EDITORIAL

Journal of Semiconductors
(2021) 42, 100101
doi: 10.1088/1674-4926/42/10/100101

Preface to the Special Issue on Flexible Energy Devices

Zhiyong Fan[1, †], Yonghua Chen[2], Yuanjing Lin[3, 4], Yunlong Zi[5], Hyunhyub Ko[6], and Qianpeng Zhang[1]

[1]Department of Electronic & Computer Engineering, The Hong Kong University of Science and Technology, Hong Kong 999077, China

[2]Institute of Advanced Materials, Nanjing Tech University, Nanjing 211816, China

[3]School of Microelectronics, Southern University of Science and Technology, Shenzhen 518055, China

[4]Engineering Research Center of Integrated Circuits for Next-Generation Communications, Ministry of Education, Southern University of Science and Technology, Shenzhen 518055, China

[5]Department of Mechanical and Automation Engineering, The Chinese University of Hong Kong, Hong Kong 999077, China

[6]Energy and Chemical Engineering, Ulsan National Institute of Science and Technology, Ulsan 44919, Republic of Korea

Citation: Z Y Fan, Y H Chen, Y J Lin, Y L Zi, H Ko, and Q P Zhang, Preface to the Special Issue on Flexible Energy Devices[J]. *J. Semicond.*, 2021, 42(10), 100101. http://doi.org/10.1088/1674-4926/42/10/100101

Flexible energy devices are the building blocks for next-generation wearable electronics. Flexible energy devices are expected to have multiple functions, such as energy conversion from light to electricity and vice versa, energy generation from triboelectric, energy storage and so on. These functions can be efficiently realized by solar cells, light-emitting diodes (LEDs), triboelectric nanogenerators (TENG), batteries and supercapacitors, etc. The flexible energy devices can be integrated into flexible, wearable, and/or portable platforms to enable wide application prospects in the fields of information, energy, medical care, national defense, etc. However, flexible energy devices face more challenges when compared to their rigid counterparts, which requires more breakthroughs and research efforts on fabrication techniques, materials innovation, novel structure designs, and deep physical understandings.

This special issue assembles 8 review articles providing a comprehensive summary of the latest development on flexible energy devices based on various technologies and functional semiconductor materials. Briefly, Dong and Wang have comprehensively reviewed and discussed the challenges of TENG-based self-charging power textiles that can become the future energy autonomy power sources[1]. The self-charging power textiles hybridizing fiber/fabric shaped batteries/supercapacitors are summarized from the aspect of textile structural designs. Ma *et al.* reviewed the flexible energy devices for wearable bioelectronics[2]. These flexible energy devices can be constructed in flexible platforms as the stable power supply for smart sensing, personalized healthcare, and robotics applications. More importantly, they summarized the existing challenges for flexible energy devices: mechanical stability, energy storage capacity for miniaturized devices, and biocompatibility. More specifically, Li *et al.* reviewed the recent advances in zinc ion batteries (ZIBs)[3]. Because of the intrinsic safety, abundant storage, and low cost, the rechargeable aqueous ZIBs have become one of the most promising portable candidates for wearable energy storage devices with medical and primary safety. They also summarized the advances in overcoming the most important challenges for ZIBs, namely the rigid current collector and/or metal anode, easily detached cathode materials, and the relatively narrow voltage window of flexible electrolytes. This timely review makes the ZIBs one step closer to commercial applications.

Zhu *et al.* delivered a timely review on the progress of efficient flexible solar cells made of nanostructures[4]. The nanostructures enhance the mechanical robustness of flexible solar cell devices while optimizing the light-trapping capabilities. Kong *et al.* provided a focused discussion on the flexible perovskite solar cells (FPSCs)[5]. Considering the power conversion efficiency (PCE) of FPSCs has already achieved 21.1%, their thorough review on the development of flexible substrates, carrier transport layers, perovskite films, and electrodes are highly appropriate and enlightening. Moreover, they also pointed out the future work on FPSCs can be focused on the directions, such as large-area solar cells modules, environmental stability, and mechanical stability. Tang *et al.* reviewed the development of FPSCs from three aspects, namely the small-area flexible devices, roll-to-roll (R2R) processed devices with large scale, and emerging flexible cells with deformability and stretchability[6]. These deformable and lightweight FPSCs can be applied in wearable and portable electronics as the power supply. Their review shows a pathway to the high possibility of commercialization of FPSCs for self-powered systems. On the other hand, Ye *et al.* reviewed the recent advances on the asymmetric non-fullerene small molecule acceptors for polymer solar cells[7]. The advantages of asymmetric small molecules were discussed in three aspects: charge transport, molecular energy level, and active layer accumulation morphology. They also pointed out that the complicated synthesis of asymmetric small molecule acceptors (A-NF-SMAs) is still a critical problem that scientists need to address in the future.

