ICAC 2025

8th International Conference on Advanced Capacitors, Taiwan

第八屆國際先進電容器研討會

Nov. 30-Dec. 03, 2025

台灣電化學學會
The ElectroChemical Society of TaiWan

THE COMMITTEE OF CAPACITOR TECHNOLOGY
THE ELECTROCHEMICAL SOCIETY OF JAPAN

明志科技大學
MING CHI UNIVERSITY OF TECHNOLOGY

Content

Welcome to 2025 ICAC

You are cordially invited to participate in the 8th International Conference on Advanced Capacitors (ICAC2025), to be held in Ming Chi University of Technology, New Taipei City, Taiwan from November 30 to December 3, 2025. Following the previous conferences (ICAC2003, ICAC2007, ICAC2010, ICAC2013, ICAC2016, ICAC2019 and ICAC2023) which were held in Japan, we hope that ICAC2025 in Taiwan will serves as a platform to discuss emerging trends and future challenges in advanced capacitors with the international contribution from both academia and industry. The Electrochemical Society of Taiwan, The Committee of Capacitor Technology ECSJ, and Ming Chi University of Technology will co-host this important international event.

Now we are at a global economy rapidly changing. Capacitors including conventional capacitors, EDLCs, electrochemical capacitors, and metal-ion capacitors are highly expected to play concrete roles as highly efficient energy storage devices. ICAC2025 is a truly significant chance for showing the state-of-the-art R&D in this field. We look forward to welcoming you in early winter of 2025, and hope that you will take this opportunity to experience New Taipei City.

Sincerely yours,

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Conference Chair

Prof. Soshi SHIRAISHI

Committee Chair of Capacitor Technology ECSJ / Gunma University, Japan

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Prof. Thu-Hua Liu

President of Ming-Chi University of Technology, Taiwan

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President of Ming-Chi University of Technology, Taiwan

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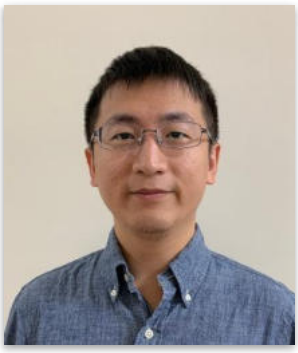

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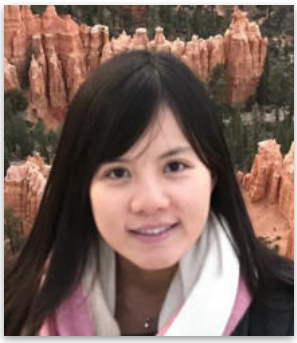

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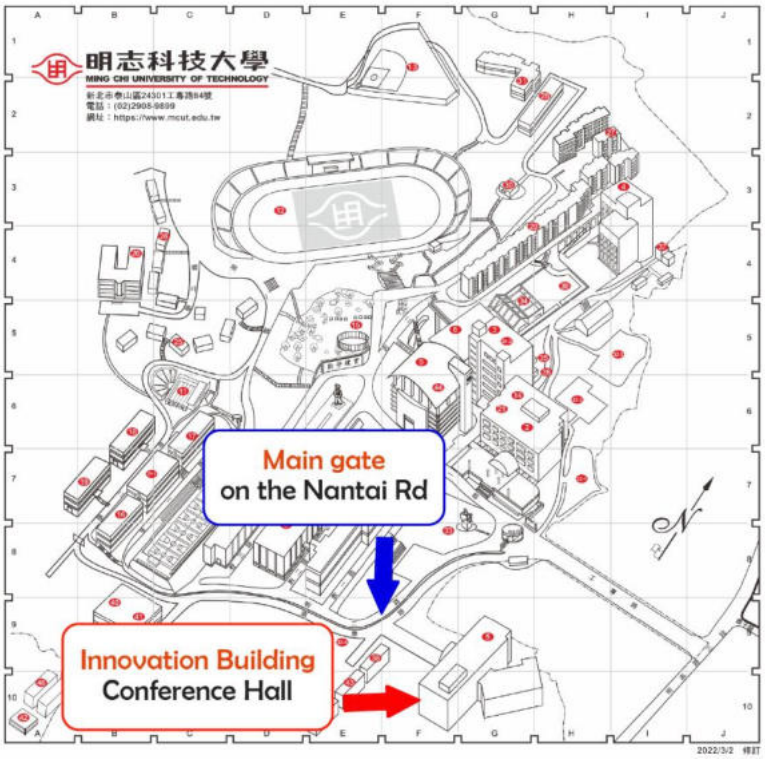
Conference Venue

Entrance of

Innovation Building, MCUT

Main gate on the Nantai Rd



Conference Hall

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Program for 2025 ICAC

Day 1

Time	November 30 (Sunday)
13:00-16:00	**Registration**
16:00-16:20	**Open Remarks**
16:20-17:30	**Session 1: Chair: Prof. Chi-Chang Hu**
16:20-17:00	**Plenary Speaker: Prof. Hirotomo Nishihara** Title: 3D graphene materials for advanced capacitors
17:00-17:30	**Keynote Speaker: Prof. Enn Lust** Title: Development of high power and energy density supercapacitors
17:30-19:30	**Welcome Reception**

Day 2

Time	December 01 (Monday)
08:40-10:10	**Session 2: Chair: Prof. Jeng-Kuei Chang**
08:40-09:20	**Plenary Speaker: Dr. Jon Ajuria** Title: From Interface Design to Prototyping: A Scalable Pre-Lithiation Strategy for Advanced Lithium-Ion Capacitors
09:20-09:50	**Keynote Speaker: Prof. Katsuhiko Naoi** Title: Back to Science, Forward to Innovation - toward Next-Generation Power Architectures
09:50-10:10	**Invited Speaker: Dr. Yu-Liang Chen** Title: High-Performance and High-Voltage Supercapacitors Based on Activated Carbon with Low Functional Group Derived from Mesocarbon Microbeads (MCMB)
10:10-10:30	**Coffee Break**
10:30-12:00	**Session 3: Chair: Prof. Hirotomo Nishihara**
10:30-10:50	**Invited Speaker: Prof. Scott Donne** Title: The Nature of the Electrified Interface
10:50-11:10	**Invited Speaker: Prof. Daisuke Takimoto** Title: High Capacitance and Durability of Molecular Solid Electrodes
11:10-11:30	**Invited Speaker: Prof. Wan-Yu Tsai** Title: Visualization of Ionic Liquid Electric Double Layer Structure by operando AFM
11:30-11:45	**Oral Speaker: Dr. Yoshikiyo Hatakeyama** Title: Operando Time-Resolved SAXS and Electrochemical Dilatometry of Electric Double-Layer Capacitor Electrodes
11:45-12:00	**Oral Speaker: Ms. Yun Ku** Title: Deciphering Self-Discharge Mechanisms in EDLCs: A Molecular-Level Perspective on Carbonate Additive Effects
12:00-14:20	**Lunch**
	Poster*50
14:20-15:50	**Session 4: Chair: Dr. Dr. Jon Ajuria**

14:20-14:40	**Invited Speaker: Prof. Masashi Okubo** Title: Pseudocapacitive MXenes for All-Solid-State Electrochemical Storage Devices
14:40-15:00	**Invited Speaker: Dr. Cristian Jaimes-Paez** Title: Electrochemical Expansion as a Versatile Route for 2D Materials: From Graphene to MXenes for Energy Applications
15:00-15:20	**Invited Speaker: Prof. Masanobu Chiku** Title: Hybrid Capacitor Using a Metal Aluminum Negative Electrode
15:20-15:35	**Oral Speaker: Mr. Rajesh Kumar** Title: Porous W2N Fibrous-Nanograins and TiN Nanopyramids Framework for High Energy Density Flexible Asymmetric Supercapacitors
15:35-15:50	**Oral Speaker: Dr. Narayanamoorthi Eswaran** Title: Bimetallic Ni-Cu/NiO-Cu_2O Heterostructures on N-Doped Porous Carbon as Advanced Electrodes for Non-Aqueous Li/Na-Ion Capacitors
15:50-16:10	**Coffee Break**
16:10-18:00	**Session 5: Chair: Prof. Andrea Balducci**
16:10-16:30	**Invited Speaker: Prof. Masayuki Morita** Title: Research and Development of Zinc-based Hybrid Capacitors
16:30-16:50	**Invited Speaker: Prof. Soorathep Kheawhom** Title: Co-Designing Heterointerfaces and Electrolytes for Asymmetric Supercapacitors
16:50-17:10	**Invited Speaker: Dr. Adam Slesinski** Title: Aqueous iodide/iodine-based electrochemical capacitor of high energy and increased cycle life
17:10-17:30	**Invited Speaker: Prof. Frederic Favier** Title: Composite electrode materials from metal hyperaccumulating plants
17:30-17:45	**Oral Speaker: Ms. Rene Mary Amirtha Suthie Jeyakumar** Interface Engineering of Cu Current Collector with Mixed Electronic–Ionic Conductivity for Next-Generation Aqueous Zn-Ion Hybrid Supercapacitors
17:45-18:00	**Oral Speaker: Mr. Zher Yu Yu** Title: Systematic designs of single metal compounds synthesized using ammonia fluoride-based complex as structure directing agents for energy storage
18:30-21:30	**IAB Meeting & Dinner**

Day 3

Time	December 02 (Tuesday)
08:40-10:10	**Session 6: Chair: Prof. Soshi Shiraishi**
08:40-09:20	**Plenary Speaker: Prof. Jeng-Kuei Chang** Title: Electrolyte Formulations and Prelithiated Electrode Design for High-Performance Activated-Carbon Supercapacitors
09:20-09:50	**Keynote Speaker: Prof. Pooi See Lee** Title: Rapid ions transfer driven electrochemical energy storage systems
09:50-10:10	**Invited Speaker: Prof. Shinichi Komaba** Title: Exploring Highly Concentrated Electrolytes for K-Ion Batteries and Capacitors
10:10-10:30	**Coffee Break**
10:30-12:00	**Session 7: Chair: Prof. Thierry Brousse**
10:30-10:50	**Invited Speaker: Prof. Bruce Dunn** Title: New Directions for Niobate Electrochemical Materials
10:50-11:10	**Invited Speaker: Prof. Daniel Chua** Title: Supercapacitors based on Carbon and Carbide based Nanomaterials
11:10-11:30	**Invited Speaker: Prof. Masashi Ishikawa** Title: High Capacitance Arising from Specific Anion Storage at Poorly Graphitized Carbon Cathodes
11:30-11:45	**Oral Speaker: Mr. Chuang Kai Jie** Title: Fast Fabrication of High-Performance Supercapacitor Electrodes Based on Two-Dimensional Trimetallic Zinc Manganese Cobalt Layered Double Hydroxide Nanosheets Derived from Metal-Organic Frameworks
11:45-12:00	**Oral Speaker: Mr. Mohammad Saquib** Title: First report of Bridgman-type crystal puller-assisted synthesis of polycrystalline SnTe/MWCNT for dual energy storage and sensing, integration of flexible microsupercapacitors and humidity sensors in one platform
12:00-13:30	**Lunch**
13:30-15:30	**Session 8: Chair: Prof. Bruce Dunn**
13:30-13:50	**Young Scholar Speaker: Prof. Han-Yi Chen** Title: Toward Durable and Multifunctional Zinc-Based Capacitors for Next-Generation Energy Storage Applications
13:50-14:10	**Young Scholar Speaker: Prof. Yasuyuki Kondo** Title: Electrochemical Properties of High-Voltage Aqueous Hybrid Capacitors
14:10-14:30	**Young Scholar Speaker: Prof. Che-Ning Yeh** Title: Facile Synthesis of MOF-derived NiMn Oxides/rGO Hybrid Architectures for Supercapacitor Electrodes
14:30-14:50	**Young Scholar Speaker: Prof. Keisuke Muramatsu** Title: Charge Storage Capability of Layered Ruthenates with Different Interlayer Hydration States
14:50-15:10	**Young Scholar Speaker: Prof. Prasit Pattananuwat** Title: Engineering Bismuth-Based Materials for Photo-Assisted Charge Storage in Supercapacitors
15:10-15:30	**Young Scholar Speaker: Dr. Andrés Parejo-Tovar** Title: Tracking of ion population changes in the electrical double-layer electrode of a lithium-ion capacitor while extending the polarization beyond its cathodic stability potential
15:30-15:50	**Coffee Break**
15:50-17:50	**Session 9: Chair: Prof. Hiroki Habazaki**

