EDITORIAL

Journal of Semiconductors
(2023) 44, 020101
doi: 10.1088/1674-4926/44/2/020101

Preface to Special Issue on Novel Semiconductor-biochemical Sensors

Zhao Li[1, 2, 3, †], Xiangmei Lin[4], Dongxian He[5], Yingxin Ma[6], and Yuanjing Lin[7]

[1]State Key Laboratory on Integrated Optoelectronics, Institute of Semiconductors, Chinese Academy of Sciences, Beijing 100083, China

[2]Center of Materials Science and Optoelectronics Engineering, University of Chinese Academy of Sciences, Beijing 100049, China

[3]Beijing Key Laboratory of Genome and Precision Medicine Technologies, Beijing 100101, China

[4]Chinese Academy of Inspection and Quarantine, Beijing 100123, China

[5]College of Water Resources and Civil Engineering, China Agricultural University, Beijing 100083, China

[6]CAS Key Laboratory of Quantitative Engineering Biology, Guangdong Provincial Key Laboratory of Synthetic Genomics and Shenzhen Key Laboratory of Synthetic Genomics, Shenzhen Institute of Synthetic Biology, Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences, Shenzhen 518055, China

[7]School of Microelectronics, Southern University of Science and Technology, Shenzhen 518033, China

Citation: Z Li, X M Lin, D X He, Y X Ma, and Y J Lin, Preface to Special Issue on Novel Semiconductor-biochemical Sensors[J]. *J. Semicond.*, 2023, 44(2), 020101. https://doi.org/10.1088/1674-4926/44/2/020101

Since 2020, the global outbreak and continued evolution of the COVID-19 pandemic have brought the concepts of nucleic acid, antigen-antibody, gene sequencing, and other biochemical testing into ordinary families. In this regard, novel semiconductor-biochemical sensors that convert biochemical information into monitorable electrical and optical signals according to specific rules have become increasingly important and indispensable. These sensors deeply fuse the technical advantages of semiconductors and biochemistry, integrating interdisciplinary subjects such as molecular biology, nanomaterials, microfluidics, artificial intelligence (AI), etc. With the advantages of fast speed, high sensitivity, high integration, easy mass manufacturing, the novel technologies are the "pioneer" of biomedical information acquisition and the "heart" of modern medical diagnostic equipment. Currently, the technologies are showing a spurt of development, with new products emerging, new functions being developed, and new application scenarios being expanded. The research hotspots cover a wide range, including immediate detection, non-invasive analysis, wearable devices, on-site monitoring, etc. This issue looks at the latest advances in the novel technologies for physiological dynamic monitoring of animals/plants and rapid detection of highly pathogenic pathogens, while covering applications in agriculture, fisheries, animal husbandry, biosecurity, and wearable medicine.

This special issue assembles 6 review articles and 2 research articles, providing a comprehensive summary of the latest development on novel semiconductor-biochemical sensors. Liang *et al.* have comprehensively introduced the synthesis and biofunctionalization of quantum dots (QDs), a variety of methods based on QDs for virus detection as well as the prospects and challenges of QDs-based sensors for viral nucleic acid detection and immunoassays[1]. Strategies such as reducing the biotoxicity of QDs, enabling high-scale QDs preparation, and incorporating the nucleic acid free-extraction method are promising to satisfy the demand for virus detection in times of pandemics. Zheng *et al.* summarized the advances of semiconductor biosensors based on graphene, carbon nanotube and silicon nanowire for detection of viral zoonoses[2]. They focused on the working principles, design directions and application prospects of the biosensors. For increasing complex epidemic conditions of viral zoonoses, the development of the sensors tended to develop new materials and integrate multiple technologies to achieve shorter detection times and higher detection sensitivity and specificity. Liu *et al.* summarized the limitations and challenges of traditional methods in detecting early viral diseases and highlight a review of current developments in the detection of viral diseases in salmonids[3]. Moreover, they described the material properties, working principles, and application prospects of the nucleic acid test-based semiconductor biosensors suitable for *in situ* detection of salmonid diseases. He *et al.* reviewed advanced biosensors for monitoring pests and diseases, including image-based technology, electronic noses and wearable sensors[4]. They pointed out that the future trend of the field is to improve plant health management and crop production efficiency by integrating various technologies through interdisciplinary cooperation. Wang *et al.* discussed the theoretical analysis of microcantilever-based biochemical sensors and their applications in gaseous and aqueous environments[5]. They concluded that the sensors had the advantages of high sensitivity, fast response and small size. However, the anti-interference capability of the sensors depends on the signal amplification technique, and it is difficult to miniturize the optical lever setup, which repectively limit the application scenarios and the portability. The combination of the technologies with AI will explore more potential applications. Shi *et al.* reviewed recent advances in textile-based sweat sensors, including the mechanisms of biosensors, fabrication of textile conductors, system integration, and applications[6]. They discuss two strategies toward high-performance wearable textile-based biosensors and the challenges of textile-based sweat sensing devices in terms of reusability, stability, and reproducibility. Cao *et al.* developed an antibody-modified graphene transistor for ultrasensitive minute-level detection of methamphetamine (Met) in complex environments[7]. The