Besides the solar cells devices which convert light energy to electrical energy, this special issue also includes the review on blue perovskite LEDs for next-generation displays from Yoon *et al.*, as one kind of efficient energy conversion devices[8]. They summarized the three types of perovskite structures: perovskite nanocrystals (PeNCs), 2-dimensional (2D) and quasi-2D perovskites, and bulk (3D) perovskites. Moreover, they brought researchers' attention to the remaining challenges of blue perovskite LEDs, namely the quantum

Correspondence to: Z Y Fan, eezfan@ust.hk
Received 23 SEPTEMBER 2021.

efficiency of the emissive layer, the operational stability, and color stability, by solving which people can further boost the development of next-generation displays.

We sincerely hope this special issue could provide the meaningful and profound review and perspective on the field of flexible energy devices. We would like to thank all the authors for their outstanding contributions to this special issue. We are also grateful to the editorial and production staff of the *Journal of Semiconductors* for their kind assistance.

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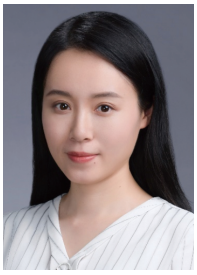
Zhiyong Fan is currently a Professor of the Department of Electronic & Computer Engineering, HKUST, Hong Kong SAR, China. His current research interests include the design and fabrication of novel nanostructures and nanomaterials for high-performance optoelectronics, energy harvesting devices, and sensors. He has published about 200 papers in *Nature*, *Nature Materials*, *Nature Communications*, *Science Advances*, and *Journal of Semiconductors* with a total citation of more than 21 000 times. Prof. Fan is a Fellow of the Royal Society of Chemistry, a Senior Member of IEEE, and the founding member of The Hong Kong Young Academy of Sciences.

Yonghua Chen is currently a full professor at Institute of Advanced Materials at Nanjing Tech University. He has got the Young 1000 Talents, Jiangsu Specially-Appointed Professor, Jiangsu Distinguished Young Scholars projects, and Jiangsu Province six talent peak projects. He has been focusing on perovskite photovoltaic cells in view of their efficiency and stability by taking ionic liquids as the main research line. In last 5 years, as a correspondence author, he has published 50 papers (including *Science*, *Nature Energy*, *Nature Photonics*, *Chem*, *Advanced Materials*, *Nano Letters*, *Angewandte Chemie International Edition*, etc).



Yuanjing Lin received her Ph.D degree in Electronic and Computer Science, Hong Kong University of Science and Technology in 2018. From 2019 to 2020, she was a Postdoctoral Fellow in Electrical Engineering and Computer Sciences at the University of California, Berkeley. She is currently an Assistant Professor at the Southern University of Science and Technology. Her research interests focus on flexible electronics and wearable sensing systems.

Yunlong Zi is an Assistant Professor in Department of Mechanical and Automation Engineering at the Chinese University of Hong Kong since 2017. Dr. Zi received his Ph.D. in Physics from Purdue University in 2014; his Bachelor of Engineering in Materials Science and Engineering from Tsinghua University in 2009. Before joining CUHK, he worked as a Postdoctoral Fellow at Georgia Institute of Technology during 2014–2017. His current research interests mainly focus on high-efficiency mechanical energy harvesting through triboelectric nanogenerators (TENG), triboelectric effect, discharge, TENG triggered high-voltage applications, and self-powered systems.

Hyunhyub Ko is a professor of Energy and Chemical Engineering at Ulsan National Institute of Science and Technology (UNIST) in South Korea. He joined the UNIST as an assistant professor in 2010. He received his PhD in Materials Science and Engineering from Georgia Institute of Technology in 2008. From 2008 to 2010, he worked at University of California, Berkeley as a postdoctoral fellow in the Department of Electrical Engineering and Computer Sciences. His research interests are in the area of functional nanomaterials for flexible electronics, sensors, and energy devices.

Qianpeng Zhang received his Ph.D. degree in Electronic & Computer Engineering (ECE) from The Hong Kong University of Science and Technology (HKUST) in 2019. He is currently a Research Assistant Professor of the Department of ECE, HKUST, Hong Kong SAR, China. His research interests focus on the nanophotonics in perovskite nanowires and LEDs. He is also devoted to the study of stable high-performance perovskite LEDs for advanced displays.