15:50-16:10	**Young Scholar Speaker: Dr. Omar Gómez Rojas** Title: Electrolyte-Driven Solid-Electrolyte Interphase (SEI) Evolution on Graphite Anodes Under Rapid Cycling
16:10-16:25	**Oral Speaker: Dr. Cheng Jie Chng** Title: Impact of electrochemical preconditioning of highly porous activated carbon cathode on Si-based Li-ion capacitors
16:25-16:40	**Oral Speaker: Mr. Ching-Yu Hu** Title: Electrolyte Engineering to Regulate Li^+ Solvation and Strengthen Interphases in Wide-Temperature Lithium-Ion Capacitors
16:40-17:10	**Keynote Speaker: Prof. Lu-Yin Lin** Title: Engineering Nanostructured Derivatives from Zeolitic Frameworks Using Novel Chemical Modulators for Electrochemical Energy Storage
17:10-17:50	**Plenary Speaker: Prof. Andrea Balducci** Title: Development of new methodologies to elucidate the influence of electrolyte in degradation processes occurring in electrochemical capacitors
18:30-21:30	**Banquet (Lotus Room 3F, Fullon Hotel MRT A8)**

Day 4

Time	December 03 (Wednesday)
08:40-10:10	**Session 10: Chair: Prof. Chi-Hsien Huang**
08:40-09:20	**Plenary Speaker: Prof. Yoong Ahm Kim** Title: Engineering Edge Structures in Porous Carbon: A Versatile Strategy for Optimizing Energy Storage Devices
09:20-09:50	**Keynote Speaker: Prof. Krzysztof Fic** Title: Intriguing Role of Electrolyte in Hybrid Capacitors
09:50-10:10	**Invited Speaker: Prof. Hiroki Habazaki** Title: Defect and Interface Engineering in Enhancing the Breakdown Voltage of PEDOT:PSS Solid Al Capacitors
10:10-10:30	**Coffee Break**
10:30-12:00	**Session 11: Chair: Prof. Jarrn-Horng Lin**
10:30-10:50	**Invited Speaker: Prof. Thierry Brousse** Title: How to optimized the electrochemical properties of vanadium nitride thin films for micro-supercapacitors?
10:50-11:10	**Invited Speaker: Prof. Jeng-Yu Lin** Title: Solvent-Free Synthesis of Zeolitic Imidazolate Framework-derived Carbon Composites for Micro-supercapacitors
11:10-11:30	**Invited Speaker: Prof. Soshi Shiraishi** Title: Seamless Activated Carbon Electrode ~Toward Further Enhancing Durability~
11:30-11:45	**Oral Speaker: Prof. Jarrn-Horng Lin** Title: Potential Route for CCU to Green Nanocarbons and Porous Carbons Used in Supercapacitors
11:45-12:00	**Oral Speaker: Dr. Selvakumar Muthu** Title: Screen-Printed rGO–CNF Nanocomposite Inks Enabling Flexible Strain Sensors, Sensitive Paracetamol Detection, and High-Performance Microsupercapacitors
12:00-13:30	**Lunch**
13:30-15:00	**Session 12: Chair: Prof. Jeng-Yu Lin**
13:30-13:50	**Invited Speaker: Prof. Olivier Crosnier** Title: Tuning perovskite materials for high power energy storage
13:50-14:10	**Invited Speaker: Olivier Fontaine** Title: Distortion-Aware Electrochemical Computing and Spatially Resolved Marcus Theory in Nanoporous Electrodes
14:10-14:25	**Oral Speaker: Mr. Shun-Feng Kuan** Title: Cobalt–Manganese Glycerate Derived Sulfides for Efficient Energy Storage in Supercapacitors
14:25-14:40	**Oral Speaker: Dr. Gurumurthy Sangam** Title: One-Dimensional Nickel Cobalt Bimetallic Oxide Nanostructures for High-Stability Supercapacitor Electrodes
14:40-15:00	**Invited Speaker: Prof. Wataru Sugimoto** Title: Strategic modification to increase the pseudocapacitance
15:00-15:30	**Awards / Close Remarks (Prof. Wataru Sugimoto)**

Plenary Speaker **08:40-09:20 Dec. 01**

Jon Ajuria

Research Line Manager (Dr.)

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Dr. Jon Ajuria obtained his bachelor's degree in chemistry from the University of the Basque Country in 2003, where he completed his thesis at the University of Bergen, Norway. Following his graduation, he joined the Energy Department at CIDETEC, dedicating three years to pioneering research on hydrogen fuel cells. In 2007, Dr. Ajuria moved to IKERLAN, where he earned his PhD in 2012 from the University of the Basque Country. His doctoral research focused on the development of hybrid organic-inorganic flexible solar cells with nanostructured electrodes.

As part of his PhD work, he also spent four months in Germany at SIEMENS in Dr. Oliver Hayden's group. Upon completing his PhD, Dr. Ajuria remained at IKERLAN for three years, contributing to several European projects aimed at advancing organic solar cell technology.

In 2015, he joined CIC energiGUNE as a post-doctoral fellow in the newly established Hybrid Supercapacitors Research Line. Since 2018, he has served as an Associate Researcher and Project Leader for multiple industrial and public funded projects at CIC energiGUNE. In 2022, he completed an MBA with a specialization in entrepreneurship. Since 2022, he has been the Research Line Manager for the Metal-ion Capacitors Research Line, where his research focuses on the development of metal-ion capacitors, from materials to devices. In 2024, he was also appointed Research Line Manager for Sodium-ion Batteries..

From Interface Design to Prototyping: A Scalable Pre-Lithiation Strategy for Advanced Lithium-Ion Capacitors

Jon Ajuria
CIC energiGUNE, Basque Research and Technology Alliance (BRTA) Alava Technology Park, Albert Einstein 48, 01510 Vitoria-Gasteiz, Spain
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1. Introduction to Lithium-Ion Capacitors and Pre-Lithiation

LICs combine the high energy density of lithium-ion batteries with the fast charge/discharge capabilities of supercapacitors. They feature high-potential positive electrodes and low-potential negative electrodes, delivering high specific capacity at elevated charge/discharge rates. Despite their promise, LICs face challenges related to energy density, stability, and cyclability, primarily due to the limitations of conventional electrolytes and electrode materials. One critical strategy to enhance LIC performance is pre-lithiation, which addresses the issue of irreversible capacity loss during initial cycling and improves energy efficiency. Pre-lithiation involves the introduction of lithium into the negative electrode material before assembly, thereby stabilizing the SEI. This process can be achieved using different lithium sources, such as lithium salts or lithium-containing compounds. In this talk, we focus on the use of $Li_2C_4O_4$ as a pre-lithiation agent, which offers significant advantages in manufacturing over conventional pre-lithiation methods by enabling roll-to-roll processing of the sacrificial salt together with the activated carbon, enhancing the electrochemical stability and extending the lifespan of LICs.

2. Prototyping and Scalability of $Li_2C_4O_4$ as a Sacrificial Salt

In this section, we present the prototyping and scalability demonstration of LICs using $Li_2C_4O_4$ as a pre-lithiation agent. Beginning with lab-scale 0.5F cells, we demonstrate how the scalability of $Li_2C_4O_4$ extends to larger 8F and 100F prototype cells. These developments highlight the ability to maintain high performance, even as the cell size increases, demonstrating the potential for large-scale manufacturing. $Li_2C_4O_4$ has shown potential in enhancing the charge/discharge performance of LICs, with prototypes exhibiting stable cycling at higher power densities. Through systematic optimization of electrode manufacturing processes, such as slurry preparation and coating techniques, we have successfully scaled up the manufacturing of cells, with a focus on minimizing cell-to-cell variation while maximizing electrode loading and material utilization. The scaling strategy not only shows the potential for cost-effective manufacturing but also contributes to the reduction of environmental impacts, avoiding the use of any critical raw material during fabrication.

3. Impact of $Li_2C_4O_4$ on Interface Formation and SEI Evolution

The final part of the presentation delves into the impact of $Li_2C_4O_4$ on the interface formation within LICs, focusing specially on the SEI. The formation of a stable SEI is crucial for the long-term performance and safety of LICs. $Li_2C_4O_4$ decomposes at suitable potentials during cycling, releasing CO_2 and CO, which play a critical role in forming a robust carbon-rich SEI. The SEI formed in the presence of $Li_2C_4O_4$ is stable and effectively reduces the electrolyte decomposition, thus improving the cycling stability and overall efficiency of the LICs. Furthermore, we explore the versatility of $Li_2C_4O_4$ as a film-forming additive, enabling the use of non-carbonate electrolytes. This approach is particularly advantageous for extending the operational life of LICs under extreme conditions, where conventional electrolytes might fail. By forming a protective SEI even in the absence of carbonate-based solvents, $Li_2C_4O_4$ opens the door to broader applications of LICs, including in non-carbonate-based electrolytes. Finally, the role of fluorine in the positive electrode interface is also discussed, showing how its presence enhances the capacitance and improves the overall electrochemical performance of the system.

References

1) M. Arnaiz et al., Energy Environ Sci. 2020; 13(8), 2441
2) M. Arnaiz et al., J. Phys. Energy, 2024, 6, 015001
3) M Granados-Moreno et al. ACS Applied Materials & Interfaces 2024 16 (45), 61846-61857; M Granados-Moreno et al., Chemical Engineering Journal 2025, 511, 162277

Plenary Speaker 17:10~17:50 Dec. 02

Andrea Balducci

Professor

- Friedrich Schiller University Jena, Germany
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Prof. Dr. Andrea Balducci took his PhD in Materials Science in 2006 at the Paul Sabatier University of Toulouse, France. From 2009 till 2014, he was the scientific leader of the supercapacitors group at MEET Battery Research Center of the University of Münster, Germany. From January 2015 till May 2016 was working as senior scientist at the Helmholtz Institute Ulm (HIU), Germany. Since June 2016 is Professor for "Electrochemistry" at the Institute for Technical Chemistry and Environmental Chemistry and at the Center for Energy and Environmental Chemistry Jena (CEEC Jena) of the Friedrich-Schiller University Jena, Germany.

