新闻

信电学院林宏焘研究员二维材料光电子集成技术入选“Opticsin2018”

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近日，信电学院林宏焘研究员同麻省理工学院JuejunHu教授课题组联合开发的基于硫基材料的二维材料光电子集成技术“Photonic Integration of 2-D Materials via Chalcogenide Glass”入选美国光学学会旗下新闻杂志*Optics & PhotonicsNews*评出的“Opticsin2018”。林宏焘研究员是第一作者和通讯作者，浙江大学是第一单位。

自2004年石墨烯发明以来，数百种新型二维材料已被合成利用。由于特殊的量子限域效应的存在，二维材料具备传统材料所不具备的优异的光电子特性，使得它们非常适合下一代新型纳光电子器件的研发。

但由于二维材料是由单层或少层原子组成，传统垂直入射方式往往无法使它们与光产生足够的相互作用。利用波导结构使得光能沿着二维材料表面方向传播将能显著提高两者之间的相互作用。然而过去的方法是将二维材料转移到已做好的集成光子器件上，这无法全面发挥二维材料所具备的独特性能，并存在成品率低等问题。

针对这个限制二维材料光电子难题，林宏焘研究员同美国麻省理工学院、中佛罗里达大学、英国南安普敦大学组成的研究团队一道，开发出了一套基于硫基材料的二维材料光电子单片集成技术（Nat. Photon. 11, 798-805 (2017)）。该技术无需传统介质薄膜生长技术需要的高温或等离子体生长环境，可以避免二维材料表面沉积的高性能硫基薄膜对结构及性能的破坏，而且还能对二维材料起到隔绝保护，以及作为电介质层实现栅极调控等功能。

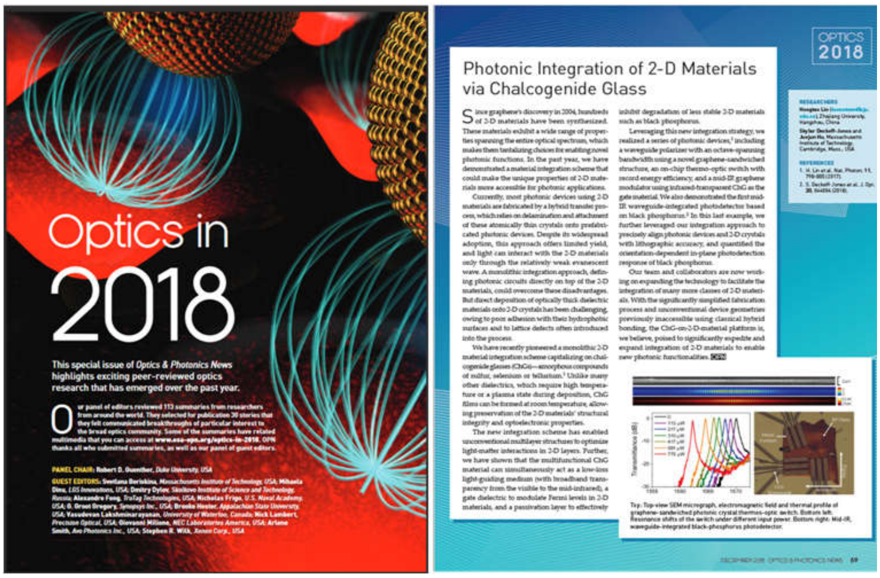
该技术不仅可以制备如同金属电极结构的波导结构，还能制备多层结构，真正地发挥二维材料独特光电子性能，实现器件性能的极大提升。同时，通过将单层石墨烯集成在波导结构正中央，研制出当前片上工作波段最宽的片上起偏器、峰位移能耗最低的热光调制器。也研制出首个波导集成中红外石墨烯电吸收调制器及黑磷探测器。

基于硫基材料的二维材料光电子集成技术，极大地降低了从微米级尺寸到晶圆级尺寸二维材料的光电子集成难度。不仅将对新型二维材料在集成光电子器件方面的基础研究起到极大地推动作用，还将为大规模二维材料集成光电子芯片地研发提供一条非常可行的技术路线。而且该平台型技术也将在超快超低功耗信息处理链路、柔性可穿戴传感、中红外波段物质检测及成像等领域具有重大的应用前景。

