frequency of 0.104 s⁻¹, about 2.5-fold higher than the ternary NiCoFe analogue. An assembled anion-exchange-membrane (AEM) seawater electrolyzer built from this catalyst delivers 1.12 A cm⁻² at 2.2 V and sustains stable operation for 300 h and 700 h at an industrially relevant 1 A cm⁻² and 500 mA cm⁻², respectively, demonstrating that entropy engineering of multimetal LDHs is an effective, noble-metal-free strategy for durable, scalable green hydrogen production from seawater.

Keywords

High-Entropy Layered Double Hydroxide, Bifunctional Electrocatalyst, Seawater Electrolysis, Lattice Oxygen Modulation, Green Hydrogen

References

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[S3-6] Invited Presentation

Multiple Nutrient Recovery from Aquaculture Wastewater Through Membrane Separation Processes

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Abstract

The sustainable management of aquaculture wastewater is crucial for environmental stewardship and resource valorization. A two-stage Vacuum Membrane Distillation (VMD) was systematically investigated as an advanced process for recovering ammonia (NH_3) and concentrating nitrate (NO_3^-) and phosphate (PO_4^{3-}). Initial batch tests established optimal process conditions for selective NH_3 separation and high concentration factors of non-volatile nutrients (NO_3^- and PO_4^{3-}). Applying these conditions to prefiltered inland aquaculture wastewater, the first-stage VMD achieved >85% NH_3 removal, recovering it in ammonium (NH_4^+) up to 40-fold from 25 mg/L to 1,015 mg/L in a 5 mM phosphoric acid trap alongside potassium (K) co-transport, yielding a valuable liquid NPK fertilizer. Subsequently, the second-stage VMD concentrated the remaining nitrate and phosphate by approximately 5-fold within 60 h. The VMD membrane exhibited <20% flux decline and maintained excellent conductivity rejection (>99%), producing high-quality permeate with 80% water recovery. The techno-economic analysis showed that baseline NH_3 recovery costs (<USD 189/kg NH_4^+ recovered) in the first-stage VMD could potentially be offset by the recovered NPK product revenue at elevated NH_4^+ feed concentrations (>385 mg/L). Conversely, the ambient membrane contactor (MC) system demonstrated greater economic viability for NH_3 recovery, with a lower break-even NH_4^+ feed concentration (>70 mg/L). The second-stage VMD system for nitrate-phosphate recovery was economically unfeasible at baseline due to the high purified water production cost (USD 80/m³). Sensitivity analysis indicated that low nutrient feed concentrations (>48 mg/L NH_4^+ and >29 mg/L NO_3^- and PO_4^{3-}) combined with targeted energy and membrane area optimization could enable economic feasibility for both VMD stages. Overall, these results provide a robust reference for recovering concentrated, multiple nutrients from aquaculture wastewater, demonstrating strong potential to achieve complete resource recovery, zero-waste discharge, and production of valuable, high-quality liquid fertilizers for agricultural reuse.

Keywords

Selective ammonia separation; Nitrogen and phosphorus recovery; Aquaculture wastewater valorization; Circular economy

Poster Presentations

- P-01 On-Site Thermal Performance of a 15-kW Adsorption Chiller Driven by Integrated PEMFC Waste Heat and Solar Energy
Ji Hyun Jeong and Jongmin Choi (JNU)
- P-02 Verification of Pan's Green Function and Its Application to Cavity Problems in a Transversely Isotropic Solid
Hajime Muraoka, Yohei Sonobe and Akihide Saimoto (NU)
- P-03 Body Force Method with Adaptive Basic Density Functions for Cavity Interaction Near a Free Surface
Kanato Miyazaki, Yohei Sonobe and Akihide Saimoto (NU)
- P-04 Data-Efficient Hydrogen Crossover Prediction for PEM Water Electrolysis via Hard-Constraint Physics-Residual Learning
Yong-Woon Kim, Hasnain Hyder and Yung-Cheol Byun (JNU)
- P-05 Thermal Stresses Around a Thermally Permeable Crack in an Anisotropic Plate
Mahiro Nomura, Yohei Sonobe and Akihide Saimoto (NU)
- P-06 Analytical Integration of Resultant Forces in the Three-Dimensional Body Force Method
Koki Fujimatsu, Yohei Sonobe and Akihide Saimoto (NU)
- P-07 Sustainable Brewer's Spent Grain-Derived Fe-NC Electrocatalyst with Hybrid Atomic Fe Sites and Clusters for High-Performance Aluminum-Air Batteries
Arif Khan and Sang-Jae Kim (JNU)
- P-08 Analysis of Crack Problems in an Infinite Piezoelectric Plane of Arbitrary Poling Direction
Zhang Yi, Yohei Sonobe and Akihide Saimoto (NU)
- P-09 Numerical Simulation of Heat and Mass Transfer in Ceramic Kilns During the Firing Process
Ritsuki Yamamoto, Tomohiko Yamaguti, Satoru Momoki (NU)
- P-10 Embedding Crystalline Ion Channels in a Sulfonated Polymer Membrane for Selective K^+ Transport in Aluminium-Iron Aqueous Batteries
Konanchery Muralleedharan Athira and Sang-Jae Kim (JNU)
- P-11 Appearance of the Viscous-Convective Range at Very Low Diffusivity
Ryunosuke Arakawa and Takuya Kitamura (NU)
- P-12 Scale-by-Scale Analysis of Turbulence Dynamics in an Axisymmetric Swirling Jet
Yuta Ura and Takuya Kitamura (NU)
- P-13 Topology Optimization and Numerical Evaluation of an Overhead Crane Girder
Atif Niaz, Osama Ali, Osama Salem, Anisha Karki, Ai Ting and Dong Won Jung (JNU)
- P-14 Structures in MHD Turbulence and Effects of the Lorentz Force
Kotaro Nishi and Takuya Kitamura (NU)
- P-15 Fundamental Study on Steel Joints Using Highly-Expansive Material
Masahiro Fuchi, Iathong Chan, Tetsuto Harada and Daitaro Taniguchi (NU)
- P-16 Intermittency-Resilient Green Hydrogen Production via Coupled Energy Conversion and Storage Using Tri-Functional $NiFe_2O_4$ Nanostructures
Janakiraman Chennakrishnan, Parthiban Pazhamalai and Sang-Jae Kim (JNU)
- P-17 Effects of Nd-Al Grain Boundary Diffusion on the Magnetic Properties of Isotropic Nd-Fe-B Film Magnets Fabricated by Pulsed Laser Deposition
Shogo Mori, Akihiro Yamashita, Takeshi Yanai, Masaki Nakano, Hirotooshi Fukunaga (NU)
- P-18 Effects of Bath Additives on the Properties of Soft Magnetic Ni Films Prepared by Gel Plating
Ryo Kirihara, Mayuri Tashiro, Shota Enokida, Rintaro Takeshita, Akihiro Yamashita, Takeshi Yanai, Masaki Nakano, Hirotooshi Fukunaga (NU)
- P-19 Beyond Energy Generation: Aluminium-Driven Electrochemical Energy Systems for Coupled Power Production and Nitrate Valorization
Alex Joshua and Sang-Jae Kim (JNU)
- P-20 Development of Platinum-Based Micromagnets via Laser-Induced Forward Transfer Technique
Hayato Todoroki, Itsuki Fukuda, Kohei Fujii, Kosei Maki, Akihiro Yamashita, Takeshi Yanai, Masaki Nakano, Hirotooshi Fukunaga (NU), Kunihiro Koike (Yamagata Univ.)

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- P-21 Development of Fe-Pt Bulk Magnets Using PLD Method
Kohei Fujii, Hayato Todoroki, Akihiro Yamashita, Takeshi Yanai, Masaki Nakano, Hirotoshi Fukunaga (NU)
- P-22 Upcycled Ru-Doped Co₃O₄ from Spent LiCoO₂ Batteries as a Cost-Effective, Industrially Viable Oxygen Evolution Electrocatalyst
Keyru Serbara Bejigo and Sang-Jae Kim (JNU)
- P-23 Increase in Coercivity of LIFT-Fabricated Nd-Fe-B Micromagnets by Controlling Laser Irradiation Conditions
Taiga Kitahara, Hiroto Ono, Itsuki Fukuda, Akihiro Yamashita, Takeshi Yanai, Masaki Nakano, Hirotoshi Fukunaga (NU), Kunihiro Koike (Yamagata Univ.)
- P-24 Room-Temperature Transfer Deposition Technology for Nd-Fe-B Micromagnets
Gaiya Sugimoto, Akihiro Yamashita, Takeshi Yanai, Masaki Nakano, Hirotoshi Fukunaga (NU)
- P-25 Interfacial Reconstruction of Recycled Graphite through Artificial SEI Engineering for Fast-Charging Anodes
Alphonse Raj Ruby and Sang-Jae KIM (JNU)
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[P-01]

On-Site Thermal Performance of a 15-kW Adsorption Chiller Driven by Integrated PEMFC Waste Heat and Solar Energy

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Abstract

This study presents the first operational deployment of a 15-kW-class adsorption chiller employing a CAU-10-H/water working pair, designed to provide chilled water for an on-site greenhouse facility (602.8 m²) in Jeonju, South Korea. The system is driven by hot water supplied through a multi-source thermal network integrating waste heat from a proton exchange membrane fuel cell (PEMFC) system and solar energy collected via solar thermal collectors. Due to the low-grade temperature of the PEMFC waste heat, a heat pump was utilized for active thermal upgrading prior to delivering thermal energy to the adsorption chiller. Field experiments conducted from August 14 to 20, 2025, demonstrated that the system stably provided an average cooling capacity of 13.3 kW (± 1.1 kW) with a thermal coefficient of performance (COP_{th}) of 0.56 (± 0.03), achieving a peak cooling capacity of 15.1 kW. The hot water supplied for a desorption process maintained an average temperature of 71.7°C (± 3.1 °C). Notably, solar thermal collectors provided up to 9.4 kW of peak daytime thermal energy, accounting for 38.7% of the total driving heat input supplied to the adsorption chiller at that instant.

Keywords

Adsorption chiller, Waste heat, Solar thermal energy, Greenhouse cooling

[P-02]

Verification of Pan's Green Function and Its Application to Cavity Problems in a Transversely Isotropic Solid

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Abstract

The displacement field satisfying the equilibrium equations of a stationary elastic solid can be represented in terms of the Papkovitch-Neuber displacement potentials. In general, these potentials consist of one scalar potential and one vector potential, both of which are harmonic functions satisfying Laplace's equation. The fundamental solution describing the displacement at an arbitrary point in an isotropic elastic solid subjected to a concentrated force at a point is known as the Kelvin solution and has been widely used in stress analyses of isotropic elastic solids. For a transversely isotropic infinite solid, Pan et al. derived a Green's function that describes the displacement field generated by a concentrated point force. Their solution is considerably more complicated than the Kelvin solution because, although the elastic properties are isotropic in the transverse plane, those in the axial direction are different.

In this study, the validity of Pan [1]'s Green's function for a transversely isotropic elastic solid is examined using both theoretical and numerical approaches. After verifying the correctness of the Green's function, the solution is incorporated into the body force method and applied to the stress analysis of spherical cavities. Detailed numerical analyses are then performed for the interaction between two spherical cavities in two configurations: one in which the cavity centers are aligned in the plane of isotropy, and the other in which they are aligned along the axis of transverse isotropy. The numerical results clarify the effects of the relative cavity arrangement and transverse isotropy on the stress distributions and maximum stresses around the cavities.

Keywords

Transverse Isotropy; Body Force Method; Cavity Interaction

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[P-03]

Body Force Method with Adaptive Basic Density Functions for Cavity Interaction Near a Free Surface

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Abstract

In the body force method (BFM) [1], an unknown body force density is commonly expressed as the product of a basic density function and an unknown weight function. Choosing an appropriate basic density function that captures the dominant spatial variation of the density allows the weight function to be approximated accurately with relatively few boundary divisions. An unsuitable choice, however, can impair accuracy and convergence. Continuous approximations of weight functions have also been developed [2], and their ability to resolve localized variations depends on the chosen density representation and approximation functions.

This study proposes an adaptive basic density function approach that updates the basic functions iteratively while enforcing the boundary conditions. The body force density is represented as the product of an adjustable continuous function and an elementwise weighting coefficient. For a given continuous function, the weighting coefficients are determined from the boundary conditions. The continuous function is then modified to reduce the spatial variation of these coefficients. Repeating these steps adapts the basic density function to the problem. The aim is to make the remaining weighting coefficients nearly uniform while preserving the nonuniform body force density required to satisfy the boundary conditions.

The method is applied to analyze the interaction between two spheroidal cavities near the free surface of an isotropic elastic half-space under remote uniaxial tension. Mindlin's fundamental solution [3] accounts for the traction-free surface of the half-space. Numerical examples confirm the effectiveness of the adaptive density representation for this problem. The formulation adjusts the density representation to interactions between the cavities and the free surface, reducing reliance on a basic density function prescribed in advance.