He is author of more than 220 publications in peer-reviewed scientific journals, which have been cited more than 16500 times (H-index 63). He served as Chair in Division 3 of ISE and he is member of the editorial board of several journals (Energy Storage Materials, Electrochimica Acta, Batteries & Supercaps, ChemSusChem, etc.). Since December 2024 he serves as associated Editor of the Journal of the Electrochemical Society.

He has been working on innovative electrolytes for energy storage devices, with particular focus on high power systems, for several years. His research activities focus particularly on the development of innovative and sustainable electrolytes. Furthermore, he is working on the development of in-situ and in-operando techniques suitable for investigation of the degradation processes taking place in these electrolytes.

Development of new methodologies to elucidate the influence of electrolyte in degradation processes occurring in electrochemical capacitors

Andrea Balducci
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Electric double-layer capacitors (EDLCs) are considered among the most important energy storage devices utilized in our daily lives. They display high specific power, the advantages of fast charge and discharge times, and a long operational lifetime. Due to these properties, they are implemented in many applications, e.g. transportation, grid stability, memory backup, or wind turbines. The storage processes occurring in EDLCs are of physical nature. The formation/depletion of an electric double-layer at the electrode/electrolyte interphase determines the features of these high-power devices and thus affect their aging [1-2].

The aging of EDLCs, which typically leads to loss of capacitance and increases in resistance is a very complex process that involves various failure mechanisms, each playing a crucial role. These mechanisms involve structural and chemical changes, material dissolution, and corrosion of metal current collectors during cell operation. All of them can impact the performance of these devices under varying operating conditions like temperature, humidity, and voltage, with increased temperatures potentially inducing undesired chemical reactions and low temperatures causing electrolyte freezing and mechanical stress [3-4].

In the past, most effort has been directed towards examining and understanding the aging occurring on the electrodes of EDLCs. On the other hand, less attention has been dedicated to the processes occurring on the electrolyte. It has been shown that the degradation of the electrolyte, e.g. during high voltage test, might lead to the generation of gases and side products which, in turn, lead to increased pressure and pore blocking. The formed gases and electrode decomposition products have been investigated, but many aspects related to the electrolyte's aging are still poorly understood. For example, it is not fully clear how the different electrolyte decomposition processes affect the performance of EDLC's [3-4].

In this work we report about some of our latest studies dedicated to the investigation of the degradation processes occurring in the electrolyte of EDLCs.

Gas chromatography-mass spectrometry (GC-MS) is well-suited for examining trace amounts of dissolved analytes in a solvent, making it an ideal technique for investigating formed degradation products within the electrolyte of an electrochemical storage device [4]. Initially, the information about the aging of EDLCs containing 1 M tetraethylammonium tetrafluoroborate (TEABF4) in acetonitrile (ACN) which have been acquired with this technique will be critically discuss and analyzed. Afterward, the use of an electrochemical three-electrode cell for in-operando GC-MS analysis of the liquid electrolyte of electrochemical energy storage devices will be considered. By utilizing this cell, we investigated the behavior of EDLCs containing the conventional electrolyte 1 M TEABF4 in ACN, obtaining a detailed time-resolved insight into the formation and possible causes of degradation products. (Figure 1). Particularly, it has been determined that the formation of acetamide derivates as well as the formation of the triazine derivate occurs at both, the positive and

the negative electrodes. Further, it was possible to identify the potential at which the electrodes begin to age, and to show that the aging of ACN-based EDLCs is mainly driven by the processes occurring at the positive electrode because this latter electrode is the first one that reaches an unstable potential [5].

In the second part, the use of a novel in-operando cell specifically designed cell for post-mortem GC-MS measurements for the investigated the aging of EDLCs will be considered. Post-mortem GC-MS measurements can supply important information, from the qualitative and quantitative point of view, about the degradation processes taking place in EDLCs [6]. We show that in devices containing 1 M TEABF4 in ACN the most relevant peaks were decomposition compounds of diacetamide, N-ethylacetamide and 3-aminocrotononitrile. Further, interestingly, it was possible to show that the addition of 2 wt.% triethylamine accelerate the formation of 3-aminocrotononitrile, leading to the strongest deterioration of the cell. With the aim to correlate the electrolyte degradation with that occurring on the electrodes, the same cells can also be used to gather together electrochemical data and GC-MS analysis and linking it to XPS surface analysis. To investigate this latter approach, we considered the aging of EDLCs containing the salt 1-1-dimethylpyrrolidinium tetrafluoroborate (Pyr11BF4) in different solvents of ACN, ethyl isopropyl sulfone (EiPS) and a 75:25 wt% mixture. We showed that the addition of EiPS as a co-solvent revealed higher thermal stability and that this improvement can be detected from the less irreversible decomposition products observed in GC-MS and XPS. These results are indicating that post-mortem GC-MS measurements can supply important information, from the qualitative point of view, about the degradation processes taking place in EDLC and, also, that linking the degradation processes that occur in different cellular components strengthens the overall understanding of the ageing mechanisms of EDLCs.

Finally, in the last part of the work, we will consider the use of GC-MS for the analysis of the gaseous species formed during the aging processes of commercial EDLCs. With the aim to understand these processes, which are of great industrial relevance, we developed a methodology to extract the gas formed in industrial cell (3400F), and to analyze the evolution over time of the gases formed in the cell.

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Plenary Speaker **08:40-09:20 Dec. 02**

Jeng-Kuei Chang

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Prof. Jeng-Kuei Chang received his Ph.D. from National Cheng Kung University. He is currently a Distinguished Professor at National Yang Ming Chiao Tung University and serves as Technical Director at the Green Energy and Environment Research Laboratories, Industrial Technology Research Institute (ITRI), Taiwan. His research focuses on energy storage systems, supercapacitors, rechargeable batteries, hydrogen technologies, and corrosion prevention. Prof. Jeng-Kuei Chang has held visiting positions as a scientist at Pennsylvania State University and the Massachusetts Institute of Technology in the United States, and as a visiting professor at Kyushu University in Japan and the Helmholtz Institute Ulm in Germany.

He has published 351 SCI-indexed papers and has an h-index of 63. Prof. Chang has received numerous honors, including the Outstanding Young Scientist Award from the National Science and Technology Council (NSTC) in 2017, Outstanding Research Award from the NSTC in 2020, the Y. Z. Hsu Foundation Scientific Paper Award in 2021, the Outstanding Young Alumni Award from National Cheng Kung University in 2021, and the Cross-Generation International Outstanding Young Scholar Award from NSTC in 2021.

Electrolyte Formulations and Prelithiated Electrode Design for High-Performance Activated-Carbon Supercapacitors

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State-of-the-art supercapacitors employing acetonitrile (ACN)-based electrolyte offer excellent high-power capability but are inherently limited by high-voltage stability issues, particularly the corrosion problems of aluminum (Al) current collectors and the narrow electrochemical stability window of the electrolyte.

Such corrosion causes the loss of electrical and mechanical contact between the activated carbon electrode material and the current collector, leading to capacity degradation and power fading. Electrochemical measurements combined with post-mortem analysis are conducted to examine the underlying Al corrosion mechanism. To mitigate the corrosion damage, we develop corrosion inhibitors in spiro-(1,1′)-bipyrrolidinium tetrafluoroborate/ACN electrolyte. An improved cyclability of the supercapacitors has been observed.

To expand the electrochemical stability window of the electrolyte, a ternary solvent system consisting of ACN, adipotrile (ADN), and ethylene carbonate (EC) is developed. The composition of this ternary solvent is systematically optimized to enhance the charge-discharge performance and cycling stability of supercapacitors. Three-electrode measurements are employed to simultaneously monitor the capacitance and resistance variations of both the positive and negative electrodes during cycling. At an operating voltage of 3.5 V, the proposed electrolyte exhibits superior performance and effectively suppresses side reactions compared to the conventional ACN electrolyte.

In a separate study, a lithiated Al foil anode for Li-ion capacitors (LICs) is fabricated via a chemical lithiation method. This facile and cost-effective method enables the preparation of LiAl alloy anodes with readily controllable lithiation extent. The impact of lithiation degree on the cell performance is thoroughly investigated.

Overall, this work provides scalable strategies for improving the energy density, cycling stability, and reliability of carbon-based supercapacitors..

Plenary Speaker 08:40~09:20 Dec. 03

Yoong Ahm Kim

Professor

- School of Polymer Science and Engineering, Chonnam National University, South Korea
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- Distinguished Visiting Professor, Shinshu University, Japan
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Education & Career:

Assistant Professor in Shinshu University (2002.12–2004.02)
Associate Professor in Shinshu University (2004.03–2013.08)
Associate Professor in Chonnam National University (2013.09–2016.02)
Distinguished Visiting Professor in Center for Biomedical Sciences, Shinshu University (2013.11–2018.12)
Director of Innovation Center for Engineering Education, Chonnam National University (2020.08–2022.07)
Vice Dean of Faculty of Engineering, Chonnam National University (2020.08–2022.07)
Director of Alan G. MacDiarmid Energy Research Institute, Chonnam National University (2016.03 –2024.02)
Full Professor in Chonnam National University (2016.03 –the present)

Professional Activities:

1. Associate Editor, CARBON (Elsevier) (2018-the present)
2. Editorial board member, Scientific Reports (Nature Publishing Group) (2017-the present)
3. Associate Editor, Carbon Letters (Springer) (2017-the present)
4. Editorial Board member, Applied Science (MDPI) (2018-the present)

Publications and Citations:

http://scholar.google.co.kr/citations?user=91PIrw0AAAAJ&hl=en
(Publications: 350, Citation: 26,209, h-index: 81, i10-index: 274)
http://orcid.org/0000-0003-4074-7515

Recent Representative Publications:

1. S. Hong, Y. A. Kim, et al., Carbon 167, 881 (2020)
2. G. B. Choi, Y.A. Kim et al., Nano Lett. 20, 5885 (2020)
3. J. W. Wee, Y. A. Kim et al., Carbon 185, 419 (2021)
4. S. Hong, Y. A. Kim et al., Carbon 184, 207 (2021)
5. V. Meunier, Y. A. Kim et al., Carbon 195, 272 (2022)
6. W.Q. Neves, Y. A. Kim et al., Carbon 196, 20 (2022)
7. G. B. Choi, Y. A. Kim et al., Carbon 204, 587 (2023)
8. J. H. Kim, Y. A. Kim et al., Constr. Build. Mater. 392, 131983 (2023)
9. S. B. Seo, Y. A. Kim et al., Carbon 218, 118731 (2024)
10. B. Youn, Y. A. Kim et al., ACS Nano 18, 24532 (2024)

Engineering Edge Structures in Porous Carbon: A Versatile Strategy for Optimizing Energy Storage Devices

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Over the past decade, carbon-based supercapacitors have emerged as promising energy storage systems, particularly for applications demanding high power density and extended cycle life. Among the diverse range of electrode materials, porous carbon has maintained its preeminence due to three key properties: tunable pore structure, high surface area, and exceptional chemical stability. Recent research has systematically demonstrated that surface chemistry and structural defects—particularly edge sites—play a fundamental role in determining the electrochemical performance of carbon materials. Carbon surfaces comprise two structurally distinct regions with contrasting properties: (1) the basal plane, characterized by atomic flatness and electrochemical inertness, and (2) the edge plane, distinguished by abundant defect sites and frequent functionalization with oxygen-containing groups. These regions exhibit substantially different physicochemical properties, which directly influence charge storage mechanisms, including electric double-layer capacitance and pseudocapacitance.

