Inkjet-printed 2d crystals

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Abstract

Ink-jet printing is one of the most promising techniques for large area fabrication of flexible electronic devices [1,2]. Despite much progress, ink-jet printed organic Thin Film Transistor (TFT) still show poor air stability, limited lifetime [3], mobility (μ<0.5 cm^2 V^{-1} s^{-1}) [3], and ON/OFF ratios(<10^5). Near-ballistic transport and high mobility, make graphene an ideal material for nanoelectronics [6]. Its optical and mechanical properties are ideal for thin-film transistors and transparent and conductive electrodes [7]. Two-dimensional (2d) crystals offer properties that are complementary to, yet distinct, from those in graphene. Several semi-conducting 2d crystals show a transition from an indirect band-gap in the bulk to a direct gap in the monolayer. For example, in Molybdenum Disulfide (MoS_2) the bulk indirect bandgap of 1.3 eV increases to a direct bandgap of 1.8 eV in single-layer [9], promising interesting new FET [10] and optoelectronic devices [11,12]. Here we prepare graphene, MoS_2 inks (Figure 1a) and exploit the properties of MoS_2 to fabricate inkjet-printed MoS_2-based TFTs (Figure 2a) and graphene/MoS_2 heterostructures. High quality MoS_2 flakes are dispersed in organic solvents by ultrasonication followed by ultracentrifugation [13] to remove large fragments that are likely to clog the nozzle of the ink-jet printer. We investigate MoS_2 exfoliation in Isopropanol, 1-Methyl-2-pyrrolidone, Dimethylformamide as well as two solvents mixtures. By Optical Absorption Spectroscopy, Transmission electron microscopy and Raman spectroscopy we find that Water/Ethanol mixture gives the highest yield of MoS_2 single layers. MoS_2-ink stripes are then inkjet-printed on Si/SiO_2. The electrical and optical performances of our devices, demonstrate the viability of 2d-crystals printable inks.

References

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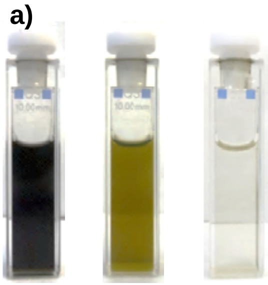
Figures:

a)



b)

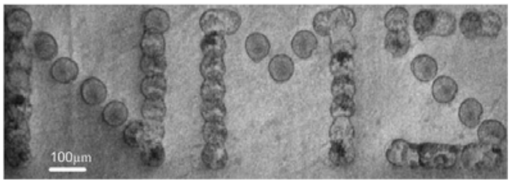


Figure: a) Graphene-ink (left), MoS_2-ink, Boron Niride-ink. b) Example of graphene ink-jet printed pattern.