Mono-Layer and few-layer Tansition Metal Dichalcogenides (TMDCs) have attracted great interest since the discovery of graphene due to their outstanding properties\(^1\). Semiconducting 2D Molybdenum Disulfide (MoS\(_2\)) is considered a good candidate for optoelectronic 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 equipped 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 MoS\(_2\) 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 \(\mu\)-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


Figures

Figure 1. Optical image of a fabricated device. Blue circle indicates the chosen device to be patterned. Scale bar is 500 \(\mu\)m.

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 \(\mu\)m.