The Physical, Chemical and Electrochemical Properties of Boron-Doped Nanocrystalline Diamond Thin Film

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The deposition, characterization, and electrochemical properties of boron-doped nanocrystalline diamond thin-film electrodes will be reported on. The films consist of clusters of diamond grains, ~50-100 nm in diameter, and possess an rms surface roughness of 34 nm over a 5 x 5 μm^2 area. The individual and randomly ordered diamond grains are approximately 10-15 nm in diameter, as evidenced by TEM. The ~4 μm-thick films (Si substrate) are deposited by microwave-assisted chemical-vapor deposition (CVD) using a $CH_4/H_2/Ar$ source gas mixture (1%/5%/95%) with 10 ppm of B_2H_6 added. Under these conditions, C_2, rather than $CH_3\bullet$, appears to be the dominant nucleation and growth precursor. The nanocrystallinity is a result of a growth and nucleation mechanism discovered by Gruen and coworkers, which involves the insertion of C_2 carbon dimer into C-C and C-H bonds on the growth surface. The nanocrystalline morphology results from a high rate of renucleation. However, unlike previously reported nanocrystalline diamond thin films that have electrical properties dominated by the high fraction of π-bonded carbon atoms in the grain boundaries, the present films are doped with boron and the electrical properties appear to be governed by the charge carriers in the diamond. Hall measurement data (carrier type, concentration and mobility) will be presented. Characterization data by scanning-electron microscopy (SEM), atomic-force microscopy (AFM), high resolution transmission-electron microscopy (TEM), visible-Raman spectroscopy, x-ray diffraction (XRD), boron-nuclear-reaction analysis, and cyclic voltammetry will also be presented. One electronalytical application of this advanced carbon electrode material for the detection of trace metal ions will be discussed.