Keywords

Body Force Method; Adaptive Basic Density Function; Weight Function; Cavity Interaction; Elastic Half-Space

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Data-Efficient Hydrogen Crossover Prediction for PEM Water Electrolysis via Hard-Constraint Physics-Residual Learning

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Abstract

Reliable prediction of hydrogen crossover is a prerequisite for safe high-pressure polymer electrolyte membrane water electrolysis (PEMWE), yet the field is data-poor: published crossover measurements number in the hundreds, are expensive to acquire, and rarely cover the operating conditions of industrial interest. This paper asks how much labelled data a crossover predictor actually needs, and shows that the answer is governed primarily by *how* physics is integrated rather than by model capacity. We evaluate a hard-constraint physics-residual network (PR-Net), which embeds Henry's, Fick's and Faraday's laws as a non-trainable backbone and learns only the residual correction, against a purely data-driven neural network, a soft-constraint physics-informed neural network, and four classical regressors (XGBoost, random forest, Gaussian-process regression, support-vector regression). The benchmark comprises 184 observations compiled from eight peer-reviewed sources across six membrane types (1–200 bar, 25–85 °C, 0.05–5.0 A cm⁻²). With only 20 labelled points, PR-Net attains $R^2 = 99.4 \pm 0.1\%$, whereas the data-driven network and the soft-constraint PINN reach $44.9 \pm 22.5\%$ and $44.1 \pm 22.4\%$ respectively, and require more than 120 points to exceed 94%. Under pressure-axis extrapolation trained exclusively on ≤ 80 bar data, PR-Net retains $R^2 = 86.7 \pm 12.4\%$ from ten training points while both learned baselines are already negative; the classical regressors, trained on the full low-pressure set, collapse at 200 bar (-27.7% to -223.2%) against 94.0% for PR-Net. Freezing the backbone further enables adaptation to an unseen operating axis (porous-transport-layer compression), improving from 82.9% zero-shot to 98.6% with 20 new measurements, and the 34,305-parameter model infers in 1.08 ± 0.34 ms on a Raspberry Pi 5. Hard-constraint residual learning thus turns data scarcity from a blocking constraint into a manageable one for field-deployable electrolyser safety monitoring.

Keywords

Physics-residual network · Hard-constraint learning · Data efficiency · Few-shot adaptation · Hydrogen crossover · PEM water electrolysis · Edge inference

[P-05]

Thermal Stresses Around a Thermally Permeable Crack in an Anisotropic Plate

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Abstract

Localized heating during semiconductor processing generates thermal stresses that can affect the mechanical response of cracked materials. In anisotropic solids, directional thermal conductivity determines the temperature distribution, while elastic anisotropy influences the stress induced by thermal expansion. An analytical description of both effects is essential for interpreting crack-tip loading conditions and assessing numerical thermoelastic solutions.

This study derives closed-form expressions for the two-dimensional, steady-state thermoelastic field in an infinite anisotropic plate containing a straight crack and subjected to a point heat source. The principal material directions coincide with the coordinate axes, and the heat source lies on the crack axis. The crack is assumed to be fully thermally permeable: the temperature field is identical to that in the uncracked plate, and no thermal insulation condition is imposed on the crack faces.

The temperature field is first obtained from the steady anisotropic heat-conduction equation. The elastic field is represented using Lekhnitskii's complex potentials [1], and a particular thermoelastic solution for the uncracked plate is constructed. An auxiliary elastic field is then superposed to cancel the tractions generated by this solution on the crack faces. Consequently, the resulting total stress field satisfies the tractionfree mechanical boundary conditions while retaining the prescribed temperature field.

The derived complex potentials yield explicit expressions for the stresses and crack-tip stress intensity factors as functions of the heat source location and material properties. This formulation provides an analytical benchmark for boundary integral equations in thermoelasticity under the stated assumptions while clarifying the thermal modeling of the crack. Furthermore, analyzing the mathematical properties of the derived solutions under appropriately modeled conditions facilitates a deeper understanding of how heat sources and material anisotropy influence thermoelastic fields and mechanical behavior near the crack tip.

Keywords

Steady Point Heat Source; Anisotropic Thermoelasticity; Complex Potentials; Thermally Permeable Crack; Stress Intensity Factor

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[P-06]

Analytical Integration of Resultant Forces in the Three-Dimensional Body Force Method

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Abstract

Imposing boundary conditions in terms of resultant forces is an established technique for improving the accuracy of the body force method (BFM), as demonstrated by Isida and co-workers [1]. A resultant force is obtained by integrating the surface traction over a boundary element. In three-dimensional analysis, the resultant force generated by distributed body forces involves integration over both the source surface and the surface on which the resultant is evaluated. Direct numerical evaluation therefore requires a fourfold integral and can be computationally expensive.

This study combines analytical evaluation of resultant forces with numerical integration of the body force distribution. Following previous work on the resultant force technique [2,3], the surface integral of the traction induced by a point force over a planar triangular boundary element is evaluated in closed form. The remaining double integral over the source surface is evaluated by numerical quadrature. Thus, the numerical integration is reduced from four variables to two while retaining resultant-force boundary conditions.

To mitigate the geometric discretization error associated with planar boundary elements, the source points are positioned directly on the actual curved surface. The effectiveness of this approach is verified through the numerical analysis of cavities in an infinite elastic body. Specifically, the present method yields highly accurate stress concentration factors for the cavities, demonstrating significant improvement over conventional approximations. These findings validate the proposed integration procedure for curved boundaries, confirming its broad applicability to general three-dimensional elastic boundary value problems.

Keywords

Body Force Method; Resultant Force; Analytical Integration; Triangular Element; Curved Boundary

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[P-07]

Sustainable Brewer's Spent Grain-Derived Fe-NC Electrocatalyst with Hybrid Atomic Fe Sites and Clusters for High-Performance Aluminum-Air Batteries

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Abstract

Developing low-cost and sustainable oxygen reduction reaction (ORR) electrocatalysts with highly dispersed active centers and performance comparable to commercial Pt/C remains a major challenge for practical aluminum-air batteries. Herein, we present a simple, scalable, and biomass-assisted route for synthesizing an Fe-NC catalyst using brewer's spent grain (BSG)-derived porous carbon as a conductive support. The activated BSG carbon provides a high specific surface area and a favorable porous framework, promoting efficient mass transport and effective distribution of Fe-containing species. Structural characterization reveals a hybrid Fe configuration comprising atomically dispersed Fe sites together with small Fe clusters embedded within the N-doped carbon matrix. The optimized catalyst exhibits excellent ORR activity, delivering an onset potential of 0.94 V and a half-wave potential of 0.88 V versus RHE, approaching the performance of commercial Pt/C. When employed as the air-cathode catalyst in an aluminum-air battery, it also achieves a power density comparable to Pt/C and MnO₂-coated steel-mesh benchmarks. This work highlights a sustainable strategy for converting biomass waste into a high-performance Fe-NC electrocatalyst, offering a promising alternative to noble-metal-based cathode materials for next-generation metal-air energy systems.

Keywords

Oxygen reduction reaction, Al air batteries, Fe-NC catalyst, Pt/C.

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[P-08]

Analysis of Crack Problems in an Infinite Piezoelectric Plane of Arbitrary Poling Direction

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Abstract

Piezoelectric crack analysis requires a consistent treatment of the poling direction in both the material properties and the resulting fields. Rotating the poling direction within the plane introduces coupling coefficients that vanish in the aligned configuration and requires a general sixth-degree characteristic equation [1]. This study verifies a numerical body-force procedure for a line crack in an infinite piezoelectric plane with an arbitrary in-plane poling direction. The elastic, piezoelectric, and dielectric matrices are rotated into crack coordinates; characteristic roots, Green-function coefficients, and crack-tip extraction matrices are then reconstructed. The procedure is examined under remote normal stress, shear stress, and electric displacement at representative poling directions. This infinite-plane problem is chosen because its generalized intensity factors have an exact solution, while its internal source densities and fields still reflect material orientation.

For a fixed crack half-length, the known exact solution gives $K_I = \sigma_{xx}^\infty \sqrt{\pi a}$, $K_{II} = \tau_{xy}^\infty \sqrt{\pi a}$, and $K_D = D_x^\infty \sqrt{\pi a}$ [2]. Here, σ_{xx}^∞ , τ_{xy}^∞ , and D_x^∞ denote the remote normal stress, remote shear stress, and remote electric displacement, respectively, and a is the crack half-length. The computed intensity components approach their corresponding exact values as numerical integration is refined. Crack-face residuals remain small at the evaluation points, and unintended intensity components are negligible under the separate remote loads. Although the benchmark intensity factors are independent of poling direction, the computed crack-source densities and sampled stress and electric-displacement fields change with angle. Reflection and polarity-reversal symmetries are also reproduced, confirming that material rotation is active in the numerical formulation.

Agreement with the exact solution, integration convergence, crack-face checks, and internal symmetries validates the rotated-material implementation through crack-tip extraction for this infinite-plane benchmark. It provides a reference for future analysis of free-surface effects in a piezoelectric half-plane.

Keywords

Piezoelectric fracture; Poling-direction rotation; Body force method; Generalized intensity factors

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Numerical Simulation of Heat and Mass Transfer in Ceramic Kilns During the Firing Process

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Abstract

In the ceramics industry, the firing process—which is designed for mass production—allows for the maintenance of relatively stable quality and high yield rates based on the empirical rules accumulated by artisans through many years of operation. However, in small-batch, high-variety production aimed at meeting diversifying market needs, the layout of the kiln and heating conditions change frequently. As a result, it is difficult to control the optimal thermal profile based solely on empirical rules, and a key challenge is the decline in yield caused by defects such as uneven firing, warping, and cracking. Furthermore, since the ceramic firing process consumes large amounts of fossil fuels, there is a strong demand to reduce CO₂ emissions. In addition, recent global increases in energy costs and soaring prices for raw materials and supplies are driving up manufacturing costs, placing severe financial pressure on manufacturers in the region.

Against this backdrop, a technical approach that simultaneously optimizes energy efficiency and enables the rapid selection of high-quality firing conditions has become essential. Therefore, this study aims to introduce numerical simulation technology into the firing process to gain a detailed understanding of the thermal flow phenomena and temperature distribution inside the kiln, which are difficult to measure under high-temperature conditions.

As a research method, we first use Autodesk Fusion, a 3D CAD software, to create a three-dimensional model of the kiln's shape, internal structure, and product layout. Next, we import this geometry into Ansys Fluent, a thermal-fluid analysis software, to perform thermal-fluid analysis. As part of the ongoing efforts, a basic simplified model—featuring simplified internal structures and burner arrangements—has been created, and we are currently conducting fundamental steady-state analyses and verifying the suitability of the analysis mesh and boundary conditions. Moving forward, based on the insights gained from these simplified analyses, we plan to gradually expand the model to a high-precision version that accounts for the complex geometry of actual kilns and the chemical reactions occurring during the actual firing process, with the goal of visualizing the thermal flow phenomena and temperature distribution within the ceramic kiln.

Keywords

Ceramics; Kiln; Firing process; Mass and heat transfer; Oxidation-reduction reaction

Embedding Crystalline Ion Channels in a Sulfonated Polymer Membrane for Selective K^+ Transport in Aluminium-Iron Aqueous Batteries

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Abstract

The aluminum-based electrochemical energy system (Al-EES) has emerged as a promising alternative to conventional aluminum-air batteries by replacing the sluggish oxygen reduction cathode with a soluble catholyte electron acceptor, eliminating the Oxygen Reduction Reaction (ORR) bottleneck and the humidity dependence of Al-air chemistry. All Al-EES devices reported to date have relied on sodium persulfate as the catholyte and sodium-ion transport across the membrane. Extending this concept to an iron(III) chloride catholyte offers substantially lower cost, industrial maturity, and a higher redox potential, but requires a membrane engineered to transport K^+ at high flux while suppressing Fe^{3+} crossover and remaining chemically stable in the acidic and oxidizing Fe^{3+} environment. Herein, we report a sulfonated poly(ether ether ketone) (SPEEK) membrane embedded with a sulfonic acid-functionalized β -ketoenamine covalent organic framework (TppASO₃H-COF) as ordered 14.5 Å K^+ transport channels. The ordered COF channels, densely lined with $-SO_3^-$ groups, supplement the amorphous conduction pathways of pristine SPEEK, producing a composite membrane that combines high K^+ flux with strong Fe^{3+} rejection. In an Al-EES cell, the composite membrane reduces Fe^{3+} crossover to 89% suppression relative to Nafion 117, and delivers a specific capacity of 2879 Ah kg⁻¹ and energy density of 3023 Wh kg⁻¹ at 96.6% aluminum utilization efficiency, sustaining stable discharge for over 400 h. This work establishes crystalline sulfonated COF-embedded polymer composites as a K^+ -selective membrane platform for aqueous aluminum-based energy devices built from Earth-abundant elements.

Keywords

Aluminum-based electrochemical energy systems, SPEEK-COF composite membrane, K^+ -selective transport, Fe^{3+} crossover, Aluminum-iron battery.

