Deterministic and Scalable Growth of Electrically Self-Contacted 2D Materials-Based Devices

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We will present a chemical vapor deposition process to selectively grow 2D materials in a deterministic manner around lithographically defined bulk metallic patterns which concurrently provide as-grown electrical contact to the material [1]. With this process, monolayer films, with lateral extent of up to hundreds of microns are controllably grown on and around patterned regions of transition metals. The materials display strong luminescence, monolayer Raman signatures, and relatively large crystal domains. In addition to producing high optical quality monolayer material, the metallic patterns remain conductive providing as-grown metallic contacts to the material. Preliminary results (Figure 1) have demonstrated the feasibility of this process through the direct growth of MoS_2 based metal-semiconductor-metal photodiodes and Schottky barrier FET devices. Since the material grows controllably around the lithographically defined patterns, complex device structures and wafer scale circuits can be envisioned. Preliminary results also indicate the technique has the added potential of producing self-contacted heterostructured devices as well as the possibility of controllable doping of the 2D material using alloyed metallic contacts. This is the first report of using bulk metallic patterns resulting in as-grown, self-forming, electrical contact to the monolayer material, providing a simple, scalable, and reproducible method for creating 2D materials-based devices with broad implications for basic research and industrial applications.

References

[1] Khadka, S., Lindquist, M., Aleithan, S. H., Blumer, A. N., Wickramasinghe, T. E., Kordesch, M. E. and Stinaff, E. Adv. Mater. Interfaces, (2016) doi:10.1002/admi.201600599.

Figures

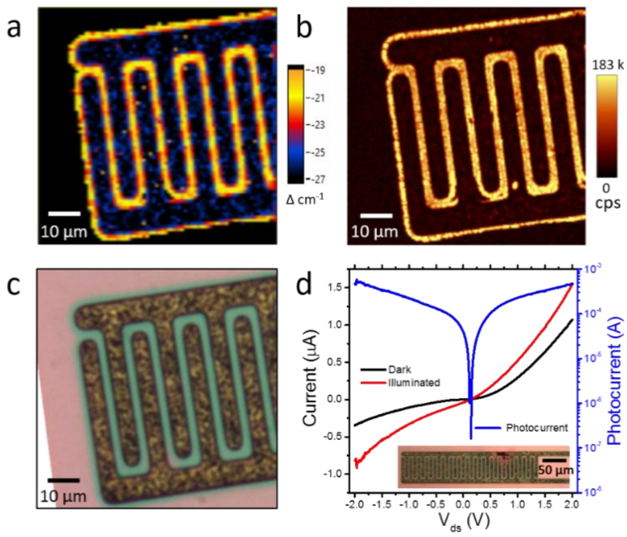

Figure 1: Analysis of as-grown monolayer MoS_2 metal-semiconductor-metal photodiode. a-c, Raman analysis map, photoluminescence map, and optical image respectively. d, Current versus voltage measurements of the device with and without illumination from an unfocused broadband white light led with a power density of approximately 100 pW/µm^2. The inset in d shows the active device region with uniform monolayer coverage.