Epitaxial Cubic Boron Nitride Grown by Ion Beam-Assisted Molecular-Beam Epitaxy on Diamond

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Cubic boron nitride (c-BN) shares several properties with diamond, including high mechanical hardness; high thermal conductivity, second only to diamond; and an ultra-wide band gap (E_g ~ 6.2 eV, indirect). In addition, c-BN can be doped both *n*- and *p*-type, and the lattice mismatch between c-BN and diamond is only ~1.3%. These similarities suggest the potential for novel electronic devices based on c-BN/diamond heterostructures for high temperature and high power applications. However, the growth of device-quality layers of c-BN is challenging: boron nitride occurs in multiple phases; the desired cubic phase is metastable at pressures and temperatures typical of vapor-phase growth; and the absence of large-area bulk c-BN crystals necessitates heteroepitaxial growth on non-native substrates.

Single crystal epitaxial cubic boron nitride films were grown on (100) oriented IIa diamond substrates by ion beam-assisted molecular-beam epitaxy (MBE) in a custom MBE system equipped with an Ar ion source, a N_2 plasma source, and an electron beam evaporator for supplying elemental boron. The films are fully cubic, as indicated by Fourier transform infrared spectroscopy and corroborated by x-ray photoelectron spectroscopy. Transmission electron microscopy reveals an epitaxial c-BN film with the presence of isolated misfit dislocations but no indication of h-BN. The interface between the c-BN layer and the diamond substrate is structurally abrupt, and no interlayer between the c-BN film and diamond substrate is seen. It was found that trace amounts of impurities, such has Mg, Be, and Si, facilitate the growth of c-BN on diamond by ion-assisted MBE.