2D materials as a new platform for photonic applications

Jianji DONG (✉)¹, Zhipei SUN (✉)²

¹ Wuhan National Laboratory for Optoelectronics, Huazhong University of Science and Technology, Wuhan 430074, China

² Department of Electronics and Nanoengineering, Aalto University, Tietotie 3, Espoo FI-02150, Finland

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Two-dimensional (2D) layered materials possess sheet-like structures with single-atom or few-atom thicknesses. They exhibit exceptional electronic and optical properties due to quantum confinement in the direction perpendicular to the 2D plane. Besides being the basis of various modulators and photodetectors, 2D materials have realized light sources with femtosecond pulse duration utilizing their ultrahigh optical nonlinearity. Recent developments and explorations of various 2D materials and their heterostructures have prompted intense research on various photonic devices with superior performance and functionalities. These developments can pave the way for realistic applications of 2D materials, and boost the fundamental study of various physical effects and phenomena.

This special issue on “2D materials for photonic applications” covers the most recent progresses in photonic applications of 2D materials. In the three reviews and two original research articles included, it introduces light sources, modulators, and fabrication methods of 2D materials. The significant benefits of 2D materials for electronics and photonics are also presented, providing a roadmap for a broad range of application fields.

Mustonen et al. [1] summarized the fabrication methods of large-area transparent graphene electrodes for industry, including liquid exfoliation and chemical vapor deposition. Zhong et al. [2] reviewed different graphene-based all-optical modulators, and comprehensively discussed their performances in detail. Yao et al. [3] focused on integrated optical switches enabled by 2D materials and beyond. They summarized state-of-the-art optical switches (e.g., all-optical, thermo-optical, and electro-optical modulators) in terms of their energy consumption and response time, showing several stimulating charts. Mu et al. [4] and Li et al. [5] demonstrated pulse generation based on 2D nanoparticles, which can potentially generate stable and rectangular pulses. These researches are highly promising for practical applications.

The five articles selected for this special issue cover only a portion of the recent advances and applications in this rapidly growing domain of 2D materials. In the future, significant developments in 2D materials for photonic applications are expected. We hope that this special issue on “2D materials for photonic applications” will interest readers, and provide useful references that will inspire future research in this exciting field.

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References

1. Mustonen P, Mackenzie D M A, Lipsanen H. Review of fabrication methods of large-area transparent graphene electrodes for industry. *Frontiers of Optoelectronics*, 2020, 13(2): 91–113
2. Zhong C Y, Li J Y, Lin H T. Graphene-based all-optical modulators. *Frontiers of Optoelectronics*, 2020, 13(2): 114–128
3. Yao Y H, Cheng Z, Dong J J, Zhang X L. Performance of integrated optical switches based on 2D materials and beyond. *Frontiers of Optoelectronics*, 2020, 13(2): 129–138

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E-mails: jjdong@hust.edu.cn (J. Dong), zhipei.sun@aalto.fi (Z. Sun)

4. Mu H R, Liu Z K, Bao X Z, Wan Z C, Liu G Y, Li X P, Shao H Y, Xing G C, Shabbir B, Li L, Sun T, Li S J, Ma W L, Bao Q L. Highly stable and repeatable femtosecond soliton pulse generation from saturable absorbers based on two-dimensional $\text{Cu}_3\text{-xP}$ nanocrystals. *Frontiers of Optoelectronics*, 2020, 13(2): 139–148
5. Li X H, Peng J J, Liu R S, Liu J S, Feng T C, Qyyum A, Gao C X, Xue M Y, Zhang J. Fe_3O_4 nanoparticle-enabled mode-locking in an erbium-doped fiber laser. *Frontiers of Optoelectronics*, 2020, 13(2): 149–155

Jianji Dong is Professor of Wuhan National Laboratory for Optoelectronics (WNLO), Huazhong University of Science and Technology (HUST), China. He received his Ph.D. degree in Optical Engineering from HUST in 2008. He then completed postdoctoral work at Cambridge University, UK. In March of 2010, he returned to HUST and was promoted to a full professorship in 2013. His research interests include integrated microwave photonics, silicon photonics, and photonic computing. He has published more than 100 papers in high-profile journals such as *Nature Communications*, *Light Science and Applications*, and *Physical Review Letters*. He has made special contributions to an energy-efficient graphene–silicon microheater, a programmable temporal cloak, and a complex spectrum analyzer in orbital angular momentum mode. He was awarded the Fund of Excellent Youth Scholar by the National Natural Science Foundation of China, and the First Award of Natural Science of Hubei Province. He is the editorial member of *Scientific Reports*, associate editor of *IET Optoelectronics*, and executive editor-in-chief of *Frontier of Optoelectronics*. He is an IEEE Senior Member and an OSA member.

Zhipei Sun is Professor of Photonics and head of the Photonics Research Group at Department of Electronics and Nanoengineering of Aalto University, Finland. He earned his Ph.D. degree from Institute of Physics, Chinese Academy of Sciences, China in 2005. His research interests include nonlinear optics, nanophotonics, and ultrafast photonics. His work has focused on 2D materials and their mixed-dimensional heterostructures for photonics and optoelectronics. Currently, he is actively involved with the European Quantum Flagship, the Academy of Finland Photonics Flagship, and the Academy of Finland Centre of Excellence in Quantum Technology projects. In 2019, he was awarded an Advanced Grant from the European Research Council. He has published more than 200 conference proceedings and articles in high-profile journals, such as *Nature Photonics*, *Nature Materials*, *Nature Nanotechnology*, *Science*, and *Nature Communications*.