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[P-11]

Appearance of the Viscous-Convective Range at Very Low Diffusivity

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Abstract

The transport and mixing of temperature and mass concentrations in turbulent flows play important roles in many natural and engineering phenomena, including heat transport in the atmosphere and oceans and the mixing of substances in chemical reactors. In particular, when molecular diffusion is weak, scalar structures can develop at scales much smaller than the smallest characteristic scales of the flow. However, scalar behaviour at such small scales remains poorly understood because numerical simulations require expensive computational costs, while experiments require measurements with very high spatial resolution.

In this study, we investigate the behaviour of second-order scalar statistics in the viscous-convective range, which is expected to exist for scalars with very low diffusivity [1, 2]. To this end, we introduce a Lagrangian stochastic approach based on the Langevin equation for homogeneous isotropic turbulence governed by the Navier–Stokes equations and perform first-principles numerical simulations. Instead of resolving the advection-diffusion equation with a very fine computational grid, the proposed method evaluates second-order scalar statistics by tracking fluid-particle trajectories backward in time. Using this approach, we calculate the second-order scalar structure function over a wide range of Schmidt numbers, $Sc = \nu/\kappa$, from $Sc = 1$ to 10^5 , where ν is the kinematic viscosity and κ is the scalar diffusivity. Under the conditions considered in this study, a distinct viscous-convective range emerges for $Sc \geq 10^3$. We also find a buffer range between the viscous-convective and inertial-convective ranges, which causes the Batchelor constant to be underestimated at low Sc . Furthermore, the Batchelor constant increases with the Péclet number and is suggested to approach a finite asymptotic value at sufficiently high Péclet numbers.

This study presents a new approach for investigating extremely low-diffusivity regimes that are difficult to access using conventional numerical methods and provides new insight into the behaviour of high- Sc scalars and the viscous-convective range.

Keywords

turbulence; scalar transport; mixing; low diffusivity

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[P-12]

Scale-by-Scale Analysis of Turbulence Dynamics in an Axisymmetric Swirling Jet

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Abstract

Jets are widely encountered in engineering applications such as combustion devices, propulsion systems, and inkjet technologies, and constitute an important class of flows in fluid engineering. Axisymmetric free jets exhibit spatially distinct turbulent structures, including the formation and breakdown of vortex rings in the potential-core region and the development of self-similarity farther downstream. Clarifying the roles of turbulent structures at different spatial scales is therefore important for understanding these phenomena.

In this study, direct numerical simulations (DNS) are performed for axisymmetric turbulent jets with and without swirl imposed at the nozzle exit. The objective is to investigate how swirl affects turbulent structures and the scale-dependent production mechanisms of enstrophy and strain. For scale decomposition, an efficient filtering method based on fast sine and cosine transforms is constructed for nonuniform three-dimensional flow fields. The transport budgets of enstrophy and the squared strain-rate magnitude, $S_{ij}S_{ij}$, are evaluated at several filter widths, and the individual transport terms are compared between the swirling and non-swirling cases.

Adding swirl promotes the breakdown of vortex rings and advances the transition to turbulence, while having little effect on the downstream velocity decay and jet spreading. In contrast, scale decomposition reveals a clear scale dependence of the swirl effect. At small scales, no pronounced difference is observed between the two cases, consistent with local isotropy. At large scales, however, the influence of swirl becomes evident. In particular, the production and advection terms in both the enstrophy and $S_{ij}S_{ij}$ budgets tend to increase near the jet centerline in the swirling case.

Keywords

turbulent jet; direct numerical simulation; enstrophy; strain rate; scale decomposition

[P-13]

Topology Optimization and Numerical Evaluation of an Overhead Crane Girder

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Abstract

Overhead crane girders are critical structural components in industrial material handling systems, where structural efficiency and weight reduction play a significant role in operational performance and cost. This study presents a topology optimization-based structural redesign of an overhead crane girder, integrating density-based optimization with finite element analysis to improve mechanical performance while reducing material usage. The optimization problem was formulated to minimize structural compliance under mass constraints, leading to an efficient material distribution that removes low-stress regions. The optimized geometry was further refined to ensure manufacturability and evaluated under realistic service conditions, including hoist movement and combined vertical and lateral loading scenarios. Structural performance was assessed through static stress analysis, deflection evaluation, fatigue life prediction, and global buckling analysis. The results demonstrate that the optimized design achieves a 15.3% reduction in structural mass while simultaneously reducing peak stress by 9.3% and increasing minimum fatigue life by 42.5%, without exceeding allowable deflection limits or compromising buckling resistance. These improvements highlight the effectiveness of topology-driven design in enhancing structural efficiency. The study establishes a systematic and transferable workflow for the development of lightweight and structurally reliable crane girders, combining optimization techniques with engineering design constraints. The proposed approach offers valuable insights for advancing modern manufacturing and structural design practices in heavy-duty mechanical systems.

Keywords

Finite element analysis, Fatigue, buckling, Structural performance, Numerical integration.

[P-14]

Structures in MHD Turbulence and Effects of the Lorentz Force

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Abstract

In magnetohydrodynamic (MHD) turbulence, the magnetic field is amplified by the velocity field, while the amplified magnetic field acts back on the velocity through the Lorentz force. The kinetic dynamo, in which the magnetic field is sufficiently weak that influence of the Lorentz force on the velocity field can be neglected, has been studied as a fundamental problem for understanding magnetic field amplification [1]. On the other hand, once the magnetic field has been sufficiently amplified, the Lorentz force feeds back on the velocity field, leading to changes in the statistical properties and small-scale structures of both the velocity and magnetic fields. In particular, MHD turbulence is known to exhibit local anisotropy even at small scales [2]. It is therefore important to clarify how the Lorentz force affects such small-scale structures and their anisotropy.

In this study, we conduct numerical simulations of MHD turbulence with mean velocity field and analyze the results. We investigated the effects of the Lorentz force and the anisotropy induced by the mean flow, as well as the similarities and differences in the statistical properties and small-scale structures.

Visualizations of the magnetic energy show that, when the Lorentz force is included, tube-like structures are formed and their major axes are preferentially aligned with the extensional direction of the mean strain. When the Lorentz force is neglected, tube-like and sheet-like structures coexist, and no clear preferential alignment is observed. This suggests that the feedback from the magnetic field to the velocity field through the Lorentz force plays an important role in maintaining and enhancing the anisotropy and preferential alignment of the magnetic field.

Keywords

magnetohydrodynamic turbulence; structure; Lorentz force; numerical simulation

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[P-15]

Fundamental Study on Steel Joints Using Highly-Expansive Material

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Abstract

Numerous joints must be assembled on-site during the construction of steel structures. High-strength bolt friction joints and complete joint penetration weld joints are frequently employed because of their satisfactory structural performance. However, high-strength bolt connections pose challenges related to limited installation clearance, whereas on-site welding involves a substantial workload before, during, and after construction and is highly dependent on the welder's skill.

In response to these challenges, the authors investigated a joining method that utilizes a highly expansive material (HEM) for anchoring continuous fiber tendons in civil engineering structures [1]. The HEM anchoring method secures components by restraining the relative displacement between the steel tube and steel bar through the friction force generated by the hardening expansion of the HEM filled between them [2]. The proposed joint in this study, referred to as the "HEM joint," integrates multiple HEM anchorages. This design necessitates only the filling of the HEM and the on-site positioning of the members, which is expected to substantially decrease the workload relative to traditional joining methods.

To examine the elastoplastic behavior of HEM joints, tensile tests were performed on individual HEM anchorage units, and shear-bending experiments were conducted on HEM joints. The results of the tensile tests verified that the HEM anchorage possesses adequate tensile performance. Furthermore, the shear-bending experiments indicated that the HEM joint is capable of transferring shear forces and exhibits sufficient bending resistance. From these experimental findings, we developed a method for calculating the yield bending strength of HEM joints and verified that the calculated values generally corresponded with the experimental data.

Consequently, this study demonstrated the feasibility of implementing HEM joint design in steel structures.

Keywords

Steel Joints; On-Site Joining Method; Highly-Expansive Material; Loading Experiment; Combined Stress; Yield Bending Strength

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Intermittency-Resilient Green Hydrogen Production via Coupled Energy Conversion and Storage Using Tri-Functional NiFe₂O₄ Nanostructures

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Abstract

The potential applications for integrated self-powered systems combining both electrochemical energy conversion and storage devices are gaining attraction due to their novel design in the energy system. To develop a self-powered system for uninterrupted hydrogen (H₂) production, we examined the trifunctional electrochemical properties (energy storage, hydrogen evolution reaction (HER), and oxygen evolution reaction (OER) of nickel ferrite nanoparticles (NFO NPs) prepared by solid-state synthesis method. At first, the energy storage properties of the NFO are examined as positrode and then the ASC device is fabricated with an operating voltage of 1.45 V with high device capacitance, energy/power density and excellent cycle life. Further, we explored the electrocatalytic characteristics of NFO NPs revealing that they have had low overpotential compared to the state of art of electrocatalytic HER and OER. Physicochemical, theoretical and electrochemical characterizations including XRD, Raman, XPS, EPR, Insitu-Raman, SECM and KPFM analysis confirm the structural integrity, favorable surface properties, and catalytic activity of the NFO nanostructures. Finally, a proof-of-concept for the self-powered system is developed to address the power fluctuation problems for efficient H₂ production. Notably, the system maintained high hydrogen output under overcast conditions, compared to that of system directly connected to renewable source. These findings highlight the potential of nickel ferrite as a multifunctional material for scalable, self-powered and uninterrupted sustainable green H₂ production.

Keywords

Nickel Ferrite nanoparticles; Energy Storage; Energy Harvesting; Power fluctuation; Density functional theory; Intermittent Self-powered hydrogen production.

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[P-17]

Effects of Nd-Al Grain Boundary Diffusion on the Magnetic Properties of Isotropic Nd-Fe-B Film Magnets Fabricated by Pulsed Laser Deposition

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Abstract

Nd-Fe-B magnets are widely used in various applications; however, their relatively low Curie temperature limits their performance at elevated temperatures. Heavy-rare-earth (HRE) elements such as Tb and Dy are commonly added to enhance coercivity, but their high cost and unstable supply have increased the demand for HRE-free Nd-Fe-B magnets. Grain boundary diffusion (GBD) has been reported as an effective method for enhancing coercivity without HRE elements in sintered magnets [1,2]. We have previously fabricated isotropic Nd-Fe-B film magnets by pulsed laser deposition (PLD) and applied them to small motors [3]. However, further improvement in coercivity remains a challenge.

In this study, a heavy-rare-earth-free grain boundary diffusion process (GBDP) using an Nd-Al diffusion layer was applied to isotropic Nd-Fe-B film magnets fabricated by PLD. The Nd-Fe-B film and Nd-Al diffusion layer were sequentially deposited by PLD, followed by short-time pulse annealing. SEM-EDX revealed changes in the surface composition after heat treatment, consistent with redistribution of the Nd-Al layer; however, diffusion into the film interior and along grain boundaries was not directly confirmed. The coercivity strongly depended on the thickness ratio of the Nd-Al diffusion layer to the Nd-Fe-B film and exceeded 1500 kA/m when the ratio was greater than approximately 0.15. The maximum coercivity reached 1690 kA/m, approximately three times that of the reference film without the Nd-Al layer. The coercivity enhancement is attributed to grain-boundary modification associated with the Nd-Al diffusion process. These results demonstrate the potential of combining PLD-fabricated Nd-Fe-B films, Nd-Al diffusion layers, and short-time pulse annealing for HRE-free coercivity enhancement of micrometer-thick isotropic Nd-Fe-B film magnets.

Keywords

PLD method, Nd-Fe-B, Nd-Al, Grain boundary diffusion, Pulse annealing, Coercivity

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[P-18]

Effects of Bath Additives on the Properties of Soft Magnetic Ni Films Prepared by Gel Plating

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Abstract

Our previous studies demonstrated that soft magnetic Ni films can be fabricated by a gel-plating process using a glycine-containing electrolyte [1]. Although the glycine bath provides relatively high current efficiency, the resulting films tend to exhibit network-like microcracks. In this study, citric acid and ammonium chloride were introduced as alternative bath additives, and their effects on the plating characteristics and film properties were investigated. The fabricated Ni films were evaluated in terms of current efficiency, surface morphology, and saturation magnetization.

The surface morphology was strongly affected by the bath composition [2]. Compared with the glycine bath, both the citric acid and ammonium chloride baths reduced the formation of pronounced microcracks. However, the citric acid bath showed relatively low current efficiency and yielded films with lower saturation magnetization, suggesting that side reactions during plating influenced the film quality. In contrast, the ammonium chloride bath provided relatively high current efficiency together with smooth film surfaces, while the saturation magnetization remained comparable to that obtained using the glycine bath.

These results demonstrate that bath composition is an important factor in gel plating of magnetic Ni films and that ammonium chloride is an effective additive for improving film morphology without significantly sacrificing plating efficiency or saturation magnetization. The present results provide a useful basis for controlling the fabrication conditions of magnetic films by the gel-plating process.

