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Multidisciplinary Materials Research in KAIST Over the Last 50 Years

Seong Kwang Hong, Sang Ouk Kim, and Keon Jae Lee**

This KAIST special issue commemorating the semi-centennial anniversary as of February 2021, guest edited by Prof. Sang Ouk Kim and Prof. Keon Jae Lee, features the most innovative multidisciplinary research activities including materials science and engineering at KAIST (Korea Advanced Institute of Science and Technology).

KAIST is the first and top science and technology university in South Korea (**Figure 1**). KAIST opened in 1971 with a special legislative mandate from the Korean government. The government mandated two founding missions to KAIST: to educate scientists and engineers who would work for the nation's industrialization and to make innovations conducting basic and applied research that would drive the nation's economic growth.

Since then, KAIST has been the gateway to advanced technology, entrepreneurship and innovation. Our 62 000 graduates, including 12 400 Ph.D. candidates, have been key players behind Korea's innovations and global companies.

In less than half a century, KAIST has emerged as the most innovative university in the Asia–Pacific region with 12 000 students enrolled in five colleges and six schools, including 1000 international students from 92 countries. KAIST has a total of 638 full-time professors, including 32 in materials science and engineering (MSE), 28 in chemical & biomolecular engineering (CBE), and 88 in electrical engineering (EE). In addition, the research fund of KAIST has reached about US$ 291 million (US$ 221 million of government funds, and US$ 70 million of nongovernmental funds), balancing academic research and industrial cooperation.

In 2018, Thomson Reuters ranked KAIST the 11th World's Most Innovative University and the Most Innovative University in the Asian region. The 2018 QS World University Rankings ranked KAIST 40th overall in the world and 13th in materials sciences. In addition, the Nature Index named KAIST the 4th Top Young University in the world in 2019.

KAIST now has the opportunity to think boldly about what it can achieve over the next half century and beyond. Under Vision 2031, KAIST continues to strive to make the world better through the pursuit of excellence in education, research, entrepreneurship, and globalization.

The field of materials science and nanoscience is the most rigorous one at KAIST. In the past ten years from 2010 to 2019, KAIST authors have published 202 articles in *Advanced Materials* including the authors of this special issue, which is roughly 20 articles per year on average as shown in **Figure 2**.

For recent examples of *Advanced Materials* publications by this issue authors, Prof. Keon Jae Lee has reported research results on thin-film PZT nanogenerators (NGs), laser–material interactions, micro-light-emitting diodes, and self-powered acoustic sensors.[1–8] Prof. Sang Ouk Kim has published papers on graphene oxide liquid crystals, nanoparticles, and vertical carbon nanotubes (CNTs).[9–15] Prof. Yeon Sik Jung has developed heterojunction quantum-dot solar cell and plasmonic nanoarchitectures.[16–18] Prof. Byeong-Soo Bae has published on chitin nanofiber transparent paper and flexible hard coatings for foldable displays.[19,20] Prof. Hee-Tae Jung has reported metal nanostructures, an artificial mechanotransducer skin, and an ionic chemiresistor skin.[21–25] Prof. Haeshin Lee has also demonstrated biological materials, and a DNA–polysaccharide binder.[26,27] Prof. Insung S. Choi has published papers on nanofilm formation, cell-in-shell structures, and iron gall ink.[28–30]

This special issue introduces 17 articles, with major attention paid to the fields of flexible electronics, nanomaterials,

Figure 1. Photograph of the Korea Advanced Institute of Science and Technology (KAIST) campus in Daejeon. KAIST celebrates its 50th anniversary in February 2021.

Dr. S. K. Hong, Prof. S. O. Kim, Prof. K. J. Lee
Department of Materials Science and Engineering
Korea Advanced Institute of Science and Technology (KAIST)
291 Daehak-ro, Yuseong-gu, Daejeon 34141, Republic of Korea
E-mail: sangouk.kim@kaist.ac.kr; keonlee@kaist.ac.kr

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semiconductor fabrication, biomaterials/biomimetics, light–material interaction, and computational materials science.

In the field of flexible electronics, Prof. Keon Jae Lee surveys the recent progress of flexible piezoelectric acoustic sensors and artificial intelligence algorithms for speech processing (article number 1904020). Prof. Byeong-Soo Bae discusses the recent progress of optically transparent multiscale composite films for flexible and wearable electronics (article number 1907143). Prof. Sang Yup Lee writes about progress in microbial natural and non-natural polyesters (article number 1907138).

Regarding the field of nanomaterials, Prof. Sang Ouk Kim provides an overview on nanoscale assembly of 2D materials for energy and environmental applications (article number 1907006). Prof. Yeon Sik Jung summarizes the fabrication and applications of two-dimensional nanoarchitectures for advanced electrocatalysts and sensors (article number 1907500). Prof. Jun-Bo Yoon analyzes the geometrically structured nanomaterials for nanosensors, NEMS, and nanosieves (article number 1907082).

