Growth and Functionalization of Single-Crystal Hexagonal Boron Nitride by Chemical Vapor Deposition

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Hexagonal boron nitride (hBN) is an attractive two-dimensional (2D) material due to its unique optical properties in the deep-UV region, mechanical robustness, thermal stability, and chemical inertness. hBN thin films have garnered significant interest for a wide range of applications, including nanoelectronics, photonics, single photon emission (SPE), anti-corrosion coatings, and membranes. Consequently, the wafer-scale growth of high-quality hBN films is crucial for enabling their use in industrial applications. Chemical vapor deposition (CVD) has emerged as a promising method for producing scalable, single-crystal hBN films. Despite substantial efforts to develop continuous hBN thin films with high crystallinity, ranging from large grains to single crystals, precise thickness control at a wafer scale remains a challenge. The growth of hBN films is heavily influenced by the substrate, particularly the type of metal used, as the solubilities of boron and nitrogen vary depending on the metal. In this talk, I will demonstrate state-of-the-art strategies for growing wafer-scale, single-crystal hBN and discuss the mechanisms underlying hBN growth on catalytic substrates such as Ni and Cu. Next, I will demonstrate the functionalization of hBN layers. While it is well known that defects or carbon substitution in hBN are origins of SPE, I will show that the functionalization of hBN can also cause this phenomenon. Lastly, I will demonstrate organic reactions in confined spaces between hBN or graphene layers. Specifically, I will show that cyclodehydrogenation of hexaphenylbenzene without catalysts as a proof of concept and oxidative polymerisation of dopamine into sheet-like crystalline structure are enabled by the effective high pressure experienced by the reactants between the hBN or graphene layers. Our results demonstrate a facile, general approach for performing new high-pressure chemistry based on confinement of reactants within hBN or graphene layers that provides opportunities for realizing new materials with extraordinary properties.