

Surface characteristics of boron-doped diamond exposed to high-temperature annealing: Effect of hydrogen atmosphere

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Abstract

We report on the structure and electronic characteristics of the surface of epitaxial (100)-oriented and highly boron-doped diamond ($N_A > 10^{20} \text{ cm}^{-3}$), which was annealed at a temperature of 1500°C for 1 hour in a hydrogen atmosphere at a pressure of 10^{-2} mbar, followed by chemical etching of the graphitized surface layer. For comparison, a similarly grown diamond sample was annealed at the same temperature in high vacuum for 5 hours and analyzed. Surface analysis by X-ray photoelectron spectroscopy (XPS) revealed that high temperature annealing produces a nanometer-thin layer of presumably amorphous carbon below the graphitized surface. According to XPS, annealing in H_2 atmosphere induced a continuous amorphous layer, while the vacuum annealing process resulted only in partial conversion into such amorphous phase. In both cases studied, the annealed and chemically processed surfaces showed the presence of energy-distributed electronic states, as revealed by AC-impedance spectroscopy in 0.1M H_2SO_4 electrolyte. The total density of these surface states was about $1 \times 10^{14} \text{ cm}^{-2}$ for the H_2 annealed diamond, and about $1 \times 10^{13} \text{ cm}^{-2}$ for the vacuum annealed diamond sample, in good correlation with the amount of the amorphous phase as deduced by XPS. The higher rate of diamond corrosion in the case of H_2 annealing could be related to hydrogen diffusion into diamond, which was associated with a shift to higher binding energies of the corresponding sp^3 bulk component in XPS.

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