Growth and transfer of ultrathin boron nitride films for device preparation using Chemical Vapor Deposition

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2D materials are excellent candidates for current and future electronic devices. Among them, hexagonal boron nitride (hBN) is proving to be a key material for future graphene-based optoelectronic devices[1], as it is an insulator and an isostructural of graphene. It appears to be a substrate of choice to boost the properties of graphene and thus enable the implementation of this later in real-life applications. Recently, it has been shown that controlling the degree of crystallinity of BN can have a significant impact on its intrinsic properties. For example, amorphous BN (aBN) displays an ultra-low dielectric constant of 1.16, whereas a value of 4.0 at 1MHz is observed for hBN[2]. Moreover, the feasibility of an ultralow-k and ultrathin aBN film (k=2 for a 3nm-thick layer) as a new capping layer for copper interconnects has been demonstrated[3]. Therefore, tailoring the structure of BN and thus its properties would permit widening its application areas, from isolating interconnects and high-performance electronics in optoelectronic to spintronics[4].
Among the synthesis approaches, Chemical Vapor Deposition (CVD) of hBN has been widely reported in the literature and thin films have been obtained from different precursors such as ammonia-borane, diborane, BCl_3 and borazine (formula $B_3N_3H_6$).
In the present contribution, from borazine as a single source precursor, BN ultrathin films (<30 nm) with different degrees of crystallinity are deposited using CVD. The impact of the different growth parameters on the final material will be discussed. Four different gases are investigated: Ammonia, Nitrogen, Ar/H_2 95/5 and Ar/H_2 90/10. Particular attention is paid to the influence of the precursor flow and the deposition temperature. The obtained films are characterized by ellipsometry, X-ray diffraction, scanning electron microscopy, energy-dispersive X-ray spectroscopy, atomic force microscopy, Raman and Infra-red spectroscopy.
The deposition temperature plays a crucial role, although the nature of the carrier gas strongly influences the reactivity of the borazine and thus the final structure of BN. The results show uniform BN films with low carbon and oxygen contamination on the films deposited using an Ar/H_2 mixture on Si(100). Below 800 °C, amorphous films sensitive to oxidation in air are observed, while from 900 °C stable BN films are obtained. Films grown at 1000 °C show the presence of small crystallites. Control of the crystallinity of BN films can thus be achieved by regulating the temperature during the process, allowing the deposition of films within a range of crystallinity from aBN to hBN.
To investigate the BN electronic properties as a function of its crystallinity degree, BN-based memristor devices are targeted. Two fabrication strategies are tested: the BN direct growth at low temperatures on metallic substrates (electrodes of the device), or film transfer. In particular, different methods are studied to achieve a clean transfer preserving the thin BN layer.

References

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