**Photopatterning of graphene oxide and other two-dimensional materials for highly integrated multifunctional devices**

*Keng-Te Lin, Han Lin, Tieshan Yang, Yunyi Yang, Xiaorui Zheng and Baohua Jia*

*Centre for Translational Atomaterials, Faculty of Science, Engineering and Technology, Swinburne University of Technology, John Street, Hawthorn, Victoria 3122, Australia*

*Email:* *bjia@swin.edu.au*

**Introduction**

Graphene oxide (GO) is a graphene sheet covalently decorated with various oxygen functional groups either on the basal plane or at the edge. It is an attractive material due to a unique set of physical and chemical characteristics arising from the hybridization of sp2 and sp3 carbon atoms. Moreover, the electronic and optical properties of GO can be tailored by manipulating the size, shape and relative fraction of the sp2-hybridized domains during its reduction process, making it an emerging versatile platform for integrated device applications.

**Results and discussion**

The reduction of GO can be seen as the removal of the oxygen functional groups. Being free of the high temperature or toxic chemicals required in the thermal or chemical reduction methods, photo reduction allows not only the precise control of the reduction extent, but also the localized manipulation of the properties of GO films. Most importantly, the flexible micro-structure patterning on the GO ultrathin films can be realized simultaneously during the laser reduction process.[1] As a result, flexible and ultra light weight GO films with both controllable properties and predefined arbitrary structures can be readily achieved by using the one-step mask-free direct laser printing (DLP) method, enabling numerous integrated device applications. Such a versatile patterning technology can be also extended to other 2D materials, including hexagonal boron nitride, transition metals dichalcogenides and perovskite et al, opening enormous opportunities for new device designs, architectures and functionalities.

A wide range of topics have been covered in this paper about GO films and other 2D materials,[2-7] including various experimental and theoretical approaches, the understanding of the optical responses, and the design and optimization of the integrated devices. The 2D films show unique properties that are unavailable to conventional materials such as the tunable linear and nonlinear optical properties, a versatile patterning capability by DLP, the surface functionalization possibility, the wavefront shaping ability, and the mechanical robustness, which are highly demanded for the next generation ultralight weight, highly efficient, highly integratable, and flexible optical, electronic, and mechanical systems, opening up new avenues for various multidisciplinary applications.

**References**

1. Lin, H., Jia, B., Gu, M., (2011) Optics letters 36, 406-408.
2. Lu, H., Gan, X., Mao, D. et al. (2018) Scientific Report, 8, 1558.
3. Zheng, X., Jia, B., Chen, X., Gu, M., (2014) Adv. Mater. 26, 2699-2703.
4. Zheng, X., Jia, B., Lin, H., Qiu, L., Li, D., Gu, M., (2015) Nature Communications, 6, 8433.
5. Lin, H., Sturmberg, B. C. P. et al, (2019) Nature Photonics, 13, 270–276.
6. Yang, Y., Lin, H., et al, (2019) ACS Photonics 6, 1033–1040.
7. Yang, Y., Wu, J., X. Xu, et al, (2018) APL Photonics, 3, 120803.

**Acknowledgement**

This work is supported by Australian Research Council through the Discovery Project scheme (DP150102972, DP190103186) and Industrial Transformation Training Centres scheme (IC180100005).