Keywords

Electroplating; Gel-plating; Bath additives; Current efficiency; Surface morphology

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[P-19]

Beyond Energy Generation: Aluminium-Driven Electrochemical Energy Systems for Coupled Power Production and Nitrate Valorization

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Abstract

Conventional electrochemical energy systems primarily generate electricity, while the chemical transformations occurring during discharge remain largely underutilized. Here, an aluminium-based electrochemical energy system (Al-EES) is presented as a multifunctional platform in which spontaneous aluminium oxidation simultaneously generates electrical power and drives reduction reactions at the cathode without an external power supply. The cathodic reaction can therefore be redirected toward processes including hydrogen evolution, nitrate reduction, and urea electrosynthesis for value-added chemical synthesis. As a proof of concept, nitrate was introduced as the cathodic reactant at concentrations of 0.1-0.4 M KNO₃. The resulting Al-EES delivered an open-circuit voltage of ~1.2-1.3 V and a maximum power density of ~38 mW cm⁻², while demonstrating intermittent operation for 30 h. Post-discharge analysis revealed the characteristic 660 nm indophenol absorption, confirming the formation of ammonia through nitrate reduction during power generation. The concept was further extended toward C-N coupling using CuWO₄-coated carbon cloth in a CO₂-saturated nitrate electrolyte. Electrochemical measurements revealed distinct reduction behaviour under CO₂ compared with N₂, demonstrating the potential to redirect aluminium-derived energy toward coupled CO₂ and nitrate conversion and ultimately urea electrosynthesis. This work establishes Al-EES as a versatile self-powered electrochemical platform in which the thermodynamic energy of aluminium oxidation can be simultaneously harvested as electricity and utilized to drive environmentally and chemically valuable reduction reactions.

Keywords

Aluminium-based electrochemical energy system, CuWO₄, nitrate reduction, urea electrosynthesis,

Reference

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Development of Platinum-Based Micromagnets via Laser-Induced Forward Transfer Technique

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Abstract

Our laboratory has focused on the superior corrosion resistance and biocompatibility of Fe-Pt-based magnetic materials, leading to the development of Fe-Pt magnetic foils on Si substrates via Pulsed Laser Deposition (PLD). These foils, which spontaneously peel off the substrate, have been explored for medical device applications by bonding them to flexible PDMS substrates. Recently, we demonstrated that the Laser-Induced Forward Transfer (LIFT) technique can directly form rare-earth Nd-Fe-B micromagnets on PDMS substrates without requiring a post-annealing process, while preserving a high magnetocrystalline anisotropy. This finding underscores the potential of LIFT for fabricating magnetic structures on heat-sensitive and flexible materials, which are prevalent in biomedical and wearable devices. Building on these results, the current study employs the LIFT method on Fe-Pt magnetic films prepared using the PLD method. Fe-Pt micromagnets were fabricated using the PLD-grown films as donor materials, and their magnetic properties and crystal structures were systematically analyzed. Consequently, Fe-Pt micromagnets with a coercivity of approximately 140 kA/m were successfully fabricated without any post-annealing process, demonstrating the viability of a low-temperature fabrication route for biocompatible Fe-Pt micromagnetic devices.

Keywords

PLD method; LIFT technique; Fe-Pt magnetic ; Coercivity

[P-21]

Development of Fe-Pt Bulk Magnets using PLD Method

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Abstract

This study reports the preparation of Fe-Pt/Pr-Fe-B double-layered thin-sheet magnets to explore advanced magnetic materials. Thin-sheet magnets were prepared by utilizing the exfoliation phenomenon of a pulsed laser deposition (PLD)-made Fe-Pt film from a Si substrate. Double-layered thin sheets were obtained by varying the thickness ratio of the Fe-Pt magnet as the first layer and the Pr-Fe-B magnet as the second layer while suppressing the mechanical destruction. We also confirmed that the coercivity values varied from approximately 200–800 kA/m.

Keywords

Fe-Pt bulk magnets, PLD method, exfoliation behavior, Si substrates, mechanical characteristic

Upcycled Ru-Doped Co₃O₄ from Spent LiCoO₂ Batteries as a Cost-Effective, Industrially Viable Oxygen Evolution Electrocatalyst

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Abstract

The use of lithium-ion batteries (LIBs) has increased exponentially in recent years due to the rapid expansion of electric vehicles and portable electronic devices. Consequently, the accumulation of spent LIBs, particularly those containing mixed cathode chemistries, has become a critical environmental and technological challenge. Simultaneously, the development of cost-effective and efficient electrocatalysts is essential for advancing clean energy technologies such as water electrolysis and metal–air batteries. Here, we report the direct upcycling of spent LiCoO₂ into a Ru-doped Co₃O₄ (Ru–Co₃O₄) electrocatalyst for the oxygen evolution reaction (OER), converting battery waste into a high-performance, non-precious-metal-dominant anode material. Ru–Co₃O₄ delivers OER overpotentials of 270, 319, and 350 mV at 10, 50, and 100 mA cm^{−2}, respectively, outperforming both pristine Co₃O₄ and commercial RuO₂ at every current density tested. A Tafel slope of 58 mV dec^{−1} — roughly half that of Co₃O₄ (118 mV dec^{−1}) and RuO₂ (109 mV dec^{−1}), together with a markedly reduced charge-transfer resistance from electrochemical impedance spectroscopy, indicates faster interfacial reaction kinetics upon Ru incorporation. X-ray photoelectron spectroscopy reveals an increased Co³⁺/Co²⁺ ratio and greater lattice-oxygen character at the catalyst surface, while a threefold increase in double-layer capacitance points to substantially enlarged electrochemically active surface area relative to the undoped material. Long-term chronopotentiometry and pre/post-stability LSV overlay confirm this activity is retained without measurable degradation. Critically, to demonstrate industrial relevance beyond three-electrode testing, the recycled Ru–Co₃O₄ was evaluated as the anode in a full electrolyzer configuration, achieving 500 mA cm^{−2} at a cell voltage of only 2.1 V and sustaining stable operation for over 200 h at 250 mA cm^{−2}. These results demonstrate that spent battery cathodes can be transformed into durable, scalable OER electrocatalysts, offering a dual pathway toward battery waste valorization and low-cost green hydrogen production.

Keywords

Spent lithium-ion batteries; Recycling; Ru-doped Co₃O₄; Green hydrogen.

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Increase in Coercivity of LIFT-Fabricated Nd-Fe-B Micromagnets by Controlling Laser Irradiation Conditions

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Abstract

We have previously worked on the fabrication of rare-earth thin-film magnets using the pulsed laser deposition (PLD) method [1]. However, achieving hard magnetic properties required high-temperature heat treatment (above 500°C), which limited their integration into micro-electromechanical systems (MEMS) due to compatibility issues with other devices and low-melting-point materials. To overcome this constraint, we fabricated Nd-Fe-B micromagnets at low temperatures without the need for heat treatment by employing the laser-induced forward transfer (LIFT) method [2]. In this process, material is transferred onto a receiving substrate by irradiating a donor film—deposited on a laser-transparent glass substrate—with a laser. For instance, we utilized as a donor a high-coercivity Nd-Fe-B thin-film magnet that had been fabricated on a glass substrate via PLD and subsequently heat-treated [3].

In this study, we present fundamental experimental results regarding micromagnet development using LIFT under high-vacuum conditions and demonstrate that coercivity can be enhanced to approximately 500 kA/m by controlling laser irradiation conditions. Furthermore, we report that comparable coercivity can be achieved even when performing LIFT in an ambient atmosphere (at room temperature and atmospheric pressure).

Keywords

PLD method; LIFT technique; Nd-Fe-B magnet; low temperature process; coercivity; Microstructure

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[P-24]

Room-Temperature Transfer Deposition Technology for Nd-Fe-B Micromagnets

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Abstract

Micro-magnets are crucial components of micro-electromechanical systems (MEMS). Our laboratory has previously fabricated Nd-Fe-B micromagnets with thicknesses exceeding 10 μm using pulsed laser deposition (PLD) [1]. However, conventional fabrication processes require high-temperature heat treatment, often exceeding 500°C, to achieve hard magnetic properties, posing compatibility issues with other MEMS components and low-melting-point materials. Consequently, there is a strong demand for fabrication processes that can be performed at lower temperatures. To address this challenge, we focused on the laser-induced forward transfer (LIFT) method [2], which enables the fabrication of micromagnets without heat treatment. In this technique, a donor magnet, initially fabricated on a transparent glass substrate using PLD, is transferred to a receiver substrate by irradiating it with a laser from the substrate's side. Previous studies have shown that micro-magnets fabricated using LIFT exhibit a coercivity of approximately 500 kA/m, corresponding to about 60% of the donor magnet's coercivity. In this study, we employed a Ga-doped Nd-Fe-B alloy as the donor material to enhance the magnetic properties of the donor film and improve the performance of the micromagnets fabricated via LIFT. We successfully increased the coercivity of the donor magnet from the conventional average of 700–800 kA/m to approximately 1200 kA/m.

Keywords

Pulsed Laser Deposition (PLD); Laser-Induced Forward Transfer (LIFT); Ga Addition; High Coercivity

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Interfacial Reconstruction of Recycled Graphite through Artificial SEI Engineering for Fast-Charging Anodes

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Abstract

The demand for lithium-ion batteries has increased exponentially in recent years due to rapid advancements in electronic devices that are essential in modern society. Consequently, the recycling of spent lithium-ion batteries, which are discarded in large quantities, has become critically important. In this study, graphite anodes were recovered using a sustainable, circular economy-based green approach employing a deep eutectic solvent-assisted recovery process. Physicochemical characterization confirms the effective purification and restoration of the structural integrity of the recovered graphite. To further enhance its electrochemical performance and fast-charging capability, the regenerated graphite was modified with a Li conductive and LiF-rich artificial interphase (LiTF@Gr). This interfacial modification facilitates rapid Li⁺ transport, regulates electrolyte decomposition, and promotes the formation of a uniform and stable inorganic-rich solid electrolyte interphase (SEI). Consequently, LiTF@Gr exhibits significantly improved interfacial kinetics and rate capability, delivering a high reversible capacity of 335 mAh g⁻¹ at 3 C, demonstrating its promising fast-charging characteristics. The engineered interface further enables stable cycling by suppressing continuous electrolyte decomposition and maintaining efficient Li⁺ transport during repeated lithiation/delithiation. Post-cycling interfacial analysis confirms the formation of LiF-rich inorganic species, supporting the role of LiTF modification in stabilizing the electrode/electrolyte interface. Overall, this work integrates deep eutectic solvent-assisted graphite recovery with LiF-rich interfacial engineering, providing a sustainable pathway for converting spent graphite into high-performance anode materials for fast-charging lithium-ion batteries.

Keywords

Spent graphite, Deep eutectic solvent, Energy Storage, Artificial Solid Electrolyte Interphase.

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[P-26]

Simultaneous Plating of Different Metal Films Using Gel Electrolytes

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Abstract

Electroplating is a method widely used for fabricating magnetic films. Conventional electroplating processes consume relatively large amounts of water and generate chemical waste. To address these issues, we have developed a gel electroplating method that uses only a small amount of electrolyte [1]. The use of gel electrolytes enables film deposition techniques that are difficult to achieve with liquid electroplating baths, such as simultaneous plating using two or more gels with different compositions on a single substrate. Previous studies have successfully demonstrated gel/liquid hybrid electroplating [2]. However, it has been suggested that the difference in bath resistance between the two phases (gel and liquid) in the hybrid plating bath affects the maximum magnetic moment, $M_{\max}$, and the estimated film weight.

In this study, we investigated the effects of the electrolyte phase and the difference in bath resistance on film deposition behavior.

Hybrid plating was performed using Co-gel/Ni-liquid and Co-gel/Ni-gel configurations. In the Co-gel/Ni-liquid hybrid bath, the Co concentration in the gel phase was fixed at 100 g/kg, while the Ni concentration in the liquid phase was varied over the range of 20–100 g/kg. For the deposited films in each region, the $M_{\max}$ and the apparent film weight estimated from $M_{\max}$ were evaluated. As the Ni concentration decreased, the difference in estimated film weight between the Co-gel region and the Ni-liquid region decreased.

Furthermore, to reduce the difference in electrolyte resistance between the two regions, Co-gel/Ni-gel hybrid plating was investigated. The apparent film weights obtained were approximately 0.75–0.9 mg, and the difference between these two regions was smaller than that obtained when using a gel/liquid hybrid bath. These results indicate that the electrolyte phase in hybrid plating has a significant effect on the film weight, resulting in a difference in $M_{\max}$ between the two regions.