In the field of semiconductor fabrication, Prof. Hee-Tae Jung discusses the recent progress in simple and cost-effective top-down lithography for ≈10 nm scale nanopatterns from edge lithography to secondary sputtering lithography (article number 1907101). Prof. Sung-Yool Choi presents a review on TFT channel materials for display applications, from amorphous silicon to transition-metal dichalcogenides (article number 1907166). Prof. Seunghyup You focuses on the limits and beyond of recent organic light-emitting diodes (article number 1907539). Prof. Byoung Guk Park gives a comprehensive overview of current-induced spin-orbit torque for spintronic applications (article number 1907148).

In the direction of biomedical materials and biomimetics, Prof. Haeshin Lee gives a focused review for studies at KAIST about polydopamine and its derivative surface chemistry in material science (article number 1907505). Prof. Daesoo Kim reviews brain-compatible interfaces with soft nanomaterials (article number 1907522). Prof. Kwang-Hyun Cho focuses on realization of cancer precision medicine by integrating system biology and nanomaterial engineering (article number 1906783). Prof. Insung S. Choi presents a review of single-cell nanoencapsulation from passive to active shells (article number 1907001).

In the field of light material interaction, Prof. Bumki Min presents metamaterials for enhanced optical responses and their application to active control of terahertz waves (article number 2000250). Prof. YongKeun Park presents a review of disordered optics for exploiting multiple light scattering and wavefront shaping for nonconventional optical elements (article number 1903457). Concerning the field of computational materials science, Prof. Yousung Jung provides insights on theoretical and machine-learning methods for heterogeneous small molecule activation (article number 1907865).

Finally, in addition to strong collaboration with global industries, KAIST contributes to the launching of spin-off ventures to commercialize advanced materials research, including the authors of this special issue such as FRONICS (Prof. Keon Jae Lee), Solip Tech (Prof. Byeong-Soo Bae), PICO FOUNDRY (Prof. Yeon Sik Jung), MEMSLUX (Prof. Jun-Bo Yoon), Tomocube Inc. and The.Wave.Talk Inc. (Prof. YongKeun Park), and InnoTherapy (Prof. Haeshin Lee).

Seong Kwang Hong received his Ph.D. degree in electrical engineering at Hanyang University in 2017. He is currently working with Prof. K. J. Lee as a postdoctoral research associate in the Department of Materials Science and Engineering (MSE) at Korea Advanced Institute of Science and Technology (KAIST). His research interests include self-powered flexible electronics, energy harvesting systems, and sensor applications.

Sang Ouk Kim is a professor in the Department of Materials Science & Engineering at KAIST, associate dean for College of Engineering, and the director of the National Creative Research Initiative (CRI) Center for Multi-Dimensional Directed Nanoscale Assembly and Graphene Liquid Crystalline Fiber Center, Daejeon, South Korea. He obtained his Ph.D. at KAIST in 2000 and performed postdoctoral research at the University of Wisconsin-Madison, USA. His research group is actively researching the nanoscale assembly and chemical modification of various nanomaterials, including 2D materials.

Keon Jae Lee received his Ph.D. in materials science and engineering (MSE) at the University of Illinois, Urbana-Champaign (UIUC). During his Ph.D. at UIUC, he was involved in the first co-invention of "flexible single-crystalline inorganic electronics", using top-down semiconductors and soft lithographic transfer. Since 2009, he has been a professor in MSE at KAIST, and the director for the Center of Humanplus Artificial Intelligent Sensor. His current research topics are self-powered flexible electronic systems, including self-powered sensors/energy harvesters, micro LEDs, neuromorphic memory/large-scale integration (LSI), and laser–material interaction for in vivo biomedical applications.

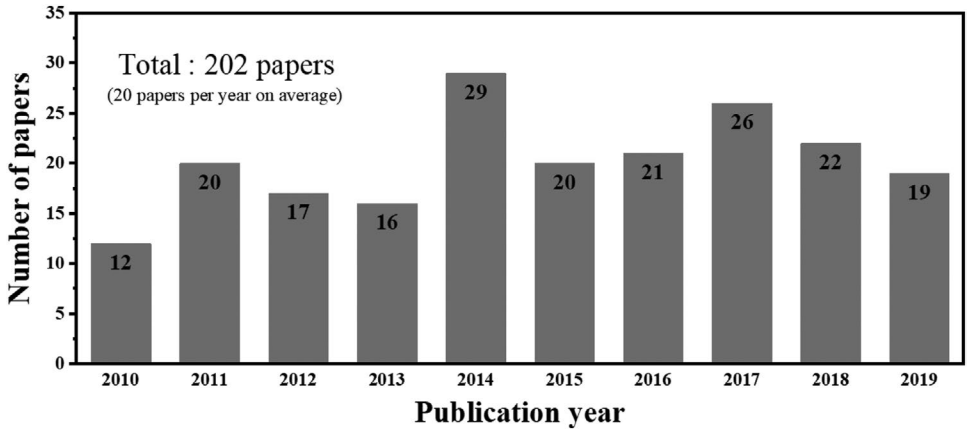

Figure 2. Graph of Advanced Materials papers from Korea Advanced Institute of Science and Technology (KAIST) in the last ten years (2010–2019).

We hope that this editorial paper of *Advanced Materials* special issue will introduce the KAIST multidisciplinary research activities to provide novel ideas and knowledge of advanced materials science and engineering.

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