In this talk, I will first outline recent methodological advances in identifying and characterizing edge structures in porous carbon, with emphasis on novel quantitative techniques for measuring edge density and edge-specific surface area. I will then present our experimental findings demonstrating a clear correlation: edge-rich carbons substantially enhance energy density in supercapacitors, while edge-minimized carbons function optimally as coating layers in high-performance lead-carbon (Pb–C) batteries. Based on this evidence, we propose that strategic manipulation of edge density in porous carbons represents a versatile and effective approach for optimizing carbon-based electrodes across multiple energy storage technologies.

Plenary Speaker **16:20~17:20 Nov. 30**

Hirotomo Nishihara

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Hirotomo Nishihara is a full professor at Tohoku University, Japan. Having obtained his academic degrees from Kyoto University (Japan), he spent most of his career working for Tohoku University up to date. He has received numerous scientific awards, including the prestigious Gottfried Wargener Prize in 2019 and the JSPS Prize in 2020.

In 2022, he took his innovations into the business sphere by establishing a startup company, 3DC. As the Chief Science Officer, he is dedicated to the industrialization of a novel porous carbon material, graphene mesosponge, which he developed. His research interests include nanoporous materials and carbon-based materials.

3D graphene materials for advanced capacitors

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1. Graphene materials

Graphene possesses excellent electrical conductivity and corrosion resistance, and its theoretical geometrical specific surface area reaches 2627 m2 g–1, making it a highly promising candidate for electrodes in supercapacitors. In recent years, graphene-related startups have been established worldwide, and graphene powders have become commercially available. However, many of the so-called "graphene" products on the market differ from the original definition, because it is inherently difficult to mass-produce two-dimensional sheet-like graphene in the form of powders. In contrast, the mesoporous material composed of curved graphene, known as Graphene MesoSponge® (GMS) [1], combines high surface area and excellent oxidation resistance while forming a three-dimensional framework. This makes it the first 3D graphene material that can be mass-produced as powders, offering wide-ranging potential applications including adsorption, separation, catalysis, energy storage, and other energy-related devices. In this lecture, I will introduce the synthesis, properties, and applications of GMS.

2. Structural parameters of graphene-based materials

Graphene is a single sheet of a hexagonal sp2 carbon lattice (Fig. 1a). Two layers are referred to as bi-layer graphene (Fig. 1b), while multiple layers are called multi-layer graphene (Fig. 1c). In practice, however, even multi-layer structures are often simply termed "graphene," which causes confusion. Most commercial products are actually thin-layer graphite consisting of several to several tens of stacked layers. Here, we refer to these as "commercial graphene" to distinguish them from true graphene.

The average number of stacked layers (nstack) can be estimated from the specific surface area (Fig. 1d). Materials with 1–2 layers behave graphene-like, 2–10 layers intermediate, and above 10 layers graphite-like. Thus, nstack is a useful indicator of how closely a material resembles true graphene, and it can be applied broadly to other carbon materials such as carbon fibers and carbon black. However, in activated carbons with highly fragmented domains (<10 nm), the contribution of edge surface area (Sedge) leads to underestimation of nstack, and the intrinsic graphene properties are also diminished. Therefore, in addition to nstack, the basal plane size (Lbasal), calculated from the number of edges (Fig. 1e) [2], is also important to evaluate "graphene-like" nature.

3. Three-dimensional (3D) graphene material, Graphene MesoSponge®

GMS was developed as a powder-form carbon material that retains the key features of graphene, uniquely fulfilling the conditions of nstack = 1–2 and Lbasal 100 nm. Its synthesis (Fig. 2) involves deposition of a single graphene layer on oxide templates such as Al2O3 or MgO via chemical vapor deposition (CVD) (Fig.

2a,b). After template removal, a mesoporous material called carbon mesosponge (CMS) is obtained (Fig. 2c). Then, CMS is annealed at 1800 °C for a zipping reaction [3] to enlarge Lbasal beyond 100 nm, yielding GMS (Fig. 2d). Unlike conventional porous carbons that shrink at high temperature, GMS maintains high

porosity (~2000 m2 g –1, ~4 cm3 g –1) due to its curved 3D framework, while numerous pentagon and heptagon defects are incorporated during growth [4].

4. Three-dimensional (3D) graphene material, Graphene MesoSponge®

Fig. 3a shows the average stacking number (nstack) and basal plane size (Lbasal) of various carbon materials, including graphite, carbon black (CB), activated carbon (AC), multi-walled carbon nanotubes (MWCNTs), and single-walled carbon nanotubes (SWCNTs). Smaller nstack gives higher surface area, while larger Lbasal improves conductivity and corrosion resistance. Thus, materials with small nstack and large Lbasal are ideal for applications such as supercapacitors. Only GMS meets this condition (nstack ≈ 1, Lbasal > 100 nm), close to the theoretical monolayer graphene region. SWCNTs, due to bundling and inaccessible internal space, show lower surface areas (~1000–1300 m2 g –1) and nstack ≥ 2. Fig. 3b plots specific surface area, which is directly linked to capacitance and guest loading, versus Lbasal. Materials in the upper-right region offer the best performance, where CMS and GMS uniquely extend beyond conventional carbons, with further expansion possible by tuning templates and synthesis conditions. While graphene and CNTs are flexible under bending yet rigid under compression, GMS, with its monolayer framework, exhibits remarkable flexibility under mechanical compression. Fig. 3c illustrates the distinctly low bulk modulus of CMS and GMS compared with conventional carbons, underscoring their exceptionally soft nature

5. Applications of GMS

As an electrode material for supercapacitors, GMS offers not only a high double-layer capacitance (C) due to its large surface area but also superior voltage stability because of its nearly edge-free structure, which enables a higher single-cell operating voltage (Vsingle-cell). In commercial supercapacitors, the typical configuration consists of activated carbon electrodes immersed in organic electrolytes using propylene carbonate or acetonitrile as a solvent. However, the edges of activated carbon catalyze electrolyte decomposition [5], limiting Vsingle-cell to below 2.8 V. SWCNTs, which have fewer edges, can extend Vsingle-cell up to 4.0 V, while self-standing GMS membranes can achieve as high as 4.4 V [6]. Among carbon materials with a specific surface area exceeding 1200 m2 g–1, GMS thus allows the highest Vsingle-cell. Since the energy density (E) of an electric double-layer capacitor (EDLC) single cell is defined as E = (1/2) CVsingle-cell2, GMS enables high energy density by combining both large C and large Vsingle-cell (Fig. 4). For applications such as automotive systems requiring outputs of 200–400 V, EDLC modules must be assembled by stacking tens of single cells in series. The module voltage (Vmodule) is given by Vsingle-cell × Ncell. Therefore, with GMS, which permits larger Vsingle-cell, fewer cells are required, allowing more compact module design (Fig. 4).

Beyond EDLCs, GMS also shows promise in various applications, including as a highly durable Pt support for PEFCs [7], a sulfur host for Li/S batteries with high capacity and durability [8], and a cathode material for Li–air batteries that combines high capacity with long cycle life [10]. Thus, GMS bridges the gap between the ideal properties of graphene and the demands of scalable applications. GMS provides a versatile platform for next-generation energy storage and conversion technologies.

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Keynote Speaker **09:20~09:50 Dec. 03**

Krzysztof Fic

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Krzysztof Fic graduated in Chemical Process Engineering at the Faculty of Chemical Technology, Poznan University of Technology, in June 2008; at the same time, he was accepted for the research assistant position in the Department of Applied Electrochemistry and he works there until now. In 2012 he defended his PhD thesis (supervisor: prof. Elzbieta Frackowiak) and in 2020 he was awarded with habilitation degree – both in chemical sciences discipline. In July 2025, he was appointed as full professor.

Since 2019 he has a status of visting researcher at Kansai University in Japan, where he collaborates with Prof. Masashi Ishikawa research team.

His research activities focus mainly on the electrochemical systems for the energy conversion and storage; in particular, he is interested in phenomena occurring at the porous electrode/electrolyte interface in so-called operando approach. Besides, he investigates the electrochemical activity of selected redox couples and their application as a novel source of pseudocapacitance of carbon-based electrochemical capacitors.

He served as principal investigator in the Starting Grant (GA 759603, 2017-2023) funded by European Research Council, followed by Proof of Concept project (GA 101138710, 2024-2025). Together with other Colleagues, he is also one of supervisors in Marie Skłodowska Curie Actions ENERCAP project (HORIZON-MSCA-2022-Doctoral Networks).

In 2009-2025, he presented nearly 80 oral communications and 20 posters during national and international conferences, in Europe, U.S., Mexico, Brazil, Japan, South Korea, Hong Kong, Taiwan and Australia. A number of oral communications and posters he has co-authored is even greater.

He is co-author of more than 80 peer-reviewed papers, cited more than 4 000 times. He co-invented more than 30 patents already granted and 20 patent applications pending.

Intriguing Role of Electrolyte in Hybrid Capacitors

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1. Introduction

Hybrid capacitors have been proposed to diminish the major drawback of electrochemical capacitors, i.e., moderate specific energy. Although these devices are not designed for delivering high-energy (while batteries are), merging the capacitive and redox-based storage in one device seems to be a reasonable and interesting approach to address this challenge. Nevertheless, having one electrode of capacitive character, another one requires special attention, as the charge must balance the potential variations during charge/discharge. There are several approaches that allow the hybrid device to be assembled, but all of them suffer from certain issues. If the choice is to preinsert the electrode, then it usually must be realised in two separate steps. This impacts the feasibility and complicates the assembling process. Some concepts have also been proposed that exploit sacrificial materials, which can deliver metal ions for insertion during the first charge; however, these materials remain in the cell body as the so-called“dead mass” and aggravate the specific energy.

In our approach, we tried to develop a novel method for assembling the metal-ion capacitor in one simple step, without adding any additive to the electrode material. In our concept, the electrolyte is the source of alkali metal (Li, Na, and K) and allows for single-step capacitor assembly.

Briefly, our contribution aims to provide a comprehensive insight into the application of redox-active electrolytes in hybrid metal ion-capacitors. Besides typical electrochemical measurements, various in-situ and operando techniques such as Raman spectroscopy, Electrochemical Dilatometry (ECD), Gas Chromatography coupled with Mass Spectrometry (e-GCMS) and On-line Internal Pressure Measurement (OIPM) were applied for determination of the charge storage phenomena and ageing factors. This paper will also be discussing certain aspects of the electrolyte (concentration, kind of solvent) that affect the capacitor performance also in the long-term perspective. In our study, we used also Step Potential Electrochemical Spectroscopy and Galvanostatic Intermittent Titration Technique to investigate the charge storage mechanisms and assign the relevant processes during electrochemical capacitor operation.

