NanoFrazor – A Nanolithography Tool for 2D & 3D Devices

Nils Goedecke
Tero Kulmala, ZhenMing Wu, Felix Holzner
Heidelberg Instruments Nano, Technoparkstrasse 1, Zurich, Switzerland
Nils.goedecke@himt.ch, www.heidelberg-instruments.com

NanoFrazor (thermal scanning probe) lithography has recently entered the market as the first true alternative to electron beam lithography (EBL) [1]. Core of the technology is a heatable probe tip that is used for both patterning and simultaneous inspection of complex nanostructures. The heated tip can pattern very high-resolution (< 10 nm half-pitch) nanostructures by locally evaporating resist materials. The structures are inspected by the cold tip in parallel with the patterning process, enabling stitching and markerless overlay with sub-5 nm accuracy [2]. The technique is compatible with all the common pattern transfer processes [3,4,5].

Shaping 2D materials into narrow ribbons, Hall bars etc. is often required in order to study their properties. Another challenge is formation of high-quality electrical contacts on them. Predominant fabrication process - i.e. EBL followed by etching or lift-off of metal – has its resolution limited by proximity effects, may require complex overlay procedures and typically yields poor quality non-ohmic metal contacts with high Schottky barriers and large contact resistances [6]. Here, we show that NanoFrazor lithography can be used for shaping 2D materials with very high precision (Figure 1a-b) [7] and for forming high-quality metal contact electrodes on them (Figures 1 c–d) [5]. The fabricated devices exhibit vanishing Schottky barrier heights (around 0 meV, Figure 1d), record-high on/off ratios of 1010, no hysteresis, and subthreshold swings as low as 64 mV per decade.

References

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Figures

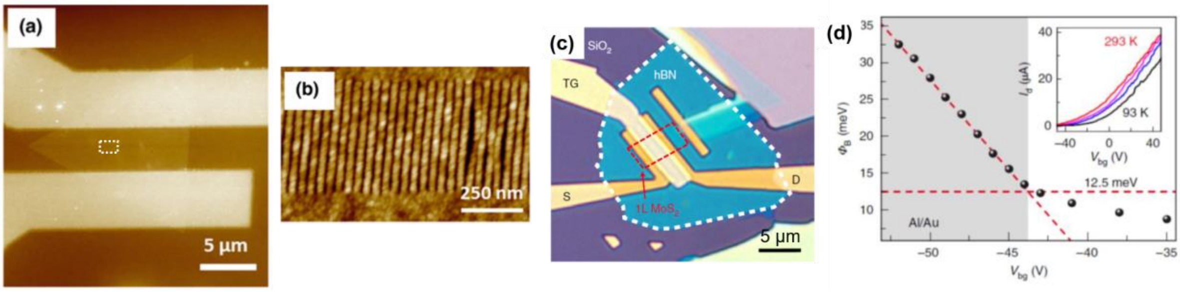

Figure 1: a) AFM image of 18-nm half-pitch 1L MoS_2 nanoribbon array patterned along the zigzag direction. (b) A close-up of the region marked with a white dashed box in (a). Figures (a) and (b) from Ref [7]. (c) Optical image of a 1L MoS_2 FET with a h-BN gate dielectric where the source, drain and top-gate electrodes have been patterned with a NanoFrazor. (d) Gate voltage dependence of Schottky barrier height of a 1L MoS_2 FET with Al/Au contacts (V_{ds} = 2 V). The deviation from the linear response at low V_{bg} (dashed red line) defines the flat band voltage and the SBH. Inset, corresponding temperature-dependent transfer curves (V_{ds} = 2 V). Figures (c) and (d) from Ref. [5].