Optical and Electrical properties of Single Crystalline 2D Material Nanoribbons

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2D material nanoribbons open up a new avenue for optoelectronics, spin orbit coupling and quantum computing due to their width confinement and controllable edge terminations. However, their realization with sufficient yield, scalability, high crystallinity and straight-forward device integrability remains a challenge. We propose a synthesis approach to fabricate single crystalline 2D material nanoribbons of hBN, graphene, and several transition metal di-chalcogenides (TMDCs). The approach is based on the usage of epitaxially grown organic nano-needles which align in predominant crystallographic directions[1] as mask. Resulting nanoribbons of TMDCs exhibit unique optical properties including Raman anisotropy (MoS_2) and tunable photoluminescence (WS_2). Field effect transistors (FET) of nanoribbon networks (NRN) show record mobilities and very high on currents for various TMDCs despite extreme width scaling (W < 20 nm). Lastly, for graphene nanoribbons we demonstrate ferroelectric effect due to attached water molecules on oxygen terminated edges[2].

References

[1] A. Matkovic, *et.al.,* Adv. Funct. Mater. 43, (2019) 1903816.
[2] J. M. Caridad, *et.al.,* Nano Lett. 18, (2018), 4675–4683.

Figures

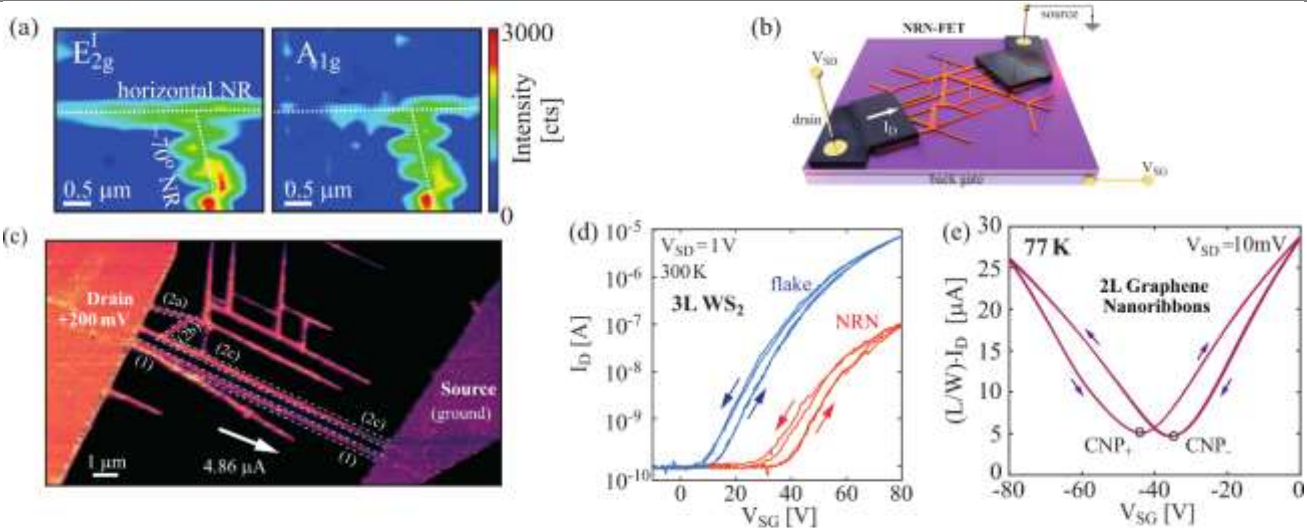

Figure 1: a) MoS_2 Raman intensity maps highlighting a distinct variation of A_{1g} mode as the ribbon direction is changed. b) Schematic diagram of an NRN-based FET. c) *in operando* FM-KPFM image of a graphene NRN-FET exhibiting percolation free nanoribbon nodes. d) Semi-logarithmic transfer curve of WS_2 FET before and after patterning the flakes into NRNs. e) L/W scaled transfer curves for graphene NRN-FET at 77 K, demonstrating bi-modal switching which prevails at low-T.