2. Results and discussion

Fig. 1 presents the constant current charging/discharging curves for different carbon electrodes operating in respective electrolytes, exploiting redox and non-redox electrolyte and the Nyquist plots for relevant cells.

Figure 1. Comparison of charging and discharging curves for systems with and without electroactive additive in electrolyte a) half-cells with activated carbon, b) half-cells with graphite, c) full hybrid cells, d) impedance spectroscopy results for graphite electrodes in half-cells and full hybrid cells.

Once can remark that in all cases the redox-activity of the electrolyte disappears with consecutive cycles, but the capacity of the first cycle allows for insertion of the negative electrode. Nevertheless,

it has been also confirmed in typical SPECS and GITT studies that the performance of both electrodes are different while the redox-active specimen is present in the electrolyte.

Figure 2. GITT results of half cells a) with activated carbon, c) with graphite, e) graphite in full cells, and b), d), f) calculated diffusion coefficients based on these results.

Full cell investigations confirmed that redox-active electrolytes allowed for full insertion of the negative electrode (graphite, hardcarbon) and good operation could be achieved of the redox species concentration being well adjusted. This also concerns the volume of the electrolyte used (not shown here). Of course, the redox activity of the thiocyanate anion impacts the overall performance of the porous carbon electrode. This research has been carried out with mentioned operando techniques, and the results will be presented and discussed during the lecture.

3. Conclusions

Redox-active electrolytes allow for single-step assembly of the hybrid electrochemical capacitors; the concentration of redox specimen, electrolyte volume, and positive electrode potential cut-off are of essential importance for successful insertion of alkali metal ions in the negative electrode. Operando measurements indicated that no harmful gases are evolved, and the carbon material remains stable during long-term cycling; however, there is still some space for the specific energy improvement by designing the porous material of optimal porosity and surface functionality.

Keynote Speaker 09:20~09:50 Dec. 02

Pooi See Lee

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Prof. Pooi See LEE is the President's Chair Professor in Materials Science & Engineering at Nanyang Technological University (NTU), Singapore. Her current research focuses on stretchable electronics and energy devices, soft actuators and stimuli-responsive materials. Professor Lee received the Nanyang Research Award in 2016 and the Nanyang Award for Innovation & Entrepreneurship Award in 2018. She was awarded the NRF Investigatorship 2016.

She has been listed as a Highly Cited Researcher by Clarivate Analytics in 2018-2024. She is being inducted in the Singapore 100 Women in Tech 2021 (SG100WIT) and received the SNIC - AsCA2019 Distinguished Woman Chemist Award 2022. She was elected the National Academy of Inventors Fellow in 2020, MRS Fellow 2022 and RSC Fellow 2022.

Rapid ions transfer driven electrochemical energy storage systems

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Designing materials with appropriate crystal lattices or molecular structures, morphological and electronic structures serve to enhance ionic transport and facilitate redox reactions for energy storage. In particular, ionic transport is of particular importance in electrochemical devices such as energy storage. We explore different redox chemistries to facilitate understanding on the electrode material-electrolyte interactions that enhances ionic transport.

Liquid metal is a promising candidate for stretchable energy storage devices due to its mechanical deformability and high electrical conductivity, however, the redox reactions of the surface oxides varied in different electrolyte conditions that require specific attention. To realize a stretchable energy storage device, liquid metal-based electrodes were used to sandwich the BMIM TFSI ionogel, forming an all-solid-state device [1]. The mechanical property and ionic conductivity of ionogel were characterized using stress-strain curve and electrochemical impedance spectroscopy. The distinctive charge storage ability of liquid metal particles with ions from ionic liquids and their deformability significantly enhance their appeal for applications in wearable electronics.

Another interesting redox active electrode material is the bioinspired eumelanin with quinone/hydroquinone redox equilibrium. Eumelanin-inspired electrode materials are enriched with charge transfer, π-π stacking, ionic-electronic conduction and metal chelation. The chemically modified eumelanin electrode was used for the preparation of multivalent Zn ion energy storage. The influence of functional groups and the steric hindrance using two different melanin derivatives show the importance of metal-ion chelation, band gap modification, and redox center availability [2].

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Keynote Speaker **16:40~17:10 Dec. 02**

Lu-Yin Lin

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Dr. Lu-Yin Lin is a Professor in the Department of Chemical Engineering and Biotechnology at National Taipei University of Technology (Taipei Tech). She received her B.S. and Ph.D. in Chemical Engineering from National Taiwan University, completing her doctorate in just three years. She later conducted postdoctoral research at the University of California, Berkeley, supported by Taiwan's Thousand Talents Program. Her research focuses on electrochemical energy materials, nanomaterials, and catalysis for water splitting and sustainable technologies.

She has published over 245 SCI papers and 7 book chapters, with more than 8,000 citations and an H-index of 51. Dr. Lin has received multiple honors, including the ISE Young Author Prize, the MOST Young Scholar Fellowship, and the Li-Chang-Rong Distinguished Young Professor Award. She has been named to the World's Top 2% Scientists list by Stanford University for several consecutive years. At Taipei Tech, she has received multiple Outstanding Research Awards, and actively serves as a reviewer for national research and industry–academia funding programs.

Engineering Nanostructured Derivatives from Zeolitic Frameworks Using Novel Chemical Modulators for Electrochemical Energy Storage

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The rational design of nanostructured materials derived from metal–organic frameworks has emerged as a powerful strategy to develop high-performance electrode materials for electrochemical energy storage. In this study, we demonstrate a novel synthesis approach that utilizes ammonium hydrogen fluoride and ammonium tetrafluoroborate as dual chemical modulators to engineer the structural and compositional evolution of zeolitic imidazolate framework-67 (ZIF-67). These dual structure-directing agents enable precise control over crystal morphology, pore architecture, and transition metal distribution, ultimately leading to a series of nanostructured derivatives with tailored electrochemical properties. Systematic modulation of the NH4HF2/NH4BF4 molar ratio induces notable changes in surface area, electronic structure, and charge transport characteristics. Fig. 1 presents the HRTEM and EDS mapping of the optimal ZIF-HB12 sample. Among the resulting materials, the optimized ZIF-HB12 electrode demonstrates remarkable capacitive performance, achieving a specific capacitance of 1933.3 F g-1 at a scan rate of 20 mV s-1.

An asymmetric supercapacitor device assembled with ZIF-HB12 as the positive electrode delivers an energy density of 19 Wh kg-1 at a power density of 1143 W kg-1, with 81.3% capacitance retention and 97.2% Coulombic efficiency over 10,000 cycles. Operando X-ray absorption spectroscopy reveals enhanced redox dynamics arising from synergistic interactions between nickel and cobalt sites, supported by improved charge transfer at the electrode–electrolyte interface (Fig. 2). The presence of mixed Co^{2+}/Co^{3+} and Ni^{2+}/Ni^{3+} redox couples play a crucial role in facilitating rapid faradaic reactions during cycling. This study highlights transformative role of dual chemical modulators in fine-tuning the properties of framework-derived materials and provides a scalable, one-step synthesis platform for engineering high-performance electrode architectures. Beyond the reported system, this methodology opens avenues for designing a broader class of framework-based energy materials with optimized structural, electronic, and redox characteristics for advanced electrochemical technologies.

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Keynote Speaker 17:00~17:30 Nov. 30

Enn Lust

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Prof. Enn Lust graduated from the University of Tartu in 1980 and began his career as an engineer at the Laboratory of Electrochemistry. He later advanced to the position of scientific collaborator. In 1989, he received his Ph.D. in electrochemistry. He was elected as an associate professor in 1991 and has been a professor of physical chemistry at the University of Tartu since 1997. Prof. Lust served as the Head of the Institute of Physical Chemistry from 2003 to 2007 and as the Director of the Institute of Chemistry from 2008 to 2023.

He has published 414 articles in the Web of Science (WoS), which have received a total of 8,556 citations, resulting in an h-index of 46. Additionally, he has over 441 publications listed in Scopus, with more than 8,867 citations and an h-index of 51 as of 2025.

Prof. Lust has received several prestigious awards, including the Theodor von Grotthuss Medal from the Lithuanian Academy of Sciences in 2018, the Wilhelm Ostwald Medal from the Estonian Academy of Sciences in 2023, the Order of the White Star, Class III in 2020, and two National Science Awards in 2008 and 2021. He has also been honored with the Grand Medal from the University of Tartu. Prof. Lust is a member of the Estonian Academy of Sciences (ETA) focusing on Energy Technologies and serves on the ETA Energy Steering Committee. He represents Estonia in the European Platform of Universities engaged in Energy Research and is a member of the Energy Development Committee of the European Association of Academies of Sciences (EASAC).

His research areas include the development of supercapacitors, lithium-ion and sodium-ion batteries, polymer electrolyte fuel cells, medium-temperature solid oxide fuel cells, synthetic fuel synthesis reactors, and their materials. He also investigates thin-film hydrogen storage in ultramicro-, micro-, and mesoporous hierarchical carbons, separation and purification technologies for rare earth metals, and nanofiber materials activated with metal nanoclusters to deactivate or eliminate viruses.

Development of high power and energy density supercapacitors

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Introduction

Different types of supercapacitors, including electrical doubler layer capacitors (EDLC), hybrid supercapacitors (HSC), and battery-type capacitors, have been developed and systematically tested [1-12]. Li-ion, Na-ion, K-ion, Mg-ion, Ca-ion, Al-ion, and Zn-ion hybrid capacitors completed demonstrated higher energy densities compared to EDLC (based on two ideally polarizable electrodes) [1-14]. A detailed analysis of these various types of capacitors will be provided in this presentation.

Results

EDLCs can be divided into four main groups: aqueous, non-aqueous, ionic liquid, and ionic liquid + non-aqueous mixed electrolyte solutions containing devices. For synthesis of ultramicro (UMP)-, micro-(MIP)-, meso-(MEP) and macroporous (MAP) hierarchical high surface area carbons, different raw materials like well decomposed Estonian peat (EP), lignin (LI), coffee bean powder used for coffee production (CP), byproducts from the white sugar industry (WS), and overtime stored D-glucose (DC) solutions were used. For the synthesis of carbon-rich materials, methods such as hydrothermal treatments or high-temperature decomposition were employed. The activation of these carbon-rich materials involves chemical activation using KOH, NaOH, ZnCl2 or combinations like KOH+ZnCl2 or NaOH+ZnCl2, typically at fixed temperatures ranging from 500 to 1400 oC. Additionally, high-temperature hydrogen treatment was conducted at 800 oC for 2 or 4 hours. The produced carbons were then analyzed using the Brunauer-Emmett-Teller (BET) adsorption method, utilizing various test gases such as N2, Ar, CO2, CH4 and H2.