Keywords

Electroplating; Gel-plating; Ni film; Co film; maximum magnetic moment

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Possible Induction of Magnetic Anisotropy in Electroplated Fe–Pt Films by Two-Step Annealing

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Abstract

We have previously reported Fe–Pt film magnets fabricated by an electroplating method [1–2]. As-plated Fe–Pt films typically exhibit an fcc crystalline structure, and high-temperature annealing ($>700^{\circ}\text{C}$) is required to transform them into the fct phase. In our previous study, we found that the magnetic properties of electroplated Fe–Pt films were affected by a two-step annealing process consisting of low-temperature annealing (LT-A) followed by high-temperature annealing (HT-A) [3]. These results suggested that changes occurring in the Cu substrate during LT-A may influence the magnetic behavior of the Fe–Pt films.

In addition, studies on electrodeposited Co–Pt alloys have reported anisotropic magnetic properties without high-temperature annealing, which have been attributed to microstructural factors such as strain and defects [4].

In this study, we investigated the possibility that the two-step annealing process affects the directional magnetic properties of electroplated Fe–Pt films through changes in the strain state of the Cu substrate. The magnetic properties were evaluated at different measurement angles, and changes in the strain of the Cu substrate were also examined.

The results showed that the magnetic properties exhibited an angular dependence after the two-step annealing process. In addition, changes in the strain state of the Cu substrate were observed. These results suggest that the two-step annealing process may induce changes in the magnetic anisotropy of the Fe–Pt films, possibly through changes in the strain state of the Cu substrate.

Keywords

Electroplating, Fe-Pt alloys, annealing, hard magnetic materials, magnetic properties

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CoFe-PBA Nanocages for Hybrid Seawater Electrolysis: Coupling Value-Added Iodate Formation with Energy-Efficient Hydrogen Production

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Abstract

The development of energy-efficient, chlorine-free hydrogen production technologies is essential for a sustainable hydrogen economy. Herein, we report bifunctional cage-like cobalt-iron Prussian blue analogue (CoFe-PBA) nanocages as highly efficient electrocatalysts for hybrid seawater electrolysis by coupling the hydrogen evolution reaction (HER) with the iodide oxidation reaction (IOR). The CoFe-PBA nanocages, synthesized via a hydrothermal aging-assisted coordination strategy, possess a crystalline face-centered cubic framework with hierarchical porosity and abundant accessible active sites. Driven by synergistic electronic interactions between Co and Fe centers through the π -conjugated $-C\equiv N-$ network, the catalyst exhibits low overpotentials, fast kinetics, and excellent durability in alkaline and real seawater conditions. The two-electron IOR pathway significantly lowers anodic potential and suppresses competing chlorine evolution. Consequently, a CoFe-PBA || CoFe-PBA electrolyzer delivers a reduced cell voltage of 1.481 V at 10 mA cm⁻². A zero-gap anion exchange membrane device achieves low cell voltage of 1.91 V at 1 A cm⁻² current density. Mechanistic studies such as operando-relevant KPFM, SECM and DFT reveal that work function modulation governs activity, with Fe as active sites and Co tuning adsorption energetics. This work establishes hybrid anodic chemistry as a scalable route for energy-efficient and sustainable seawater electrolysis.

Keywords

CoFe-PBA, Hybrid Seawater Electrolyzers, Iodide Oxidation Reaction, Low-Voltage Water Splitting, Zero-Gap AEM Electrolysis, Energy-Efficient H₂ Production.

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[P-29]

Comparison of Ni Gel-Plating Characteristics Using Chloride- and Sulfate-Based Electrolytes

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Abstract

Electroplating is widely used for the fabrication of soft magnetic films, and reducing the environmental impact of the plating process remains an important issue [1]. We have recently developed a gel-plating process in which the plating electrolyte is immobilized using a gelling agent [2]. Since the gel electrolyte can be confined to the region between the electrodes, this process is expected to reduce the amount of electrolyte required for film fabrication. In our previous experiments, the use of a chloride-based electrolyte resulted in higher current efficiency than a sulfate-based electrolyte. However, the differences in plating characteristics between these two gel electrolytes have not yet been fully clarified.

In this study, Ni gel plating was carried out using chloride- and sulfate-based electrolytes, and their plating characteristics were systematically compared. The effects of Ni salt concentration and plating time on the cell voltage and current efficiency were investigated. In addition, the magnetic properties and surface morphology of the plated Ni films were evaluated. The chloride-based electrolyte exhibited a lower and more stable cell voltage than the sulfate-based electrolyte and generally showed higher current efficiency, particularly at lower Ni salt concentrations and during prolonged plating. Measurements of the Ni anode mass also indicated that anode dissolution was strongly suppressed in the sulfate-based electrolyte, whereas more balanced anode dissolution and cathodic plating were obtained in the chloride-based electrolyte. In contrast, the saturation magnetization and overall surface morphology of the Ni films were comparable between the two electrolytes under the present conditions.

These results indicate that the electrolyte composition strongly affects the electrochemical behavior of Ni gel plating, while having a relatively small influence on the magnetic and morphological characteristics of the resulting Ni films.

Keywords

gel plating; Ni film; chloride salt; current efficiency; anode dissolution; potential distribution

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[P-30]

Fabrication of Fe-Pt Micromagnets by Laser-Induced Forward Transfer Using Donor Films with Different Thicknesses

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Abstract

Fe-Pt magnetic materials are promising candidates for biomedical devices because of their corrosion resistance and biocompatibility. To integrate these materials onto substrates with low heat resistance, a fabrication process that avoids post-transfer annealing is required. This study investigates the fabrication of Fe-Pt micromagnets by laser-induced forward transfer (LIFT), focusing on the donor film thickness and laser power. Fe-Pt films of different thicknesses were deposited on glass substrates by pulsed laser deposition (PLD) and subsequently annealed using a pulse. Films that remained attached to the glass substrates were used directly as donors, without a sacrificial layer. LIFT was performed at laser powers of 0.3–0.7 W and a fixed defocus rate. The donor films exhibited coercivities of approximately 300–520 kA/m. Fe-Pt micromagnets were obtained without post-transfer annealing, with a maximum coercivity of approximately 93 kA/m. The coercivity retention ratio, defined as the coercivity of the transferred material divided by that of the donor film, was approximately 30%. Higher retention ratios were observed for thicker donor films, although further measurements are required to establish the thickness dependence. These results demonstrate the feasibility of LIFT using Fe-Pt donor films directly attached to glass and suggest that the donor film thickness and laser irradiation conditions are important factors in retaining coercivity during transfer.

Keywords

Pulsed Laser Deposition (PLD); Laser-Induced Forward Transfer (LIFT); Fe-Pt micromagnets

MXene-Anchored Pd-Ru Bimetallene Composite as a Chloride-Tolerant Bifunctional Electrocatalyst for Efficient Seawater Electrolysis

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Abstract

Direct seawater electrolysis offers a scalable route to green hydrogen, but chloride corrosion, the competing chlorine evolution reaction, and rapid active-site deactivation make it difficult to design catalysts that are both active and durable. Precious-metal catalysts such as Pt, Ir, and Ru remain the activity benchmark for HER/OER, but their high cost, low atom-utilization, and limited chloride tolerance restrict scalable deployment. To address this, we anchor ultralow-loading Pd-Ru bimetallic nanoclusters onto two-dimensional Ti₃C₂T_x MXene via an in-situ HF-assisted synthesis method. The terminal surface functional groups (T_x = F, OH, O) of MXene strengthen metal-substrate interaction, optimize *OH/*OOH intermediate adsorption at the Pd-Ru sites, and electrostatically repel chloride ions from the active surface, suppressing competing chlorine evolution and corrosion while maximizing precious-metal utilization efficiency. In natural seawater, the MXene-Pd-Ru composite achieves ultralow overpotentials of 30 mV (HER) and 310 mV (OER) at 25 mA cm⁻², closely rivaling precious-metal benchmarks while using only 30 wt% precious-metal loading. An assembled seawater electrolyzer built from this catalyst delivers 1.4 A cm⁻² at 2.2 V and sustains stable operation for 750 h at an industrially relevant 500 mA cm⁻², demonstrating that MXene-anchored Pd-Ru nanoclusters are an effective strategy for durable, high-utilization, scalable green hydrogen production from seawater.

Keywords

MXene, Pd-Ru Bimetallene, Chloride-Tolerant Electrocatalyst, Seawater Electrolysis, Bifunctional Catalyst

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Proposed Single-Stage Bridgeless PFC Converter Integrating Phase-Shift Full-Bridge Operation

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Abstract

This paper addresses two key limitations of conventional PFC-based AC-DC converters with a 400 V intermediate bus: the increased transformer turns ratio, which raises winding loss and common-mode noise, and the large electrolytic capacitance required to buffer twice-line-frequency ripple. A single-stage converter integrating a bridgeless PFC and a phase-shift full-bridge (PSFB) is proposed to reduce the intermediate bus voltage to around 200 V while maintaining isolated 48 V output conversion. This lower bus voltage halves the transformer turns ratio and reduces the required PFC output capacitance to about 1/100 of the conventional value, enabling ceramic-capacitor implementation. PSIM simulations with 100 V AC input and 48 V DC output confirm sinusoidal input current and reduced transformer primary voltage. A light-load mode that disables PFC switching below the IEC 61000-3-2 applicable power range improves power factor and efficiency by about 10% compared with a conventional PFC + LLC circuit. Prototype experiments verify stable light-load operation, while feedback-controlled heavy-load validation remains future work.

Keywords

Power Electronics, AC-DC Converters; Power Factor Collection

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Estimation of the Distribution of Subcutaneous Hemorrhage Using a Radio-Wave System

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Abstract

In recent years, the increasing number of deaths and shortage of forensic physicians have heightened the need to improve the autopsy-centered cause-of-death investigation system. Therefore, in modern forensic medicine, there is a growing demand for non-invasive methods to evaluate injuries in human remains. This study investigates an antenna system for detecting subcutaneous hemorrhage in human remains. The authors have previously investigated a method for detecting subcutaneous hemorrhage by scanning the body surface over a blood layer using a printed monopole antenna (PMA). In a previous study [1], simulation analysis suggested that a hemorrhagic layer with a diameter of 40 mm located at a depth of 10 mm from the fat surface could be detected using the distribution of received electric field intensity. In this paper, experimental validation of the method investigated in [1] is conducted using a human-body model in which chicken liver and a fat phantom are used as models for the blood layer and subcutaneous fat, respectively. A Vivaldi antenna with broadband characteristics suitable for radar applications is used instead of the PMA. As a result, a blood layer approximately 3 mm thick located at a depth of approximately 10 mm from the fat surface was successfully detected.

Keywords

Forensic examination, Non-invasive inspection, Subcutaneous hemorrhage, Vivaldi antenna

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[P-34]

Ionic Polymer-PDMS Based Triboelectric Sensors for Real-Time Sign Language Interpretation and Translation

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Abstract

Recent developments in self-powered technologies have significantly advanced energy-harvesting systems for a wide range of applications. Triboelectric nanogenerators (TENGs) have gained considerable attention owing to their simple fabrication, cost-effectiveness, and broad applicability.

Herein, we synthesized a chlorine-functionalized polyhedral oligomeric silsesquioxanes (Cl-POSS)-based ionic polymer and investigated its physicochemical characteristics. The synthesized ionic polymer was incorporated into a polydimethylsiloxane (PDMS) matrix at different weight percentages (wt.%) to fabricate composite films. TENG devices with varying Cl-POSS concentrations were subsequently fabricated, and their electrical output and nanogenerator performance were systematically evaluated.

Furthermore, a smart glove for sign language recognition was developed by integrating the TENG-based sensors with a machine-learning algorithm and a microcontroller. The glove enables the detection of finger-bending movements and wrist rotations, achieving a sign language recognition accuracy of 96.9%. Finally, an interactive interface was developed to recognize the detected sign language and display the English term with its corresponding Korean translation. These results demonstrate the potential of triboelectric nanogenerator devices for self-powered sensing and intelligent human-machine interaction applications.

Keywords

Ionic polymers, TENG, Sign language translation, Machine learning

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A Study on Spatial Harmonic Filtering Capability of a Wave-Winding Rotor in a 6-Slot 4-Pole Concentrated-Winding Induction Motor

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Abstract

Electric motors consume a large amount of electricity worldwide. Therefore, improving motor efficiency is important for reducing energy consumption. Among various types of electric motors, induction motors are widely used in industrial applications because they are robust and can start directly from a commercial power supply. In particular, inverterless drive systems are still used in many applications because of their low cost and low risk of system failure. In recent years, stricter regulations based on IEC efficiency classes have increased the need for more efficient induction motors.

One possible approach is to use concentrated windings. Concentrated windings can reduce copper loss and motor size because they have shorter coil ends and a high slot fill factor. However, they generate large spatial harmonics in the stator rotating magnetic field. These harmonics increase losses and make it difficult to obtain sufficient starting torque.

This study aims to reduce the effect of these spatial harmonics by using a wave-winding rotor in a 6-slot, 4-pole concentrated-winding induction motor. The wave-winding rotor is designed to filter specific spatial harmonics in the stator rotating magnetic field. Finite element analysis is used to compare the harmonic filtering effect and torque characteristics of the wave-winding rotor with those of a conventional squirrel-cage rotor. The results show that the wave-winding rotor can effectively reduce the main harmonic components in the rotor current and provide sufficient starting torque. These results show that the wave-winding rotor can improve the performance of concentrated-winding induction motors.