参考链接：

https://www.osa-opn.org/home/articles/volume_29/december_2018/features/optics_in_2018/

https://www.osa-opn.org/home/articles/volume_29/december_2018/extras/photonic_integration_of_2d_materials_via_chalcoge/



OPTICS 2018

Optics in 2018

This special issue of *Optics & Photonics News* highlights exciting peer-reviewed optics research that has emerged over the past year.

Our panel of editors reviewed 113 summaries from researchers from around the world. They selected for publication 30 stories that they felt communicated breakthroughs of particular interest to the broad optics community. Some of the summaries have related multimedia that you can access at www.osa-opn.org/optics-in-2018. OPN thanks all who submitted summaries, as well as our panel of guest editors.

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Photonic Integration of 2-D Materials via Chalcogenide Glass

Since graphene's discovery in 2004, hundreds of 2-D materials have been synthesized. These materials exhibit a wide range of properties spanning the entire optical spectrum, which makes them tantalizing choices for enabling novel photonic functions. In the past year, we have demonstrated a material integration scheme that could make the unique properties of 2-D materials more accessible for photonic applications.

Currently, most photonic devices using 2-D materials are fabricated by a hybrid transfer process, which relies on delamination and attachment of these atomically thin crystals onto prefabricated photonic devices. Despite its widespread adoption, this approach offers limited yield, and light can interact with the 2-D materials only through the relatively weak evanescent wave. A monolithic integration approach, defining photonic circuits directly on top of the 2-D materials, could overcome these disadvantages. But direct deposition of optically thick dielectric materials onto 2-D crystals has been challenging, owing to poor adhesion with their hydrophobic surfaces and to lattice defects often introduced into the process.

We have recently pioneered a monolithic 2-D material integration scheme capitalizing on chalcogenide glasses (ChGs)—amorphous compounds of sulfur, selenium or tellurium.[1] Unlike many other dielectrics, which require high temperature or a plasma state during deposition, ChG films can be formed at room temperature, allowing preservation of the 2-D materials' structural integrity and optoelectronic properties.

The new integration scheme has enabled unconventional multilayer structures to optimize light-matter interactions in 2-D layers. Further, we have shown that the multifunctional ChG material can simultaneously act as a low-loss light-guiding medium (with broadband transparency from the visible to the mid-infrared), a gate dielectric to modulate Fermi levels in 2-D materials, and a passivation layer to effectively inhibit degradation of less stable 2-D materials such as black phosphorus.

Leveraging this new integration strategy, we realized a series of photonic devices,[1] including a waveguide polarizer with an octave-spanning bandwidth using a novel graphene-sandwiched structure, an on-chip thermo-optic switch with record energy efficiency, and a mid-IR graphene modulator using infrared-transparent ChG as the gate material. We also demonstrated the first mid-IR waveguide-integrated photodetector based on black phosphorus.[2] In this last example, we further leveraged our integration approach to precisely align photonic devices and 2-D crystals with lithographic accuracy, and quantified the orientation-dependent in-plane photodetection response of black phosphorus.

Our team and collaborators are now working on expanding the technology to facilitate the integration of many more classes of 2-D materials. With the significantly simplified fabrication process and unconventional device geometries previously inaccessible using classical hybrid bonding, the ChG-on-2-D-material platform is, we believe, poised to significantly expedite and expand integration of 2-D materials to enable new photonic functionalities. OPN

Top: Top-view SEM micrograph, electromagnetic field and thermal profile of graphene-sandwiched photonic crystal thermo-optic switch. Bottom left: Resonance shifts of the switch under different input power. Bottom right: Mid-IR, waveguide-integrated black-phosphorus photodetector.

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1. H. Lin et al. Nat. Photon. 11, 798-805 (2017).
2. S. Deckoff-Jones et al. J. Opt. 20, 044004 (2018).

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