It is important to note that certain critical parameters, such as pore shape and pore size distribution are often overlooked, yet they significantly influence the power and energy density values of EDLCs. For pore shape analysis of capacitors electrodes, we employed innovative methods such as small angle neutron scattering, quasielastic neutron scattering and inelastic neutron scattering, Raman spectroscopy, in situ STM/AFM and high-resolution TEM combined with SAED and EELS. SEM-EDX, XRF and XPS. It was observed that the prevailing pore shapes in the materials studied primarily include ball-shaped, cylindrical, and slit-shaped pores, which depend largely on the carbon synthesis conditions. For more detailed analysis of possible surface reactions, electrochemical operando synchrotron radiation photoelectron spectroscopy and surface-normalized Fourier transform infrared spectroscopy have been used.

A significant challenge for hybrid supercapacitors is their short lifespan and moderate energy efficiency [9,10]. One straightforward approach to enhance the limiting capacitance and energy density within a narrow cell potential range is to use specifically adsorbing ions, like halide anions (Cl-, Br- or I-) [11,12] and/ or Rb+ and Cs+ cations [13, 14], as well as d-metal oxides deposited on carbon supports [15]. Extensive measurements and analyses of processes at carbon electrodes as well as Al current collectors have been conducted using the operando/in situ XPS (SRXPS) method [16,17].

Depending on the type of carbon used, very high power and energy densities can be achieved in non-aqueous and ionic liquid-based electrolyte devices, provided that the electrolytes (including salts and solvents), electrode materials, current collectors, and membranes are properly treated. By systematically controlling the polarization of the electrodes in a step-by-step manner, the potential of the ionic liquid electrolyte EDLC can be extended up to 3.7-3.9 V [1-3]. For achieving very high power densities, the carbon materials with a moderately graphitized structure and prevailing slit-shape pores should be used in EDLCs.

The limiting potential values at which the carbon electrodes are no longer ideally polarizable have been established through SRXPS and compared with results obtained using impedance and cyclic voltammetry methods. Additionally, self-blocking oligomer surfaces layers have been deposited at fixed potentials, and the composition of the non-conductive surface polymer (oligomer) layers has been analyzed using in situ SNIFTIT and Raman spectroscopy.

The constant power method has been used for measuring and calculating experimental Ragone plots. A systematic analysis demonstrates that the shape of these plots is heavily influenced by several factors: the type of electrolyte used (whether aqueous, non-aqueous, ionic liquid, or a mixture of room-temperature ionic liquid with a non-aqueous electrolyte), the chemical composition of the electrolyte, the hierarchical structure and meso-microporosity of the carbon, and the shapes of the meso- and micropores present in the carbon structure.

Energy efficiency values have been calculated using constant current discharge/charge data. Very low energy efficiency values have been calculated for some hydride supercapacitors systems, but for some EDLCs, excellent energy efficiency values in addition to very high Cuolombic efficiencies have been established. Very highly mesoporous carbons demonstrating extremely high power density values have been prepared using sol-gel method [1-3]. For hybrid supercapacitors different ionic liquids have been tested and for Zn-ion capacitor some ionic liquids demonstrated high Cuolombic and moderate energy efficiency values [9,10].

Conclusions

For preparation of long-lasting very high power-energy density supercapacitors a whole series of parameters should be taken into detailed consideration.

Ackowlegements

This work has been supported by the Estonian Ministry of Education and Research (TK210), Estonian Research Council (TEM-TA69), and by the project „Increasing the knowledge intensity of Ida-Viru entrepreneurship“ co-funded by the European Union (ÕÜF12).

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Keynote Speaker **09:20~09:50 Dec. 02**

Katsuhiko Naoi

Professor

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Katsuhiko Naoi is Emeritus Professor at Tokyo University of Agriculture & Technology (TUAT), where he previously served as Distinguished Professor and Trustee (Vice President for Research Management and Academic Collaboration). He earned his Ph.D. in Applied Chemistry from Waseda University in 1988, following research fellowships at BASF in Germany (1982–84) and the University of Minnesota (1988–90). Since joining TUAT in 1990, he has held a number of key academic and leadership roles, including Head of Applied Chemistry, Vice Dean of the Graduate School and the Institute of Engineering, and Trustee/Vice President for Academic and Research Affairs. He was named Distinguished Professor in 2014.

K. Naoi's research centers on electrochemistry and energy materials, with a focus on lithium-ion and post-lithium batteries, supercapacitors, and nanomaterials synthesis. He is internationally recognized for pioneering hybrid supercapacitors based on nanocarbon–nanocrystal composites, work that laid the foundation for the "SuperRedox Capacitor" (SRC) concept. His group has also advanced in-situ electrochemical analysis using EQCM, XAFS, and neutron scattering to reveal nanoscale mechanisms of energy storage.

Beyond academia, K. Naoi has long promoted science–industry collaboration. Together with Wako Naoi, he co-founded K&W Inc. in 2002 and later established TUAT's Next Generation Capacitor Research Center (2012), which has become a hub for industrial partnerships and international collaboration, particularly with the University of Toulouse, France. His vision connects fundamental science with practical applications in electric vehicles, rail systems, renewable energy, and bioelectrochemical devices.

Back to Science, Forward to Innovation - toward Next-Generation Power Architectures

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Emerging Application Trends: With the rapid rise of generative AI, data centers are expanding at an unprecedented pace, driven by GPU processors that demand both extreme power density and sustained output. These GPUs generate large, recurring power surges and operate under severe thermal conditions. What is required is not merely energy storage, but a power facilitator integrated directly within GPU racks (Figure 1)—a device capable of instantly delivering spike currents. Such a device would function as an "artificial heart" (AH), supplying vital bursts of power to the "artificial intelligence" (AI/GPU) whenever demanded.

Beyond data centers, the potential applications are wide-ranging: robotic actuation systems, catenary-free trams, drone take-off propulsion, and sudden-demand scenarios in satellite communications and space platforms. Industry demand is immediate, with strong customer interest already evident. This innovation is not an academic exercise but a development initiative with a clear pathway to deployment. We are establishing a bidirectional framework that merges industrial expertise with academic innovation on ULTRAFAST REDOX MATERIALS—reconstructing practical know-how into scientific understanding while rapidly translating university discoveries into practice, thereby accelerating the transition from research to application.

New Perspectives: Nano-Engineered Ultrafast Polyanions, LVP and NVP (Figure 2)

(A) Ultrafast Li-ion Storage: $Li_3V_2(PO_4)_3$ (LVP) has a three-dimensional framework that enables ultrafast Li^+ transport, and when engineered into nanocrystals uniformly dispersed within MWCNT networks via "ULTRACENTRIFUGATION," it forms a composite architecture capable of sustaining charge–discharge at 480C (7–8 s) with stability over 100,000 cycles. Remarkably, it also operates under cryogenic conditions (–40 °C), where EDLCs fail due to electrolyte freezing and sluggish ion dynamics, highlighting its ability to perform in extreme environments beyond the reach of conventional technologies.

(B) Ultrafast Na-ion Storage: The sodium analogue, $Na_3V_2(PO_4)_3$ (NVP), extends these possibilities even further. When synthesized as nanodots anchored onto carbon nanotube networks, NVP achieves charge–discharge operation at 1,000C, corresponding to 3.6 s per full cycle, and exhibits power output levels 2-3-fold higher than conventional NVPs. This performance is achieved without sacrificing durability, as the nanodot–carbon composite maintains long-term stability under repeated cycles. The NVP system offers electrochemical superiority with also critical advantages by resource availability and sustainability.

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Poster Program

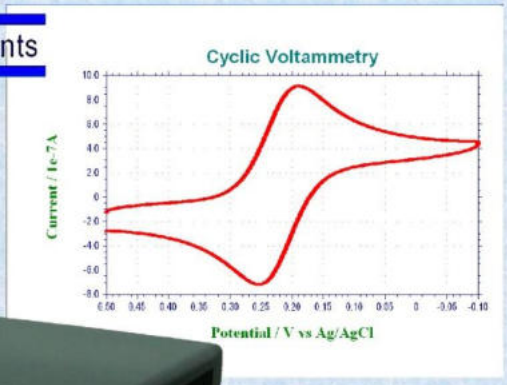
Dec. 01, 2025 (Mon.) 12:00–14:20

Poster No.	Abs. No.	Presenter	Presenter Affiliation	Title
P-01	0004	Taichi Kida*, Minako Deguchi, Masashi Ishikawa*	Kansai University, Japan	Solid-Solid Interface Design for High Energy Density Electric Double Layer Capacitors
P-02	0005	Sumire Fukuda, Junichi Inamoto, Yoshiaki Matsuo, Minako Deguchi, Masashi Ishikawa*	Kansai University, Japan	Capacitive behavior of GLG in FSI-based ionic liquid electrolytes for high voltage operation
P-03	0011	Szu-Chen Wu, Syun-Hong Chou, Ta-Chung Liu*	Minghsing University and Science and Technology, Taiwan	Hierarchical Nitrogen-Doped Porous Carbon Derived from Silk Fibroin/ZIF-8 Composite for High-Performance Supercapacitor Electrodes
P-04	0012	Pradeep Nayak*, Ismayil	Manipal Institute of Technology, India	Chitosan-Dextran Blend Polymer Electrolytes for Magnesium-Ion Devices: From Batteries to Capacitors
P-05	0013	Hao-Lun Juan, Ching-Yu Hu, Hsisheng Teng*	National Cheng Kung University, Taiwan	Design on Electrolyte and Lithiated-Anode for Wide-Temperature Operation of Lithium-Ion Capacitors
P-06	0017	Ryudo Tabata, Mitsuru Yamada, Nobuo Ando, Naohiko Soma, Mika Fukunishi, Futoshi Matsumoto*	Kanagawa University, Japan	An Improved Pre-Lithiation of Graphite Anodes Using Through-Holed Cathode and Anode Electrodes in Laminated Lithium-Ion Battery and Capacitor
P-07	0018	Dahan Sui, Mitsuru Yamada, Nobuo Ando, Naohiko Soma, Mika Fukunishi, Futoshi Matsumoto*	Kanagawa University, Japan	Improvement of High-Rate Performance of LiFePO4 Cathode with Through-Holed LiFePO4/Activated Carbon Hybrid Electrode Structure Fabricated with a Pico-second Pulsed Laser
P-08	0019	Takuya Eguchi,*, Shogo Kawamata, Reiichi Chiba, Seiji Kumagai	Nihon University, Japan	Electrochemical Characteristics of Lithium-ion Capacitors Using Binder-Coated Si Negative Electrode
P-09	0020	Tatsuki Hozumi, Reiichi Chiba, Seiji Kumagai, Daisuke Tashima, Takuya Eguchi*	Nihon University, Japan	Effect of Electrode Heat Treatment on the Rate Characteristics and Cycle Characteristics of Si Electrodes Using Kenaf-Derived Lignin Binder in Half Cells
P-10	0023	Yu-Chun Chen, Chi-Chang Hu*	National Tsing Hua University, Taiwan	Electrochemical Activation Engineering of Alkali-Treated Soft Carbons for High-Performance Energy Storage
P-11	0025	Shilpa Shetty, M. Selvakumar*	Manipal Institute of Technology, India	Engineered $SnCo_2O_4$/Carbon Nanofiber Nanocomposites for Flexible Micro-Supercapacitors, Humidity Sensor and Electrochemical Sensors toward the Sensitive Detection of Pharmaceutical Drug Naproxen
P-12	0026	Yi-Cheng Liao, Wen-Yang Jao, Chi-Chang Hu *	National Tsing Hua University, Taiwan	Enhancing Capacitance in LICs via Optimizing Irreversible Faradaic Reactions during Electrochemical Activation
P-13	0028	Yun-Syuan Liang, Wei-Lun Li, Cheng Wu, I-Ching Tseng, Shih-Lung Yu, Yun-Tai Yu, Kai-hsun Lin, Kuan-Chun Liu, Miao-Ju Lin, Sheng Yun Wu, Meng-Chu Chen*	National Taitung University, Taiwan	Structural and Electrochemical Investigation of $Sr_2SiO_4:Dy^{3+}$ Electrode Materials for Supercapacitors under Co-60 γ Irradiation
P-14	0032	Jarrn-Horng Lin	National Tsing Hua University, Taiwan	Converting Environmental Wastes (CO_2 and biomass) into value-added Carbon Materials and using them in Energy Storage Devices
P-15	0034	Che-Wei Yan, Jeng-Kuei Chang*	National Yang Ming Chiao Tung University, Taiwan	Multi-Solvent Electrolytes for Enhanced High-Voltage Performance of Electric Double-Layer Supercapacitors
P-16	0036	Jing-Cheng Liang, Yun Ku, Chi-Chang Hu*	National Tsing Hua University, Taiwan	Influence of pore distribution and functional group of Activated Carbon on the Self-discharge of Supercapacitors
P-17	0037	Shih-Sheng Chen, Bo-Hong Chen, Sheng-Kuei Chiu*	National University of Tainan, Taiwan	Hydrothermal Synthesis of Ternary Cobalt-Nickel-Molybdenum Oxide for High-Performance Supercapacitor Electrodes
P-18	0041	Nirmal Kumar Sakthivel, Mani Govindasamy*, Pin Yi Chen*	Ming Chi University of Technology, Taiwan	Synergistic NiCo-LDH/ MXene Nanoribbon Hybrids: In-Situ Engineering for Advanced Capacitor Applications
P-19	0045	Yi-Chen Sun, Yu-Jr Chang, Dhanaprabhu Pattappan, Chen-	Ming Chi University of Technology, Taiwan	Activated Carbon Derived from Waste Tire for Supercapacitor Application