Keywords

Concentrated winding, Induction motor, Spatial harmonic filtering, Wave-winding rotor

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An Experimental Study on Wave-Winding Rotors with Bar and Wound Conductors for a 12-Slot 10-Pole Concentrated-Winding Induction Motor

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Abstract

Electric motors account for approximately 40% of global electricity consumption, with induction motors representing the majority of this consumption. Therefore, improving the efficiency of induction motors has the potential to achieve substantial energy savings. One approach is to replace conventional distributed stator windings with concentrated windings. However, concentrated windings are not well suited to conventional squirrel-cage rotors, making motor starting difficult. The rotating magnetic field contains several dominant spatial harmonic components that interact with the squirrel-cage rotors and generate torques that adversely affect motor operation. To address this issue, a wave-winding rotor capable of selectively filtering undesired spatial harmonics has been proposed. Furthermore, unlike conventional squirrel-cage rotors, which use bar conductors, wave-winding rotors can be implemented using either wound conductors or bar conductors. This study experimentally compares these two wave-winding rotor structures in a 12-slot 10-pole concentrated-winding induction motor under line-start operation. Experimental results confirm that both rotors can be successfully operated. The torque–speed characteristics show that the rotor with bar conductors produces higher torque than that with wound conductors within the operating speed range due to its lower rotor winding resistance and the resulting shift of the torque–speed curve toward higher speeds. The efficiency–speed characteristics show similar efficiencies for both rotors, while the rotor with bar conductors exhibits higher maximum efficiency. These results demonstrate that bar conductors provide advantages in torque and maximum efficiency, while both bar conductors and wound conductors can be successfully applied to the wave-winding rotor.

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Solketal Oxidation Reaction Mediated Selective Electrosynthesis of Glyceric Acid in Alkaline Seawater System

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Abstract

Alkaline seawater electrolysis requires anodic electrocatalysts that combine rapid electron-transfer kinetics, effective suppression of chloride evolution, and long-term operational stability. Here, spinel NiCr_2O_4 is developed as a bifunctional anodic catalyst for the oxygen evolution reaction (OER) and solketal oxidation reaction (SOR) in alkaline seawater. The catalyst requires overpotentials of 270 mV for the OER and 1.37 V vs RHE for the SOR at 25 mA cm^{-2} , respectively, demonstrating favorable oxidation kinetics. In situ Raman spectroscopy reveals the dynamic formation of catalytically active NiOOH/Cr-OH species and confirms preservation of the solketal ring during oxidation. Scanning electrochemical microscopy further visualizes the preferential occurrence of the SOR over the OER through spatially resolved tip and substrate current maps acquired at different applied potentials. A zero-gap seawater electrolyzer incorporating NiCr_2O_4 delivers a cell voltage of 1.64 V at 250 mA cm^{-2} and operates continuously for 200 h, with a low degradation rate of $24.5 \mu\text{V h}^{-1}$, demonstrating strong resistance to chloride-induced corrosion. Moreover, ^{13}C NMR spectroscopy and *in-situ* FTIR analyses confirms the selective production of glyceric acid as a value-added SOR product. An xGBoost-based time-series forecasting model accurately predicts long-term electrolyzer performance, highlighting the potential integration of machine learning into industrial-scale hybrid seawater electrolysis systems for predictive maintenance. These findings establish NiCr_2O_4 as a durable bifunctional catalyst and demonstrate a combined electrochemical and data-driven strategy for efficient, stable, and value-generating seawater electrolysis.

Keywords

NiCr_2O_4 , Solketal oxidation reaction, glyceric acid, Zero gap electrolyzer, xGBoost ML model

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Ultra-High Tensile Strength of Nanocrystalline Fe-Ni Alloy Films Electrodeposited from Acidic Aqueous Solution Containing Sodium Saccharin

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Abstract

We investigated the effects of saccharin addition on microstructure and mechanical properties (particularly tensile properties) of Fe-Ni alloy films that were fabricated using an electroforming and exfoliation method with a chloride-sulfuric acid mixed bath. Saccharin's addition strongly inhibited the reduction reaction at the cathode surface (increasing overpotential) [1]. At low concentrations (1.0 g/L), anomalous codeposition behavior was temporarily relieved, leading to preferential deposition of Ni [2-4]. However, at sufficient concentrations (2.0 g/L or higher), the alloy composition converged to the bath composition (Fe:Ni = 1:1), resulting in a defect-free electrodeposited film due to relaxation of internal stress. As the amount of saccharin addition increased, crystal nucleation was promoted, and the microstructure was refined to the nanoscale. At 3.0 g/L, the average crystallite size estimated from the XRD profile reached 5.83 nm. In the relationship between microhardness and crystallite size, significant hardening (maximum 676 HV) following the Hall-Petch rule was observed up to a crystallite size of approximately 8.0 nm [5]. However, in the extremely fine region below this point, an inverse Hall-Petch phenomenon was observed, where hardness decreased. This suggests that the plastic deformation mechanism shifted from dislocation motion to grain boundary sliding. Tensile tests showed that under the condition of adding 3.0 g/L of saccharin, a remarkable maximum tensile strength of 2913 MPa, approximately eight times that of the anode material (SS400), was achieved, along with a good plastic strain of 5.70%. This excellent mechanical property is attributed to the grain boundary sliding and coordinated deformation of clusters, which are observed in nanocrystals. This unique mechanism alleviates the concentration of localized stress and delays brittle fractures.

Keywords

electrodeposition; Fe-Ni alloy; saccharin; tensile strength

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Effects of Microstructure of Porous In_2O_3 Particles on Acetone-Oxidation Activities and Gas-Sensing Properties

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Abstract

Introduction

Gas diffusivity in sensing materials is an important factor in determining the performance of semiconductor gas sensors. Introducing porous structures into metal-oxide particles facilitates gas diffusion throughout the sensing layer and within the particles, thereby improving the sensor response. We previously demonstrated that introducing pores into the particles enhanced the acetone response [1]. In this study, the effect of pore size on the catalytic activity for acetone oxidation and the acetone response was investigated to clarify the relationship between acetone oxidation activity and the sensor response to acetone.

Experimental

Porous In_2O_3 (pr- In_2O_3) powders were synthesized by ultrasonic spray pyrolysis employing PMMA microspheres as pore templates, as reported previously [1]. The powders prepared using the 70 nm PMMA microspheres, a mixture of the 70 and 150 nm PMMA microspheres at a number ratio of 1:1, and the 150 nm PMMA microspheres were denoted as pr- In_2O_3 (s), pr- In_2O_3 (m), and pr- In_2O_3 (l), respectively. The synthesized powders were formed into granules (250–850 μm), and the acetone oxidation activity of the granules was evaluated at 100–500°C. After the powders were screen-printed onto alumina substrates equipped with interdigitated Pt electrodes, followed by heat treatment at 700°C, the acetone-sensing properties of the fabricated sensors were evaluated at 350°C.

Results and discussion

Figure 1 shows the temperature dependence of the CO_2 production ratio over the prepared pr- In_2O_3 powders. The CO_2 production ratio decreased in the order of pr- In_2O_3 (s) > pr- In_2O_3 (m) > pr- In_2O_3 (l). In contrast, the acetone responses of the corresponding sensors to 25–100 ppb acetone at 350°C showed the opposite trend and increased in the order of pr- In_2O_3 (s) < pr- In_2O_3 (m) < pr- In_2O_3 (l). The lower catalytic activity of pr- In_2O_3 (l) was probably due to its larger pores, which allowed acetone to diffuse more easily through the particles with less contact with the oxide surface. The larger pores also facilitated acetone diffusion through the sensing layer, allowing a larger amount of acetone to reach the electrode region at the bottom of the sensing layer without sufficient oxidation. Consequently, the pr- In_2O_3 (l) sensor showed a larger acetone response. In contrast, pr- In_2O_3 (s) with smaller pores showed higher catalytic activity, and a larger amount of acetone was oxidized before reaching the electrode region, resulting in a smaller acetone response. On the other hand, pr- In_2O_3 (m) showed intermediate catalytic activity and acetone response, probably because it contained both small and large pores.

Keywords

Semiconductor gas sensor; Porous In_2O_3 ; Pore size; Acetone

Reference

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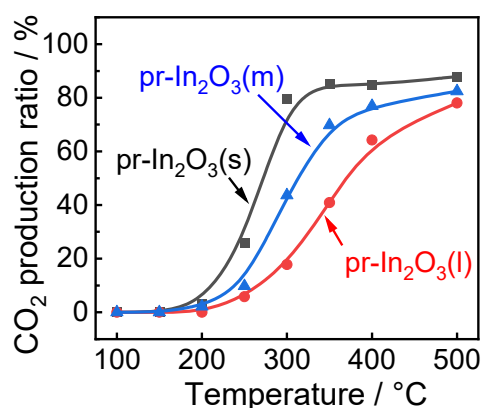


Fig. 1. Temperature dependence of the CO_2 production ratio of 100 ppm acetone over pr- In_2O_3 (s), pr- In_2O_3 (m), and pr- In_2O_3 (l) in air.

[P-40]

Polarization-Driven Optoelectronic Neuromorphic Computing in 0D/2D Heterostructures

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Abstract

In this study, we demonstrate the physical realization of both excitatory and inhibitory synaptic plasticities within a single vertically integrated mixed-dimensional (0D/2D) heterostructure [1]. This is achieved by exploiting anisotropic photon-matter interactions using linearly polarized monochromatic light. The core architecture consists of two distinct sub-elements: a Perovskite quantum dot (QD)/graphene layer and a PbS QD/graphene layer, which act as the active nodes for increasing (excitatory) and decreasing (inhibitory) the photocurrent weights, respectively. The fundamental mechanism of this polarization-dependent synaptic modulation relies on a thin optical polarizer structurally sandwiched between the upper PbS QD/graphene element and the lower Perovskite QD/graphene element. When the incident linearly polarized light is aligned with the transmission axis of the polarizer, photons successfully penetrate the entire heterostructure, simultaneously activating both layers. Under this condition, the dominant photo-response and superior charge injection efficiency of the lower Perovskite layer override the inhibitory effect of the upper PbS layer, resulting in a net enhancement of the channel conductance (potentiation). Conversely, when the incident light is orthogonally polarized, the polarizer effectively blocks optical transmission to the lower layer. Consequently, only the upper PbS QD element is selectively excited, initiating charge carrier trapping dynamics that reduce the net current weight (depression). Furthermore, by applying two orthogonal polarization states sequentially, we successfully emulate the dynamic synaptic processes of potentiation and habituation. Beyond simple binary switching, precisely adjusting the polarization angle of the incident light provides continuous, analog modulation of the optical transmission. This continuous tuning meticulously alters both the polarity (direction) and the magnitude of the synaptic weights, establishing a highly robust platform for advanced multidimensional neuromorphic computing.

Keywords

Synaptic devices; Neuromorphic; Graphene; Quantum dots

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Acetone-Sensing Behavior of SnO₂-Based Semiconductor Gas Sensors under UV Irradiation

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Abstract

A large number of semiconductor gas sensors have been commercialized worldwide, but most of them operate at elevated temperatures, resulting in high power consumption. UV-light irradiation to the semiconductor gas sensors is an attractive approach to solving such problems, because it causes an increase in the conductivity of the semiconductor gas sensors and enables their operation at room temperature. UV-light irradiation can also activate adsorbed oxygen species on the oxide surface and thereby enhance the gas response [1, 2]. The resistance of semiconductor gas sensors generally decreases upon exposure to reducing gases. However, we recently observed that SnO₂-based gas sensors under UV-light irradiation showed an increase in resistance upon exposure to acetone. In this study, the mechanism responsible for this behavior under UV-light irradiation was investigated by gas-sensing measurements and diffuse reflectance infrared Fourier transform spectroscopy (DRIFTS) measurements of surface species adsorbed during acetone exposure.

Porous (pr-)SnO₂ particles were prepared by ultrasonic spray pyrolysis employing a precursor solution containing tin tetrachloride and self-made polymethyl methacrylate (PMMA) microspheres as a mesopore template. Dense (d-)SnO₂ particles were also prepared using a precursor solution without PMMA microspheres. The resulting powders were screen-printed onto alumina substrates with interdigitated Pt electrodes and subsequently sintered (700°C, 2 h) to fabricate the sensor elements. The gas-sensing properties toward 100 ppm acetone were examined at 30°C in dry air under UV-light irradiation (main wavelength: 365 nm, intensity: 0–120 mW cm⁻²). In addition, DRIFTS measurements were performed under UV-light irradiation (10 mW cm⁻²) during exposure to 50 ppm acetone at 30°C in dry air.

