Charge transport and corrosion inhibiting properties of monolayer hexagonal boron nitride grown by chemical vapor deposition

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Abstract: Hexagonal boron nitride (h-BN), also known as white graphite, is a wide bandgap material that has found use as an appealing insulating dielectric layer in ultra-high mobility graphene devices, 2-dimensional heterostructures and tunneling devices [1–4]. We report the chemical vapor deposition (CVD) growth and characterization of monolayer h-BN. The growth was performed in a tube furnace on Cu foils using an ammonia borane (NH_3-BH_3) precursor. Scanning electron microscopy was used to study the morphology of the as-grown films and optimize growth conditions to yield high coverage of monolayer h-BN. Chemical analysis was performed by electron energy loss spectroscopy and X-ray photoelectron spectroscopy. The hexagonal crystal structure was investigated by electron diffraction of suspended films. Raman spectroscopy of h-BN transferred to SiO_2/Si substrates reveals a prominent Stokes shift at 1366-1370 cm^{-1}. The optical properties of our h-BN films were probed by cathodoluminescence and UV-Vis absorption spectroscopy. In-plane electron transport studies were performed on h-BN monolayer transferred to SiO_2/Si substrates using a variety of electrode geometries. Ni electrodes were used to provide electrical contact. We have observed quadratic scaling of current with voltage (Figure 1), consistent with space-charge limited transport with a mobility of up to ~ 0.01 cm^2/Vs [5]. Our observation of in-plane charge transport suggests that h-BN can function as a semiconductor with appropriately chosen contact electrodes, as is the case with h-BN nanotubes.
Moreover, the suitability of monolayer h-BN for inhibiting corrosion has been investigated. We report the quantitative measurements of monolayer h-BN as a Cu corrosion inhibitor by use of cyclic voltammetry (Figure 2) and Tafel analysis. We have found that CVD grown h-BN reduces the Cu corrosion rate by one order of magnitude compared to bare Cu, suggesting that this ultrathin layer can be employed as an atomically thin corrosion-inhibition coating.

References

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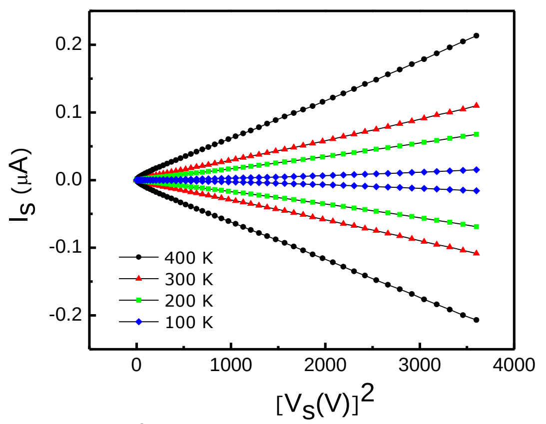

Figure 1: I_s-V_s^2 at various temperatures in vacuum (2×10^{-6} Torr) for a 8 µm channel length monolayer h-BN device.

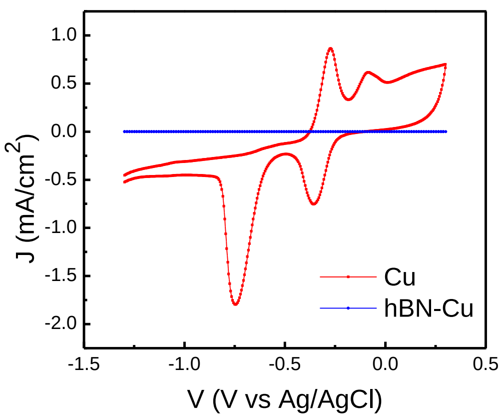

Figure 2: Cyclic voltammetry measurements for a 0.07 cm^2 area bare Cu (red) and h-BN-Cu (blue) in a 0.1 M NaOH solution.