NanoFrazor lithography for precise shaping and non-invasive contacting of 1D & 2D materials

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Thermal scanning probe (t-SPL), or NanoFrazor lithography is the first true alternative to electron beam lithography (EBL), with the tools readily available on the market [1]. A heatable NanoFrazor tip patterns by locally evaporating resist materials and inspects the sample as an atomic force microscope (AFM). The heated tip can pattern very high-resolution nanostructures (<10 nm half-pitch). The cold tip inspects nanostructures before, during and after the patterning process, enabling stitching and markerless overlay with sub-5 nm accuracy [2]. t-SPL is compatible with all common pattern transfer processes [3,4,5]. It is particularly suitable for shaping 2D materials into narrow ribbons or Hall bars and for making high-quality electrical contacts on them. Here, we show that NanoFrazor lithography can yield high-quality metal electrodes or top gates [3,5], Figures 1 and 2, and shape 2D materials with very high precision [6]. The resulting devices exhibit vanishing Schottky barrier height (~0 meV), record-high on/off ratios of 10^{10}, no hysteresis, and subthreshold swing (SS) as low as 64 mV per decade [5].

References

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[4] Kulmala et al., Proc. SPIE (2018) 1058412
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Figures

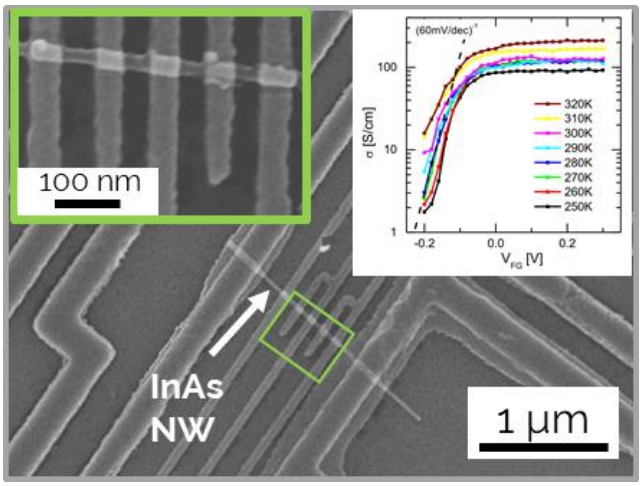

Figure 1: SEM image of an InAs nanowire FET with top gates fabricated using t-SPL. Direct sublimating of the resist prevents charge accumulation in the Al_2O_3 gate dielectric; Left inset: a close-up marked by the green frame; Right inset: the device's performance at different temperatures and SS = 60 mV per decade. [3]

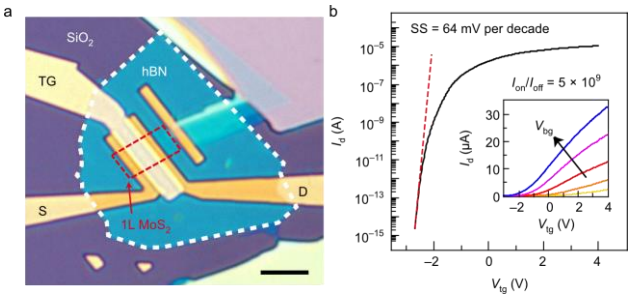

Figure 2: a) 1L-MoS_2 double-gated field-effect transistor (FET) with h-BN as a gate dielectric. Contacts and the top gate patterned using the NanoFrazor lithography; b) Transfer curve of the FET from a) measured at room temperature and source-drain voltage V_{ds} = 2 V. SS = 64 mV per decade, I_{on}/I_{off} = 5×10^9. The inset shows transfer curves at back-gate voltages from −20 V (yellow curve) to 20 V (blue curve). [5]