The resistance of both d-SnO₂ and pr-SnO₂ sensors temporarily increased and then decreased upon exposure to acetone under UV-light irradiation (Fig. 1). The pr-SnO₂ sensor showed a larger increase in resistance upon exposure to acetone than the d-SnO₂ sensor, with the maximum increase in resistance observed at a UV-light intensity of 10 mW cm⁻². When the gas was switched from acetone to air, the resistance of the pr-SnO₂ sensor decreased below the value before acetone exposure at UV-light intensities of 60 mW cm⁻² or higher. The adsorption behavior of acetone on the SnO₂ surface under these conditions was also examined by DRIFTS. The details will be discussed in the presentation.

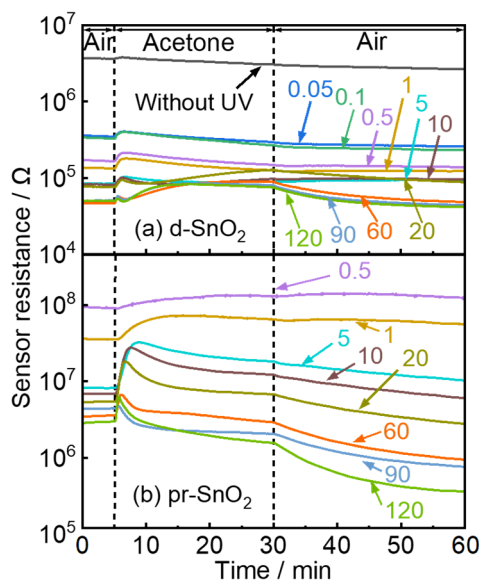


Fig. 1. Response transients of (a) d-SnO₂ and (b) pr-SnO₂ sensors to 100 ppm acetone in dry air at 30°C with and without UV-light irradiation. Numerical values: UV-light intensity (mW cm⁻²).

Keywords

Gas sensor; Acetone; UV-light irradiation; DRIFTS

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Fabrication of Cu₂O Photoelectrodes via Electrodeposition of Cu-Containing Precursor Layers and Their Photoelectrochemical Properties

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Abstract

Photoelectrochemical water splitting has attracted significant attention as a clean and sustainable method for hydrogen production using solar energy. Cuprous oxide (Cu₂O) is a promising photocathode material because of its suitable bandgap and high theoretical photocurrent density. In this study, Cu₂O-based photocathodes were fabricated on fluorine-doped tin oxide (FTO) substrates by first electrodepositing a copper(I) thiocyanate (CuSCN) precursor layer and subsequently electrodepositing Cu₂O, with the aim of improving their photocathodic performance by optimizing the fabrication conditions.

The CuSCN precursor layers were electrodeposited at -0.3 V (vs. Ag/AgCl) for x min in an aqueous solution containing CuSO₄, EDTA, and KSCN. Cu₂O layers were subsequently deposited at a constant current density of -0.1 mA cm⁻² for y min in an alkaline solution containing CuSO₄, DL-lactic acid, and K₂SO₄ at pH 12. The resulting electrodes were denoted as Cu₂O(SCNx) y (x : 2–4 min, y : 15–60 min). Their photoelectrochemical properties were evaluated in 0.1 M Na₂SO₄ aqueous solution (pH 6.7) under chopped Xe-light irradiation.

Figure 1 shows the polarization characteristics of the Cu₂O (SCN4)60 electrode. The cathodic current increased under light irradiation, and its magnitude increased with increasing cathodic polarization. This behavior was attributed to hydrogen evolution by the reduction of water under light irradiation, confirming that the electrodes exhibited good photocathodic activity. The effects of the deposition time of the CuSCN precursor layer (x) and the Cu₂O layer (y) on the photocathodic activity were also evaluated. As x increased, the photocathodic performance improved by increasing y . This was probably because a sufficient CuSCN precursor layer was formed on the FTO surface, and the subsequent deposition of Cu₂O depended on the formation state of the CuSCN precursor layer.

Keywords

Cu₂O; CuSCN; Photocathode; Electrodeposition; Photoelectrochemical water splitting

Reference

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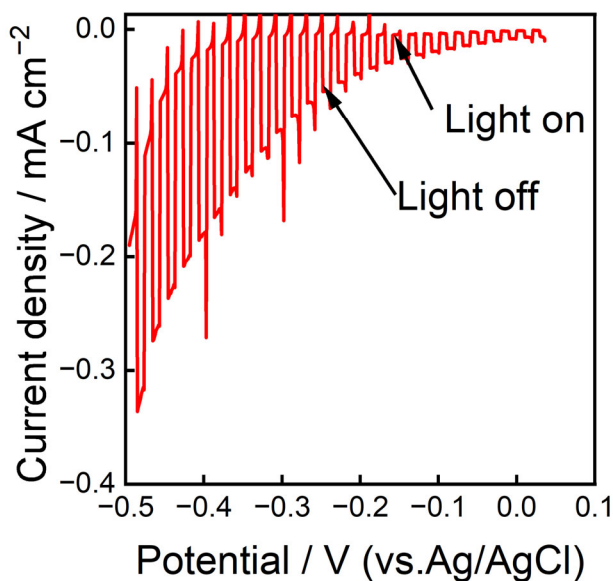


Fig. 1. Current-potential curve of Cu₂O(SCN4)60 electrode with and without xenon-light irradiation.

Transient Lumped Parameter Analysis of Space Nuclear Systems under Radiation-Induced Property Degradation

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Abstract

Space nuclear power systems require careful thermal management to maintain electrical and structural components within safe operating temperature limits. In addition to internal heat generation and solar loading, spacecraft are continuously exposed to ultraviolet radiation and charged particles, which cause cumulative degradation of thermal control materials. Passive thermal control surfaces, widely used in small spacecraft because of their simplicity and low power demand, consequently undergo changes in solar absorptance and infrared emittance. Accounting for these changes is essential for reliable spacecraft thermal design, particularly when thermal margins are limited.

This study quantitatively evaluates the effects of radiation-induced optical property degradation on the thermal safety margins of representative passive thermal control materials. A SATMO-based lumped-parameter orbital thermal analysis was performed to compare Rigid optical solar reflectors (OSRs), Flexible OSRs, and White paint under beginning-of-life (BOL) and end-of-life (EOL) conditions.

The results showed material-dependent thermal responses. Rigid OSRs exhibited negligible temperature changes, whereas Flexible OSRs and White paint produced substantial increases in both maximum and minimum temperatures. White paint showed the greatest degradation, with its hot thermal margin decreasing by 29.83% and its cold thermal margin changing by -64.54%. These results demonstrate that radiation-induced changes in optical properties can substantially reduce thermal safety margins during long-duration missions.

This study highlights the importance of incorporating irradiation-induced EOL material properties into the passive thermal design of future spacecraft, including prospective space nuclear systems. Integrating nuclear-engineering-informed radiation modeling with spacecraft thermal analysis can provide a more realistic and conservative assessment of long-term on-orbit thermal performance.

Keywords

Radiation-induced degradation; SATMO; CubeSat thermal analysis; Low Earth Orbit (LEO)

Reference

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The Effect of pH on Size Control of Silk Protein Nanoparticles Prepared by the Acetone Precipitation Method

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Abstract

Silk protein nanoparticles (SPNPs) are a promising drug delivery system (DDS), and particle size is the critical parameter strongly affecting their colloidal stability and cellular uptake. In this study, the effect of initial silk solution pH on SPNP size was investigated using the acetone precipitation method. The pH of the silk protein solution was adjusted before precipitation, and hydrodynamic size and polydispersity were evaluated by dynamic light scattering (DLS), secondary structure analysis was performed by FT-IR, and their morphology was imaged by SEM. Under acidic conditions, the SPNPs' size increased from approximately 300 nm to 1.2 μ m when the initial pH decreased from 5.0 to 1.0. Under alkaline addition, pH from 7.0 to 12.0, particle formation became increasingly heterogeneous, with larger particles observed from 400 nm to 5 μ m. The smallest particles were obtained from the untreated silk solution at its original pH of 5.3 – 6.0, with an average size of 193.3 nm $\pm$ 30.4 nm. FT-IR analysis showed that β -sheet remained the dominant secondary structure. The recovery yield also changed markedly with the pH, decreasing substantially from acidic to alkaline conditions (from 116.9% to 5.1%) before increasing again at pH 12 (80.8%). Overall, these results indicate that the initial pH is an important parameter for controlling SFNP size, size distribution, and formation behavior. The observed changes may be associated with pH-dependent changes in silk charge state and intermolecular assembly during acetone precipitation, providing insight into the formation and size control of SFNPs for DDS applications.

Keywords

Silk protein, nanoparticles, size control, drug delivery system.

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[P-45]

Fabrication of Camptothecin-Based Nanoparticles Integrated into Silk Protein Films for Local Drug Delivery

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Abstract

Camptothecin derivatives, such as SN-38, exhibit strong anticancer activity but are limited by poor aqueous solubility and high systemic toxicity, which restricts their clinical application. This study aims to develop a silk fibroin-based local drug delivery platform incorporating SN-38 particles for controlled release applications. Silk fibroin films were fabricated through solution casting. SN-38 nanocrystals were prepared using a reprecipitation method. Preliminary results confirmed the successful fabrication of self-standing silk fibroin films and SN-38 nanocrystals, demonstrating the feasibility of this composite system. Integration of SN-38 nanocrystals into silk film was performed to evaluate their potential for localized drug delivery. The resulting films maintained structural integrity under aqueous conditions, indicating that the silk matrix can support particle incorporation and sustainably delivery drugs without rapid dissolution. While further optimization of particle size and distribution are required, these results suggest the potential of this system for localized delivery of poorly soluble anticancer agents.

Physics-Informed Solar Energy Forecasting Under Varying Sky Conditions: Probabilistic Gains Across Neural and Tree-Based Models

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Abstract

Physics-informed machine learning is increasingly used to improve photovoltaic (PV) power forecasting [1], but its benefit is usually reported as a single aggregate number. Much less is known about when physics-derived inputs actually help, i.e., under which sky conditions, and for which classes of model. This study addresses that question for probabilistic PV forecasting. Using 42 inverter-level PV systems across five Australian university campuses (UNISOLAR [2], 15-min resolution), clear-sky irradiance, solar geometry, air mass, clearness index and cell-temperature features were generated with a PVLIB model chain and added to five quantile-forecasting models: two gradient-boosted tree models (LightGBM, XGBoost) and three neural sequence models (LSTM, Transformer, Temporal Fusion Transformer). The neural models additionally received a dedicated recurrent physics encoder and a clear-sky consistency loss. One-hour-ahead forecasts on 119,654 daytime test samples from unseen sites were stratified into four clear-sky irradiance regimes (overcast, partly cloudy, mostly clear, and clear sky) and scored with the Continuous Ranked Probability Score (CRPS), with paired Diebold-Mariano and Wilcoxon signed-rank tests. The physics benefit proved strongly regime- and architecture-dependent. For neural models the CRPS reduction grew monotonically with irradiance, from 16.9% to 26.5% (LSTM), 13.7% to 22.5% (Transformer) and 8.4% to 13.5% (TFT) between overcast and clear-sky conditions, whereas tree-based models gained an almost constant 5-6% in every regime. Interval-violation penalties fell by 26-72% for neural models but rose slightly (5-15%) for trees, whose intervals became sharper yet mildly overconfident at the tails. All improvements were significant ($p < 0.001$) after Bonferroni correction. These results indicate that physics-derived inputs act as an inductive bias whose value scales with how closely generation approaches its physical potential, and that this bias is exploited most by flexible neural sequence models. Physics gains in PV forecasting should therefore be reported conditionally rather than as one summary figure.

Keywords

Physics-informed machine learning; Probabilistic forecasting; Photovoltaic power; Sky-condition stratification; Temporal Fusion Transformer

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Reductive Activation of Selenite on a Dinuclear Ruthenium Complex

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Abstract

Oxyanions such as NO_x^- and SO_x^{2-} are important environmental pollutants that are abundant in both natural and industrial environments. Because these species are relatively stable in the environment, their reduction generally requires a substantial energy input. In nature, however, certain enzymes can catalyze their reduction under mild conditions, such as room temperature and atmospheric pressure. Inspired by these biological systems, synthetic catalysts that mimic the active sites of reductases have been developed to achieve efficient reduction under mild conditions.

Selenium is also an essential trace element involved in various biological processes. In nature, its redox chemistry is mediated by microorganisms. In particular, selenate (SeO_4^{2-}) and selenite (SeO_3^{2-}) are highly soluble in water and can contribute to soil and water contamination.

We have previously demonstrated the reduction of nitric oxide (NO), nitrite (NO_2^-), and sulfite (SO_3^{2-}) using dinuclear ruthenium complexes. Building on these findings, we investigated the reductive activation of selenite (SeO_3^{2-}) using a dinuclear ruthenium complex in this study.

