Innovative Patterning Method for Modifying few-layer MoS_2 Device Geometries

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Mono-Layer and few-layer Tansition Metal Dichalcogenides (TMDCs) have attracted great interest since the discovery of graphene due to their oustanding properties[1-3]. Semiconducting 2D Molybdenum Disulfide (MoS_2) is considered a good candidate for opto-electronic applications due to its remarkable electrical and optical properties. However when mechanically exfoliated, these properties strongly depend on the geometry and number of layers present in the flake. In general, these properties cannot be modified once a device is fabricated out of an exfoliated flake. In this work we present a novel nano-patterning method for 2D material based devices, Pulsed eBeam Gas Assited Patterning (PEBGAP), that allows us to fine tune their properties once the device fabrication steps have been completed. This post-processing technique allows us to modify the channel geometry or thickness of MoS_2 FETs.

PEBGAP post-processing technique is based on using a scanning electron microscope equiped with a gas injection system, and employing XeF_2 as an etching agent. The etchant gas enters the chamber through a small nozzle situated in close proximity to the desired device, adsorbing locally on the substrate. The focused electron beam is then scanned and pulsed over the device to etch away the desired geometry onto the MoS2 flake.

Field effect devices were fabricated from mechanically exfoliated few-layer MoS_2 flakes via optical beam lithography followed by a metal evaporation and lift-off process to define the gate-contact structures. The devices were characterised employing μ-Raman mapping spectroscopy, transport measurements and AFM/SEM microscopy. Afterwards, PEBGAP was utilized to alter device geometries and performance.

References

[1] Jun Lou et al., ACS Nano, 8 (2014) 7930-7937
[2] Hua Zhang et al., Chem. Soc. Rev., 42 (2013) 1934
[3] Dominik Kufer and Gerasimos Konstantanos, Nano Lett., 15 (2015) 7307-7313

Figures

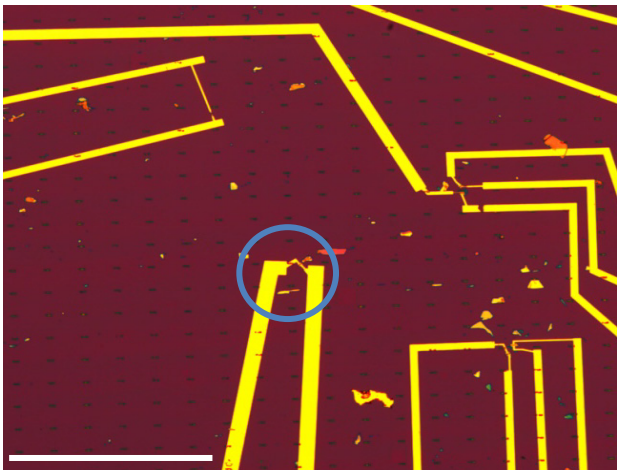

Figure 1. Optical image of a fabricated device. Blue circle indicates the chosen device to be patterned. Scale bar is 500 μm.

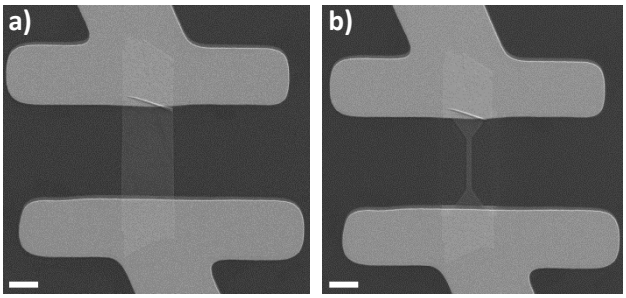

Figure 2. a) SEM image of the MoS_2 device circled in figure 1 before the PEBGAP patterning. **b)** SEM image after the XeF_2 PEBGAP pattern showing a narrowing of 500 nm. Scales bar in a) and b) are 1 μm