		Chieh Liao, You-Zheng Wu, Yi-Ting Lai*		
P-20	0046	Hsing-Mei Chou*, Yi-Heng Tu, Chi-Chang Hu	National Tsing Hua University, Taiwan	Application of Modified Activated Carbon Systems for Valuable Metal Ion Capture (canceled)
P-21	0051	Emerson Vega-Ramírez, Jessica Chaparro-Garnica, Emilia Morallon, Diego Cazorla-Amorós	Universidad de Alicante, Spain	Sustainable Biomass-Derived N, P Co-Doped Activated Carbons for High-Performance Supercapacitor Electrodes
P-22	0054	Chang-Chieh Yu*, Yi-Heng Tu, Hung-Yi Huang, Chi-Chang Hu	Department of Chmical Engineering, National Tsing Hua University	Polypyrrole Protective Layers on Hydrated Vanadium Oxides as Novel Cation Capturing Materials for Electrochemical Deionization
P-23	0056	Chen-Chieh Liao, Dhanaprabhu Pattappan, Tse-Yang Wang,Yi-Ting Lai*	Ming Chi University of Technology, Taiwan	Electro-assisted construction of silane-bridging modified graphene electrode for electrochemical method in heavy metal removal and pollutant degradation
P-24	0058	Shu-Huei Hsieh*, Zhi-Xin Yang	National Formosa University, Taiwan	Effect of pH during Hydrothermal Fabrication of MoS_2 and MoS_2/GO Composites
P-25	0059	Yue Liu, Yoshikiyo Hatakeyama, Soshi Shiraishi*	Gunma University, Japan	Heat-Treated Fullerene Mixtures for Electrochemical Capacitors
P-26	0060	Seii Yamamoto, Yoshikiyo Hatakeyama, Soshi Shiraishi*	Gunma University, Japan	The Relationship Between Battery Capacity and Double-Layer Capacitance in Lithium–Air Batteries.
P-27	0064	Camille Douard, Hugo Mazoyer, David Brown, Olivier Crosnier, Zineb El Kacemi, Laurence Athouël, Jean-Yves Mevellec, Julio Cesar De Luca, Yannick Amosse, Achraf Belkhiri, Jon Ajuria, Paulo Luis, Maria Arnaiz, Thierry Brousse	Nantes Université, CNRS, France	A second life for recycled carbon fibers in Sodium ion capacitors
P-28	0069	Jarrn-Horng Lin*, Yu-Hsien Liao, Yao-Yang Chang	National Tsing Hua University, Taiwan	Hierarchical Porous Carbon Derived from Sodium Ligninsulfonate for Enhanced Electric Double-Layer Capacitors Performance
P-29	0070	Jarrn-Horng Lin*, Li-Ming Lu, Po-Hung Wang	National Tsing Hua University, Taiwan	Converting waste polyethylene terephthalate into hierarchical porous carbons for high-performance Supercapacitors
P-30	0077	Nicharee Panyaporn, Naeti Jaiphian, Sonti Khamsanga, Jiaqian Qin, Prasit Pattananuwat*	Chulalongkorn University, Thailand	Kenaf Fiber-Derived Carbon/Polyaniline Composites for Sustainable Zinc-Ion Hybrid Supercapacitors
P-31	0078	Phetkla Sonsang, Suthima Suthasup, Chatr Panithipongwut Kowalski, Prasit Pattananuwat*	Chulalongkorn University, Thailand	Boosting Photoinduced Charging Efficiency in Polyaniline Supercapacitors via Zn(II)-Porphyrin Integration
P-32	0079	Pannarot Kitpimonkul, Nicharee Panyaporn, Prasit Pattananuwat*	Chulalongkorn University, Thailand	Polyaniline/Tungsten Trioxide Composite Films for Dual-Functional Electrochromic and Supercapacitor Applications
P-33	0082	Takumi Ambe*, David Quintero, Mana Iwai, Sho Kitano, Koji Fushimi, Hiroki Habazaki	Hokkaido University, Japan	Influence of the dielectric-conductive interface on the breakdown voltage of conductive polymer solid capacitors
P-34	0086	Yen-Shuo Huang, Tzu-Chi Su , Sanna Gull, Han-Yi Chen*	National Tsing Hua University, Taiwan	3D porous reduced graphene oxide-coated zinc anodes for highly-stable aqueous zinc-ion capacitors via electrostatic spray deposition
P-35	0088	Chung-Xun Chuang, Jeng-Yu Lin*	Tunghai University, Taiwan	Dimethyl sulfoxide–based hybrid deep eutectic electrolytes for wide-window and low-temperature for high-performance supercapacitors
P-36	0089	Po-Yu Shen, Jeng-Yu Lin*	Tunghai University, Taiwan	Binder-Free $Co_{0.85}Se/Ni_3Se_2$ Heterostructured Electrode Prepared via Electrodeposition for High-Rate Electrochemical Energy Storage
P-37	0090	Shota Kuchimoto, Keisuke Muramatsu*, Yuki Tokura, Wataru Sugimoto*	Shinshu University, Japan	Selective Dissolution of Birnessite-Type MnO_2 to Create Open Pores Serving as Pathways to Interlayer Surfaces
P-38	0091	Zhi-Ting Huang, Marcin Krajewski, Jeng-Yu Lin*	Tunghai University, Taiwan	Engineered PVDF-HFP/deep eutectic solvent membranes as non-flammable and flexible quasi-solid-state electrolytes for safe and flexible high-voltage supercapacitors

P-39	0095	Célia Clementz*, Sandrine Berthon-Fabry, Phillipe Happiot, Corinne Lagrost, Olivier Crosnier, Yann Leroux	Nantes Université - CNRS - IMN, France	Aryldiazonium grafted porous carbon electrode materials for electrochemical capacitors
P-40	0098	Yun Ku, Hao-Yu Ku, Ai-Ling Huang, Hung-Yi Huang, Wen-Yan Chang, Jing-Cheng Liang, Chi-Chang Hu*	National Tsing Hua University, Taiwan	Unraveling Self-Discharge Mechanisms and Long-Term Stability in EDLCs with Solvent Additives
P-41	0057	Wei-Cheng Chen, Lu-Yin Lin*	National Taipei University of Technology, Taiwan	Mn-G Modified Cobalt Sulfides for Supercapacitor Applications
P-42	0040	Kenji Machida*, Satoyuki Tatsumi, Kazuya Koseki, Kazuhiro Nagahara, Hidenori Okuzaki	Nippon Chemi-Con Corporation, Japan	Development of a 450V High-Voltage Aluminum Polymer Capacitor
P-43	0039	Yen-Yu Liu*, Lu-Yin Lin	National Taipei University of Technology, Taiwan	Facile Solvent-Engineered Synthesis of ZIF-67 Derivatives toward High-Performance Supercapacitor Electrodes
P-44	0035	Nindita Kirana, Jeng-Kuei Chang*	National Yang Ming Chiao Tung University, Taiwan	Fabrication of Thin Lithium-Metal Anode Using Stabilized Lithium Metal Powder for High-Energy-Density Supercapacitors
P-45	0024	Alar Jänes*, Jaanus Eskusson, Karl-Sten Põder, Enn Lust	Institute of Chemistry, University of Tartu, Estonia	High Energy Density Zn-Ion Hybrid Supercapacitors
P-46	0100	Wei-Han Chen, Ching-Yu Peng*	Department of Water Resources and Environmental Engineering, Tamkang University, Taiwan	Application of Rice Husk Activated Carbons in Flow-Electrode Capacitive Deionization (FCDI) System for Remediation of Nickel-Containing Groundwater

CH Instruments



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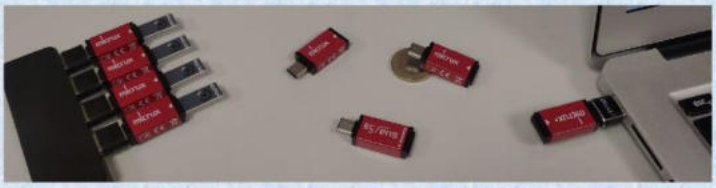

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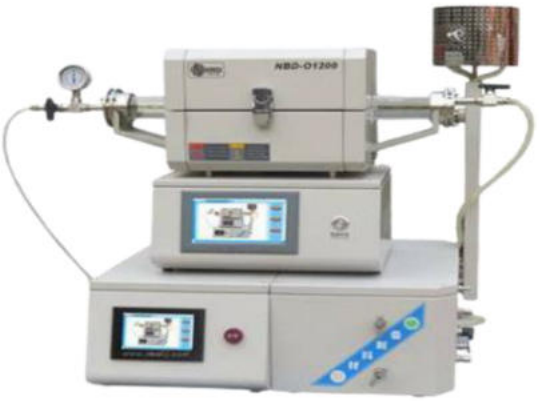

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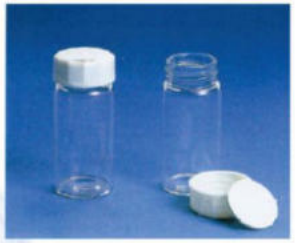

