

EDITORIAL

Functional Materials in South Korea

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Since the turn of the century, South Korea has established itself as one of the most productive and forward-looking centers of functional-materials research in the world [1–3]. Laboratories across the nation have delivered advances that combine deep mechanistic understanding with a clear route to real devices, spanning perovskite photovoltaics, neuromorphic and compute-in-memory electronics, bioinspired soft matter, single-atom electrocatalysis, and next-generation energy storage. This Special Issue, entitled *Functional Materials in South Korea*, assembles a representative cross-section of that work and presents it to the international readership of *Advanced Functional Materials*. For the convenience of the reader, we have organized them below into six thematic clusters that together map the contemporary landscape of functional-materials research in South Korea.

1 | Semiconductor, 2D Crystal Engineering and Compute-In-Memory

This theme links precise crystal and interface control with AI-relevant hardware. Kwon and co-workers develop oxygen-tunnel indium tin oxide vertical channel transistors for monolithic 3D compute-in-memory systems, addressing current density and reliability in vertically integrated oxide electronics [4]. Shim and colleagues report atomically sharp heterophase interfaces in cation-eutaxy A–III–V compounds, expanding the vocabulary of semiconductor heterostructure design [5]. The Review by Il Jeon and co-workers surveys crystal engineering pathways above, below, and between 2D materials, placing van der Waals and non-van der Waals integration into a broader materials frame-

work [6]. Sungjoo Lee and colleagues present a steep-switching memory field-effect transistor (FET) for noise-resistant reservoir computing [7], while Sin-Hyung Lee and co-workers demonstrate a small-molecule memristive framework with hybrid plasticity for flexible reservoir computing integration [8]. Collectively, these contributions echo the Fall Meeting focus on intelligent materials, devices, and systems for AI.

2 | Energy Conversion, Photovoltaics and Rechargeable Batteries

The energy theme reflects the Spring Meeting emphasis on sustainable nanotechnology. Kang and co-workers reconstruct n-type surface energetics in 2.0 eV ultra-wide-bandgap perovskite solar cells through in situ solution complexation [9, 10]. Son and colleagues introduce interfacial modulation strategies for high-efficiency large-area organic photovoltaics and perovskite-organic tandem solar modules [11], while Dong Suk Kim and co-workers use spatial ionic engineering to achieve depth-independent homogeneity and strain relaxation in efficient inverted perovskite solar cells [12]. In electrocatalysis, Hyoyoung Lee and colleagues modulate iridium electronic structure with high-valent metal doping for efficient and durable acidic oxygen evolution [13]. In energy storage, Ho Seok Park and co-workers provide a Perspective on how electrolyte additives can transform aqueous zinc metal batteries [14, 15], and John Hong and colleagues present cross-linked amine interface engineering for high-performance anode-free lithium-metal batteries with high-loading cathodes [16]. The Review by Gill Sang Han and

co-workers broadens the discussion to photovoltaic power and rechargeable battery systems for space applications, emphasizing reliability beyond terrestrial operating conditions [17].

3 | Photonics, Optoelectronics and Nanophotonic Sensing

South Korea has long been a strong center for display and optoelectronic science, and this Special Issue extends that tradition into photonic nanomaterials, sensors, and device architectures. Jiseok Lee and co-workers report speckle-engineered upconversion amplification in nanoemulsion-templated hydrogel microdomes [18]. Changhwan Lee and colleagues provide a Perspective on photon avalanching nanoparticles as next-generation upconverting nanomaterials [19]. Tae-Woo Lee and co-workers use dual confinement modulation in perovskite nanocrystals to achieve near-standard-green emission with invariant chromaticity [20]. Doo-Hyun Ko and colleagues demonstrate thermodynamic nucleation-guided alloy-like non-fullerene blends for high-performance near-infrared organic photodetectors [21]. Yong-Sang Ryu and co-workers advance plasmonic colour printing in nanophotonic devices through photothermal dynamics in a Fabry-Pérot etalon [22], while Chang Young Lee and co-workers present receptor-free identification of toxic gases using hygroscopic aqueous salt films [23]. The result is a theme that spans light generation, light detection, visual information, and chemical recognition.

4 | Biofunctional Materials, Biointerfaces and Therapeutics

Biofunctional materials form another major pillar of the Special Issue. Jin Woong Kim and co-workers review smart sol-gel hydrogels for disease-targeted therapeutics, connecting molecular design with biomedical translation [24]. Suck Won Hong and colleagues design a swelling-programmed mechanochemical hydrogel niche for dynamic spheroid self-assembly [25]. Yoonhee Jin and co-workers show how 3D anisotropic cardiac extracellular matrix can reprogram microenvironments, induce nuclear remodelling, and support epigenetic maturation of chemically induced cardiomyocytes [26]. Sooyeon Cho and colleagues review sensing modalities across the biological hierarchy for cellular efflux monitoring [27]. Dong-Wook Park and co-workers integrate a transparent inorganic-organic bilayer neural electrode array with a miniscope system for in vivo calcium imaging and electrophysiology [28]. Jung Heon Lee and colleagues introduce DENTA, a dual enzymatic nanoagent for self-activating tooth whitening and biofilm disruption [29]. These studies move from soft materials chemistry to living systems, illustrating how function emerges through feedback among molecular design, microenvironmental control, and biological response.

5 | Programmable Manufacturing, Printing and Integrated Systems

Processing is often treated as the background of materials research, but in several contributions here it becomes a central design variable. Im Doo Jung and co-workers report dispensing

volumetric additive manufacturing, opening routes to freeform functional structures [30, 31]. In a second contribution, Jung and colleagues use meniscus pixel printing for contact-lens vision sensing and robotic control [32]. These works show that fabrication methods are not secondary details; they define device form factor, integration route, and final function. Their presence in this Special Issue is important because scalable manufacturing is where many elegant materials either become technologies or remain beautiful laboratory artefacts.

