Towards Higher Growth Rate of Cubic Boron Nitride on Diamond Employing Fluorine Chemistry

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Boron Nitride (BN) is an ultra-wide bandgap material having a bandgap of 6.4 eV and 5.9 eV for the cubic (c-BN) and hexagonal (h-BN) phases, respectively. The ultra-wide bandgap of both BN phases indicates a high breakdown voltage, possibly even greater than diamond [1]. Diamond and c-BN have a small lattice mismatch of 1.4 percent [2]. Moreover, epitaxial c-BN on diamond is expected to have high thermal conductivity. Therefore, diamond is a candidate for use as a substrate for growth of c-BN.

Physical vapor deposition (PVD) including magnetron sputtering, ion-assisted pulsed laser deposition (IAPLD), ion beam-assisted deposition (IBAD) and mass selected ion beam deposition (MSIBD) have been utilized to achieve pure c-BN films [3]. However, these methods require high energy ion bombardment plus high bias voltage applied to the substrate. This leads to high compressive stress, creation of defects and possibly delamination of thick grown films. In addition, growth rate is very low in all PVD methods, i.e. few nm/hrs. Chemical vapor deposition (CVD) is another method suggested for growing c-BN. Of the CVD methods, only plasma-enhanced CVD (PECVD) has been able to successfully grow c-BN films. These methods include DC jet plasma CVD, RF plasma CVD, inductively coupled PECVD and electron cyclotron resonance microwave plasma CVD (ECR MPCVD). Absence of ion bombardment as well as low applied bias voltage in PECVD leads to low stress and fewer growth created defects as compared to PVD methods.

In this study we have investigated the possibility of achieving growth of thick c-BN films on polycrystalline boron-doped diamond at a high rate of 100 nm/hour. We have exploited fluorine chemistry using H_2, BF_3, N_2, He and Ar gases employing the ECR-PECVD method. A low negative bias, i.e. -60 Volts, is applied to enable growth of c-BN. During deposition, F_2 is responsible for etching the sp^2 bonding (representative of phases other than c-BN) formed between boron and nitrogen atoms. Research established that limited use of H_2 gas compared with BF_3, facilitates growth of c-BN. Then, we increased flow rates of the gas precursors while keeping gas ratios and applied voltage bias fixed. This resulted in growth of c-BN at a faster rate. The H_2:BF_3 ratios of 2:2 and 4:4 sccm resulted in 50 nm/hr and 100 nm/hr of BN, respectively. We then utilized *in-situ* X-ray photoemission spectroscopy (XPS) to confirm the presence of sp^3 bonding states at the surface of the grown film. Also, data acquired from ellipsometry confirms the growth rates of the two scenarios mentioned above.

As growth rate is increased there is a need to control strain in the c-BN, which will be a focus of future growth studies.

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