First, we synthesized the selenite-bridged complex **1**. Reduction of complex **1** was carried out using a proton source, HBF_4 , and a reductant, $[\text{FeCp}^*_2]$, to give the diselenide-bridged complex **2**. Next, we examined the extraction of the bridging selenium atoms from complex **2**. Upon reaction with P^nBu_3 , a $\text{Se}=\text{P}(^n\text{Bu})_3$ species was observed by $^{31}\text{P}\{^1\text{H}\}$ NMR spectroscopy, indicating that the extraction proceeded quantitatively. To establish a selenite reduction cycle, we attempted to convert complex **2** back to complex **1** using P^nBu_3 and H_2SeO_3 . Complex **1** was detected as one of the reaction products by FAB-MS, demonstrating that the conversion from **2** to **1** occurred. We achieved the reduction of selenite using the dinuclear ruthenium complex.

Keywords

Selenite; Reduction reactions; Dinuclear complexes; Ruthenium

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[P-48]

Nanofiltration and Anion Exchange Resin for Achieving High Nitrate Ion Removal During Drinking Water Treatment

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Abstract

Anion exchange (AEX) treatment is a separation technology used to remove nitrate (NO_3^-) ions from drinking water sources. However, the presence of sulfate ions (SO_4^{2-}) in water can hinder the efficiency of NO_3^- removal. This study aimed to explore the potential of nanofiltration (NF) as a pre-treatment method to prolong the operational period of AEX by eliminating SO_4^{2-} . Among the five commercial NF membranes assessed in this study, the NF270 membrane was selected due its high SO_4^{2-} rejection (89%), low transmembrane pressure, and manageable fouling when treating lake water. With NF pre-treatment, the breakthrough point of AEX was extended by 33%. Low concentrations of dissolved organic carbon in the lake water showed negligible effects on the NO_3^- adsorption capacity. Among the three commercial AEX resins, the IRA400J resin exhibited the highest adsorption capacity (78 mg- NO_3^- /g-resin), and sufficiently high regeneration efficacy (41 mg- NO_3^- /g-NaCl), and favorable reusability after two cycles. The high performance of the AEX resin can be attributed to its high content of quaternary ammonium functional groups. The adsorption capacity of the IRA400J resin decreased by only 2.4% after four cycles of filtration and regeneration using NaCl solution. These results suggest that the NF-AEX process can be sustainably operated with periodical regeneration steps during drinking water treatment.

Keywords

AEX resins; adsorption; NF membrane; sulfate removal

Influence of the Correlation between Reanalysis Data and Met Mast Measurements on Long-Term Wind Climate Estimation

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Abstract

The influence of the correlation between reanalysis data and met mast measurements on long-term wind climate estimation was investigated using various Measure-Correlate-Predict (MCP) methods. One year of wind data was collected from met masts installed at Gashiri and Sinchang on Jeju Island, South Korea. The two sites represent different terrain conditions with one met mast located inland and the other near the coast. In addition, three types of long-term reanalysis data covering periods of up to 20 years were obtained for each site and used to predict long-term wind climate conditions. The reanalysis datasets exhibited poor, moderate, and good correlations with the met mast measurements. The met mast data were paired with the three reanalysis datasets for MCP analysis. Long-term wind climate predictions for periods of up to 20 years were generated using four MCP methods including two machine learning algorithms and two traditional approaches. Next, predicted data points to the concurrent met mast measurement period were extracted from the complete MCP prediction period and used to calculate annual energy production (AEP). The calculated AEP values were compared with reference AEP values derived from the complete met mast dataset to assess the impact of reanalysis–met mast correlation on long-term wind prediction. The results showed that reanalysis datasets with poor, moderate, and good correlations produced comparable relative AEP errors, suggesting that correlation strength may not be a key factor in long-term wind climate estimation.

Keywords

Met mast, reanalysis data, correlation coefficient, measure-correlate-predict method, long-term wind climate estimation

Highly Porous Polyimide Substrates for the Fabrication of Polyamide Forward-Osmosis Membranes

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Abstract

Forward osmosis (FO) is a membrane-based concentration process driven by osmotic pressure. Water spontaneously diffuses from a dilute feed solution (FS) to a concentrated draw solution (DS) across a semipermeable membrane, while solutes are retained. FO has attracted increasing attention for water treatment applications, including wastewater treatment [1]. Thin-film composite (TFC) FO membranes typically consist of a dense polyamide (PA) selective layer supported by a microporous substrate. The substrate plays an important role in FO performance because its structure influences internal concentration polarization (ICP) [2]. One approach to reducing ICP is the use of macroporous substrates with high porosity and low tortuosity [3]. However, large surface voids may make it difficult to form a uniform and selective PA layer during interfacial polymerization. Therefore, a simple and controllable fabrication method is required for forming selective PA layers on macroporous substrates. This study investigated the fabrication of FO membranes on highly porous polyimide (PI) substrates and examined how substrate void diameter and spin-coating speed affect PA layer formation and membrane performance. Under optimized conditions using 2 wt% m-phenylenediamine and 0.15 wt% trimesoyl chloride, the membrane prepared on the 1000 nm PI substrate achieved the highest water flux of $15.6 \text{ L m}^{-2} \text{ h}^{-1}$ and the lowest specific reverse salt flux of 0.37 g L^{-1} . At a constant substrate thickness, larger void diameters were associated with improved FO performance, whereas reducing substrate thickness further lowered the structural parameter and enhanced water transport despite a smaller void diameter. During a 54 h wastewater filtration test, the optimized membrane showed a 24% flux decline and recovered 94% of its initial flux after alkaline cleaning. This study aimed to provide mechanistic insights into the formation of a PA layer by spin coating on highly porous substrates.

Keywords

TFC membrane; Interfacial polymerization; FO membrane; Wastewater treatment

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Surface-Tuning of Polyamide Nanofiltration Membranes via Controlled Solvent Activation and Graphene Oxide Coating

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Abstract

Nanofiltration (NF) membranes are known for their higher permeance compared to reverse osmosis membranes and their capability to remove most impurities from water. However, they remain susceptible to fouling. This study systematically evaluated a surface coating technique using three commercial graphene oxide (GO) materials to enhance fouling resistance and achieve higher permeance of commercial NF membranes. The method involves ethanol-water-NaOH (EWN) activation, followed by graphene oxide (GO) coating through an amide coupling reaction. The GO coating without EWN activation minimally affected salt separation but slightly reduced water permeance. The membrane coated with GO having the largest lateral size and highest oxidation degree exhibited a 19% lower flux decline during humic acid filtration compared to the pristine membrane. Surface analysis showed that GO deposition increased membrane hydrophilicity, lowering the contact angle from 38° to 16°, and enhanced the negative surface charge from -8 to -32 mV. GO patches remained stable after 6 days of filtration and 24 hours of simulated chemical cleaning. Notably, incorporating EWN activation into the selected GO-coated membrane increased water permeance to 19 L/m²hbar, which is 31 % higher than that of the pristine membrane, while maintaining a Na₂SO₄ rejection rate of over 96 %. Fouling tests conducted at constant transmembrane pressure (TMP) with similar initial permeate flux (40 L/m²h) using real municipal wastewater showed that GO grafting significantly reduced flux decline, while EWN activation primarily enhanced intrinsic permeance and lowered the required operating TMP. Overall, the two-step strategy improved the permeability–fouling balance of commercial NF membranes through an immersion-based process compatible with practical implementation, providing useful insights into the selection of commercially available GO materials for NF membrane surface coatings in wastewater treatment applications.

Keywords

Commercial GO; NF membrane; membrane fouling; wastewater treatment

Comparative Analysis of Wind Characteristics at Offshore and Coastal Sites on Jeju Island, South Korea

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Abstract

To investigate the differences in wind characteristics between offshore and coastal sites, one year of wind measurements was collected from three met masts located on eastern Jeju Island, South Korea. The Woljeong offshore met mast is located 1.3 km off the coast, while the Kimnyeong and Haengwon met masts are located along the coast. The measurements were taken concurrently from December 1, 2018, to November 30, 2019. For the analysis, wind speed at the 80 m height was used for Haengwon, whereas wind speeds at the 80 m height for Woljeong and Kimnyeong were estimated using the Power Law. Wind directions were compared using measurements from heights closest to the 80 m height at the three sites. Comparative analyses of wind speed were conducted for the annual mean wind speed, diurnal, monthly, and seasonal wind speed variations as well as turbulence intensity. As a result, the Woljeong offshore met mast exhibited the highest annual mean wind speed of 7.54 m/s, followed by Haengwon at 7.30 m/s and Kimnyeong at 7.02 m/s. The prevailing wind directions were WNW at the three sites. The Woljeong offshore met mast also exhibited the lowest turbulence intensity, followed by coastal met masts.

Keywords

Wind data; Offshore wind; Onshore wind; Wind characteristics; Wind speed

Assessment of Pilot-Scale Submerged Nanofiltration for Direct River Water Treatment

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Abstract

Submerged nanofiltration (SNF) treatment has the potential to convert contaminated drinking water sources into high-quality drinking water. Nevertheless, fouling during direct treatment without pre-filtration or regular cleaning presents a considerable challenge. This study assessed the feasibility and long-term performance of a pilot-scale SNF system for the direct treatment of river water at a drinking water treatment facility in Vietnam. The system operated continuously for six months at a transmembrane pressure below 100 kPa, without any physical or chemical cleaning. The permeate flux decreased from 4.0 to 2.5 L/m²h, primarily due to fouling and reduced water temperature. The permeate consistently complied with the Vietnamese national technical regulation on domestic water quality and the relevant WHO drinking-water guideline values. The SNF system effectively removed nearly all turbidity and color, significantly reduced organic matter, Fe, and Mn, and demonstrated compound-dependent attenuation of detected pharmaceuticals and personal care products. Conversely, nitrate exhibited limited rejection but remained within the regulatory limit. Membrane characterization revealed spatially uneven organic and inorganic fouling, with greater accumulation of inorganics in the lower section of the module. Overall, direct SNF represents a promising advanced treatment option for producing high-quality drinking water, although full-scale implementation necessitates optimized tank hydraulics and cleaning strategies to manage localized fouling.

Keywords

Drinking water; NF membrane; Advanced water treatment; Membrane fouling; PPCPs

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Ammonia Recovery from Aquaculture Wastewater via Membrane Contactor – A Techno-Feasibility Study

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Abstract

The rapid expansion of aquaculture production necessitates effective measures to minimize the environmental impacts associated with nutrient-rich ammonium wastewater discharge. This study assessed the techno-feasibility of a membrane contactor (MC) process for selective ammonia (NH_3) recovery from low-strength aquaculture wastewater and its conversion into a value-added liquid fertilizer. The effects of feed pH and phosphoric acid concentration were first investigated to optimize ammonia recovery, followed by evaluation of feed temperature and ammonium (NH_4^+) concentration to assess ammonia separation performance under variable aquaculture conditions. Under optimized conditions (feed pH 11), the MC achieved consistently high ammonia recovery (>85%) from prefiltered inland aquaculture wastewater over 120 h of operation. Co-transport of potassium (K^+) with NH_3 into the acid phase enabled recovery of a nutrient-rich liquid NPK fertilizer. Techno-economic analysis demonstrated that membrane-area scaled-up enhanced process feasibility, reducing the specific energy consumption (SEC) from 262–29 to 52–6 kWh/kg NH_4^+ recovered when treating NH_4^+ feed concentrations of 5–50 mg/L. The optimized configuration potentially reduced the break-even NH_4^+ feed concentration from 96 mg/L under the baseline configuration to 18 mg/L, at which the recovery cost was offset by the revenue from the recovered liquid NPK fertilizer. Overall, the ambient-temperature MC process offers a promising approach for ammonia recovery from low-strength aquaculture wastewater, supporting circular aquaculture management and nutrient resource recovery.

Keywords

Ammonia recovery; Wastewater valorization; Techno-economic analysis

Real-Time Chlorine Measurements During Pyrolysis of PVC

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Abstract

The increasing production of plastics and decreasing recycling rates have raised significant environmental concerns, particularly due to the challenges posed by plastic waste management. Among these, polyvinyl chloride (PVC) presents a unique challenge due to the release of harmful chlorine compounds during pyrolysis. A lab-scale pyrolysis system was designed for easy and low-cost application with a real-time chlorine content detector. This system, which is ideal for catalyst development and screening, was used to study chlorine removal from pure PVC with various molecular weights. Thermogravimetric analysis revealed typical thermal decomposition profiles for both low and high molecular weight PVC, with no significant molecular weight-dependent differences in degradation. Pyrolysis-gas chromatography/mass spectrometry (Py-GC/MS) results obtained at 400°C confirmed that hydrogen chloride was the primary volatile product, with higher concentrations observed in low-molecular-weight PVC. The hydrogen chloride concentrations measured in real time during pyrolysis using laboratory-scale equipment were compared with the chlorine content determined by the NaOH absorption method and combustion ion chromatography (IC). The results showed that nearly all of the chlorine in the PVC was detected, and chlorine contents similar to those of pure PVC were confirmed in both combustion IC and IC analyses. Although the hydrogen chloride gas measurement method indicated a higher chlorine content than that of pure PVC, suggesting it could be used as a relative value, its advantage of enabling real-time measurement without pretreatment makes it useful for high-throughput screening.

Keywords

Plastic; PVC; Pyrolysis; Chlorine; Hydrogen chloride