Structural and electrical properties of CVD h-BN for MoS_2-based heterostructure transistors

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Atomically thin hexagonal boron nitride (h-BN), is a two-dimensional (2D) insulator (band gap ~5.9–6.1eV) [1] with a layered structure very similar to graphene [2]. Because of the strong in-plane covalent bonding, 2D h–BN material has an excellent mechanical strength, high thermal conductivity, as well as, chemical inertness and flexibility [3, 4]. More importantly, it has been considered as a promising insulating material that can be integrated in novel hybrid heterostructures. However, current device fabrication requires materials to be transferred from metals, which normally induces polymer residues, metal impurities, or breakage of the h-BN samples, leading to the possibility of degraded device performance. We addressed this challenge by a direct growth of large-area h-BN and MoS_2 materials *via* the Chemical Vapor Deposition (CVD) method. Continuous h-BN films on SiO_2/Si substrates were produced using ammonia-borane (H_3N–BH_3) as precursor under a low-pressure environment by controlling the growth time. X-ray photoelectron spectroscopy (XPS) reveals B1s and N1s peaks located at 191.1 and 398.3 eV, respectively (Fig. 1). The atomic 1:1.12 ratio between the B and N elements indicates B–N bonds with sp^2 hybridization. To evaluate the dielectric properties of the h-BN films, metal–insulator–metal structures were fabricated. The relative dielectric constant of the h-BN films were calculated from the capacitance values and film thickness obtained through the Atomic Force Microscopy (AFM) (Fig. 2). Furthermore, MoS_2/h-BN heterostructures were investigated for potential electronic applications.

References

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[3] I. Jo, et al., Nano Letters, 13 (2013), 550-554.
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Figures

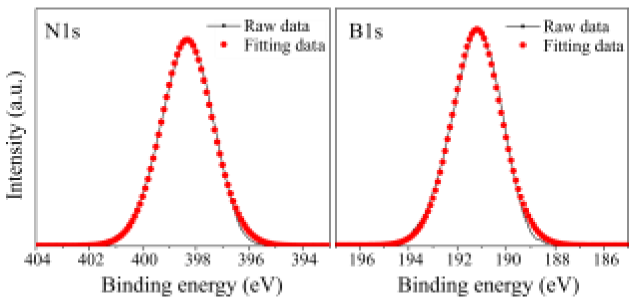

Figure 1: High resolution XPS spectra of N1s and B1s peaks for CVD h-BN films.

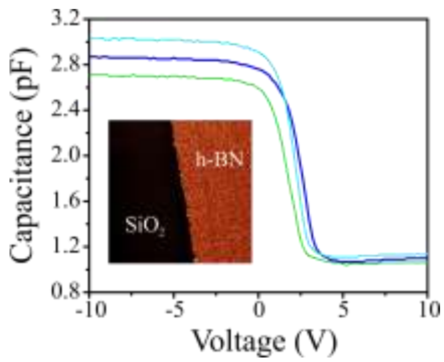

Figure 2: Capacitance-voltage (C-V) characteristics for three different CVD h-BN films. Inset: AFM image of h-BN film on SiO_2/Si.