6 | Outlook

Viewed as a whole, Functional Materials in South Korea presents a research ecosystem moving from materials discovery to integrated systems, from single performance metrics to stability and manufacturability, and from disciplinary islands to a network of nanotechnology, energy, medicine, photonics, and AI. This Special Issue offers a vivid snapshot of functional-materials research in South Korea at a moment of remarkable momentum. What unites them is not a single material system or application, but a shared philosophy: the pursuit of mechanistic understanding hand in hand with device-level performance, and a readiness to work across the traditional boundaries of chemistry, physics, biology, and engineering. The next challenge is clear. Functional materials must not only exhibit new properties; they must perform reliably, integrate cleanly, endure realistic operating conditions, and serve societal needs in energy, health, information processing, and sustainability. The contributions in this Special Issue show that the South Korean materials community is already addressing that challenge with breadth and ambition. By bringing these studies together, we hope to stimulate further collaboration across academia, industry, and editorial communities, and to support the next generation of functional materials research in South Korea and beyond. We are grateful to every author who entrusted their work to this issue, to the reviewers whose careful assessments upheld its quality, and to the editorial and production teams at *Advanced Functional Materials* and Wiley for their support throughout. Above all, we hope that readers will find in these pages not only excellent science, but also an invitation to a wider and continuing conversation between the research community of Korea and the international readership of the *Advanced series* journals.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data sharing not applicable to this article, as no datasets were generated or analyzed during the current study.

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Biographies



Il Jeon Prof Il Jeon read Chemistry for Bachelor's and Master's degrees at Oxford University, UK. Upon graduation in 2008, he worked as the youngest senior researcher at LG Display Co. Ltd., South Korea for 5 years. In 2016, he received a Ph.D. degree in Chemistry with honours from the University of Tokyo, Japan.

After working as a JSPS post-doctoral fellow, he worked as an Assistant Professor and a Lecturer at the same university. He later joined Sungkyunkwan University (SKKU) as an Associate Professor in the Department of Nano Engineering and SKKU Advanced Institute of NanoTechnology (SAINT) and achieved an Early-Tenured Professorship. Now he is a Full Professor and serves as the Associate Vice President for the SKKU International Affairs Division (IAD) as well as a Centre Director of SKKU Global Research Centre (SGRC). His team are working on nanomaterials, namely, nanocarbon and biomaterials for various device applications including Energy (solar cells & batteries), Optoelectronics (neuromorphic optomemristors & photodetectors); Carbon Neutrality; Quantum Computing, AI, and Robotics. Additionally, he is the founder and CEO of JLabNT Co. Ltd. and has, thus far, published more than 150 lead-authored SCI papers and registered more than 10 international & 30 domestic patents.



Hyeok Kim Hyeok Kim is a full professor at the School of Electrical and Computer Engineering, University of Seoul (UoS). He received a B.S from Korea Advanced Institute of Science and Technology (KAIST) and got an M.S at the School of Electrical Engineering and Computer Science from Seoul National University. Then he performed research focused on organic electronic devices, such as field-effect transistors and diodes, during his Ph.D. from the University of Paris 7 with Professor Gilles Horowitz. Afterward, he joined the Samsung Advanced Institute of Technology (SAIT) and then led the sensor research team at the Korea Institute of Industrial Technology (KITECH). Prior to joining UoS, he was with the Department of Electrical Engineering at Gyeongsang National University in Jinju, Korea. His research interests include flexible optoelectronic devices and nanogenerators. Since 2021, Prof. Hyeok Kim is the director of center for Smart Sensor Systems of Seoul (CS4) while serving as a vice-provost of academic affairs from 2023 to 2024 and now the president of the Institute of Information Technology. He is also an adjunct professor of Terasaki Institute, Los Angeles since 2023. He has more than 140 publications and has received best paper awards 28 times. In particular, he has been operating a number of international collaborations while doing the PHC Star program with CNRS in France twice.



Tae-Woo Lee Tae-Woo Lee is a professor in Materials Science and Engineering at Seoul National University, where he has been a faculty member since 2016. He received his Ph.D. in Chemical Engineering from KAIST in 2002. After a postdoctoral appointment at Bell Laboratories, USA, he worked as a research staff member at Samsung Advanced Institute of Technology (2003–2008) and subsequently served as an assistant and associate professor at POSTECH (2008–2016). He founded SN Display Co. Ltd. in 2020. His research focuses on printed electronics and optoelectronics based on organic and organic–inorganic hybrid materials for flexible displays, lighting, and bioinspired neuromorphic electronics.



Dong-Hwan Kim Dr Donghwan Kim, known as Richie, is a Professor in the School of Chemical Engineering at Sungkyunkwan University, where he also serves as Director of the Precision Biology Research Center. He received his Ph.D. in Biomedical Engineering from the University of Michigan in 2005. Prior to joining SKKU, he held faculty positions at Nanyang Technological University and conducted research at Duke University. His research focuses on optical nanomaterials for biosensing, photonic security, and biomedical applications, with particular emphasis on plasmonic nanoparticles, optical physical unclonable functions (PUFs), and upconversion nanomaterials, including biodegradable systems. He has authored numerous high-impact publications in leading journals such as *Science Translational Medicine*, *Science Advances*, *Nature Communications*, and *Advanced Materials*. Prof. Kim currently serves as an Associate Editor for *BMEMat* (Wiley) and *VIEW* (Wiley) and actively contributes to global research initiatives in nanotechnology and bioengineering.