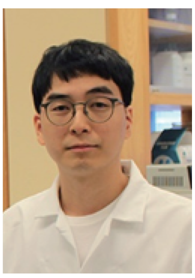
Correspondence to: Z Li, zhaoli@semi.ac.cn
Received 3 FEBRUARY 2023.

anti-Met probes capture the targets thus leading to a p-doping effect near the graphene channel. The limit of detection reaches 50 aM (5.0×10^{-17} M) Met in solution, which demonstrates its effectiveness in preventing drug abuse. Yang *et al.* designed a very large-scale biomedical sensing application-specific integrated circuit (ASIC) with a 640 × 640 ion sensitive field effect transistor (ISFET) array[8]. The chip was applied to monitor the dynamic processes of fluid flow through ion imaging and pH changes generated by CaSki cell metabolism. This platform has the potential for continuous and parallel monitoring of cell metabolism in single cell culture.

We sincerely hope this special issue could provide the meaningful and profound review and perspective on the field of semiconductor-biochemical sensors. 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.

References

[1] Liang Y Q, Mao G B, Dai J B, et al. Biofunctionalized semiconductor quantum dots for virus detection. J Semicond, 2023, 44, 023101
[2] Zheng J H, Feng C Y, Qiu S Y, et al. Application and prospect of semiconductor biosensors in detection of viral zoonoses. J Semicond, 2023, 44, 023102
[3] Liu X F, Qiu S Y, Fang H P, et al. A brief review and perspective of nucleic acid test biosensors for salmonids viral diseases detection. J Semicond, 2023, 44, 023103
[4] He J Y, Chen K, Zhai J F, et al. Advanced biosensing technologies for monitoring of agriculture pests and diseases: A review. J Semicond, 2023, 44, 023104
[5] Wang J J, Xu B X, Zhu Y F, et al. Microcantilever sensors for biochemical detection. J Semicond, 2023, 44, 023105
[6] Shi Y Q, Zhang Z Y, Huang Q Y, et al. Wearable sweat biosensors on textiles for health monitoring. J Semicond, 2023, 44, 021601
[7] Cao B P, Dai C H, Wang X J, et al. Ultrasensitive detection of methamphetamine by antibody-modified transistor assay. J Semicond, 2023, 44, 022001
[8] Yang L, Huang Y Z, Song Z G, et al. A 640 × 640 ISFET array for detecting cell metabolism. J Semicond, 2023, 44, 024101



Zhao Li received his Ph.D. degree in Physical Electronics from the University of Chinese Academy of Sciences in 2017. From 2017 to 2021, he worked as a postdoctoral researcher in Ping Wang's lab at the Perelman School of Medicine, University of Pennsylvania. His research interests focus on developing and validating of innovative point of care devices with novel biosensors and microfluidics. Since 2021, he has started as a full professor in the Institute of Semiconductors, Chinese Academy of Sciences, working on the development of novel biochemical sensors and medical testing equipments.

Xiangmei Lin got her Doctor's Degree on Veterinary Pathology in 1998 at Nanjing Agricultural University. Her research interests include detection and monitoring technologies for animal diseases, zoonotic diseases, foreign animal diseases and monitoring technologies of genetically modified animals detection.

Dongxian He is working in the College of Water Resources and Civil Engineering, China Agricultural University, and is the scientist of intelligent control technology in National Medicine Industry Technology System and Key Lab. Agricultural Engineering in Structure and Environment of Ministry of Agriculture and Rural Affairs. She graduated from Chiba University, Japan, and has long been committed to the R & D of LED plant factories and information monitoring technology.

Yingxin Ma received her Ph.D. degree in Biochemistry from Beijing University of Chemical Technology in 2016. She is currently a professor in Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences. Her research interests are focused on fluorescence nanosensors, labeling and imaging of virus.

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 nanomaterial innovation for wearable and printable electronics, micro/nanostructured sensors, flexible energy storage devices and their applications in smart systems.