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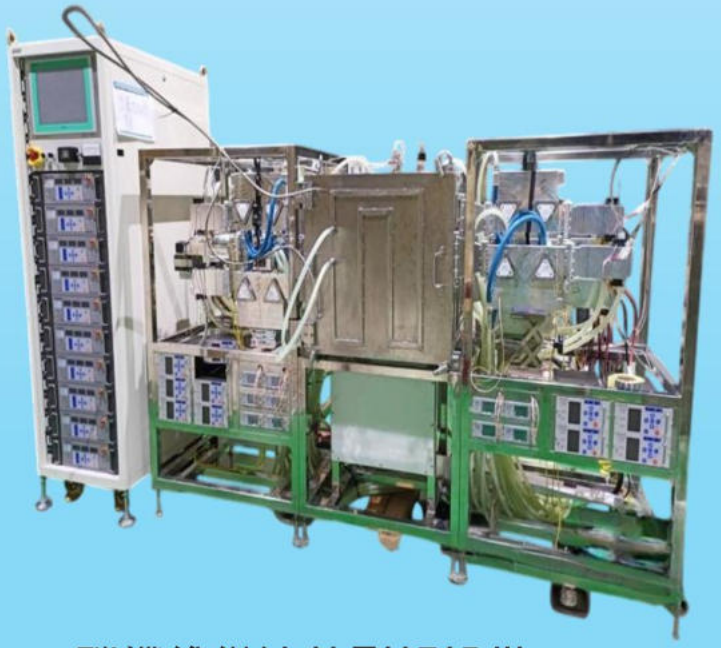

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Anode Materials for Li-ion Batteries and Advanced Carbon Materials for Supercapacitor and Batteries

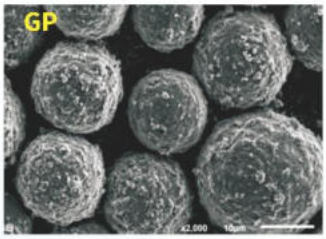
產品特性 Product characteristics

介相碳微球(GP系列,生球)作為高性能石墨材料的前驅體,可精確控制不同的顆粒尺寸。介相石墨(MG系列,熟球)具有優異的倍率性能與循環壽命,主要應用於高功率鋰離子電池,如快速充電電動車(EV)、電動堆高機(E-forklift)、儲能系統(ESS),以及用於賽車油電混合車(HEV)的超高功率鋰電池。先進碳材料(ACS系列)具有高體積電容,主要應用於風機系統備援電源的超級電容器。此外,少量添加劑亦可提升鋰離子電池與鉛酸電池在不斷電系統(UPS)及怠速啟停系統(ISS)應用中的倍率、循環壽命與低溫性能。

Green Mesophase Powders (GP series) as a precursor for high-performance graphite materials can be accurately controlled with various particle sizes. Mesophase Graphite (MG series) with characteristics of excellent rate capability and cycle life are mainly used in high power Li-ion batteries for fast-charging EV, E-forklift and ESS and ultra high power LIB for HEV of racing cars. Advanced Carbon materials (ACS series) with its high volumetric capacitance, are primarily used in supercapacitors for backup power supply of wind pitch system. Additionally, a small amount of additives can enhance the rate, cycle life, and low-temperature performance of Li-ion batteries and lead-acid batteries for UPS and ISS applications.

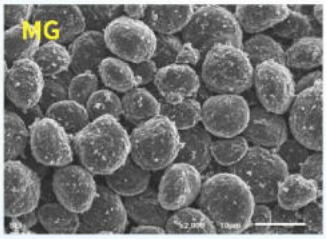
A. 介相碳微球系列 GP series

應用 Application	產品 Products	粒徑 D50(μm)	固定碳 Fixed Carbon (%)	揮發份 V.M.(%)
鋰離子電池 Li-ion Batteries	GP40	40 ± 3	≥ 90	8 ± 2
石墨塊材 Graphite Block	BCP20	20 ± 2	≥ 88	10 ± 2



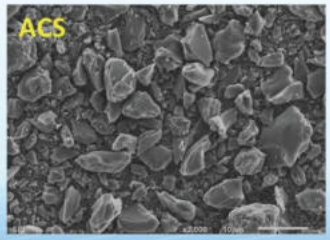
B.負極材料 MG series for Li-ion Batteries

應用 Application	產品 Products	粒徑 D50(μm)	比表面積 BET(m^2/g)	振實密度 Tap D(g/cm^3)	電容量 Capacity(mAh/g)
超高倍率應用 Ultra High Power	UF1	3 ± 1	≤ 6.0	≥ 0.7	≥ 330
	UF2	5 ± 2	≤ 5.0	≥ 0.8	≥ 340
高倍率應用 High Power	MG11	11 ± 2	≤ 2.2	≥ 1.2	≥ 345
	MG10	10 ± 2	≤ 2.0	≥ 1.1	≥ 337
平衡型應用 Middle Power	PCA20	21 ± 3	≤ 1.7	≥ 1.3	≥ 330
	MG12	18 ± 3	≤ 1.3	≥ 1.3	≥ 350
高容量應用 High Energy	BS481	11 ± 3	≤ 3.5	≥ 1.1	≥ 470



C.先進碳材料 ACS series for Supercapacitor and Batteries

應用 Application	產品 Products	粒徑 D50(μm)	比表面積 BET(m^2/g)	灰份 Ash (%)	電容量 Capacitance(F/cm^3)
超級電容器& 鉛蓄電池用 Supercapacitor & Lead-acid Batteries	ACS15	6.5±2	1500 ± 200	≤ 0.30	≥ 19.5
	ACS20		2000 ± 200		≥ 18.5
超級電容器& 鋰離子電池用 Supercapacitor & Li-ion Batteries	HV11		1400 ± 200	≤ 0.15	≥ 18.0
	HV21		1900 ± 200		≥ 17.5



Schottky Field Emission Scanning Electron Microscope

Scientific / Metrology Instruments

JSM-IT810 <HL> <SHL> <SIL>

JSM-IT810<SHL>

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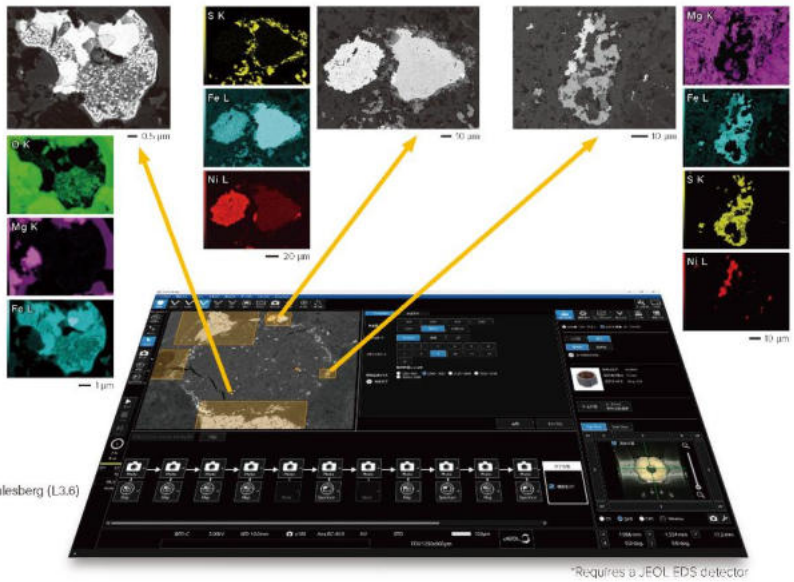
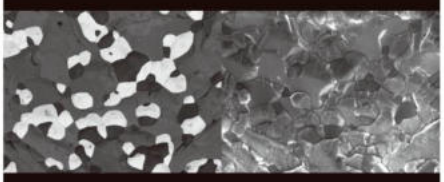


Specimen:
Chondrules in chondrite Julesberg (L3.6)
Landing voltage: 5 kV
Observation mode: STD
Detector: BED

*Requires a JEOL EDS detector

JSM-IT810<HL>

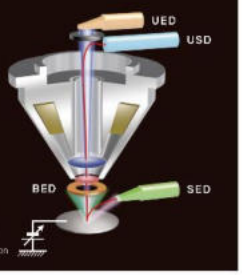
The adoption of a hybrid lens facilitates focusing the electron beam into a narrower probe. Since this lens design has no magnetic flux below the lens, it also permits the observation of ferromagnetic steel and iron samples. Furthermore, by employing a TTL(Through The Lens) detector, efficient electron collection can be realized even at low landing voltages.



Specimen: Metal particles, Landing voltage: 5 kV, Observation mode: HL, Detector: UED (left image), USD (right image)

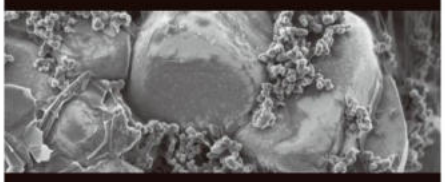
The Upper Electron Detector (UED) is capable of selecting and collecting high-angle backscattered electrons, which convey compositional information while minimizing topographic information. Upper Secondary Electron Detector (USD), designed to detect secondary electrons enables observation of surface topography with a reduced illumination effect. Moreover, the JSM-IT810<HL> can utilize multiple detectors simultaneously for observation.

Hybrid Lens



JSM-IT810<SHL>

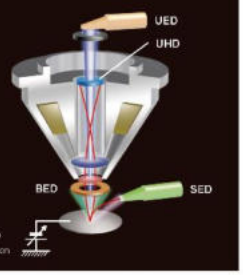
An enhanced hybrid lens design enables an even higher resolution observation and analysis.
Positioning UHD inside the objective lens can improve the collection efficiency mainly of secondary electrons.



Specimen: Cathode sheet of Lithium ion battery, Landing voltage: 0.5 kV, Observation mode: SHL, Detector: UHD

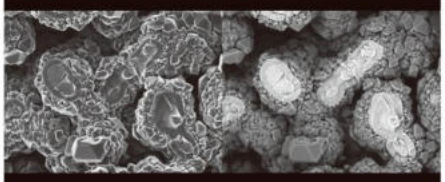
Upper Hybrid Detector(UHD) facilitates efficient secondary electron collection, allowing high-quality, high S/N imaging to be achieved even when using a low landing voltage.

Super Hybrid Lens



JSM-IT810<SIL>

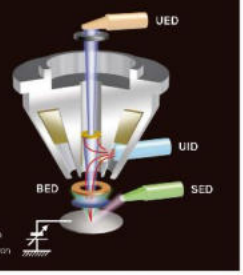
In the semi-in-lens configuration, a strong magnetic field Is formed below the objective lens, enhancing both focusing and control of the electron beam.
Electrons emitted from the specimen are efficiently guided by the magnetic field and then detected by a UID within the objective lens.



Specimen: Fracture surface of Tantalum condenser, Landing voltage: 1.5 kV, Observation mode: SIL, Detector: UID, UID filter mode: SE+BE(left image), BE(right image)

By switching the mode of the UID filter, it is possible to obtain either secondary electron images(surface topography) in SE+BE mode or backscattered electron images(including compositional information + topographic information) in BE mode.

Semi-in-lens



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