The incorporation and properties of hydrogen in single crystal CVD diamond.

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A unique and recently extensively studied feature of diamond surfaces is a highly conductive p-type layer, which is usually observed when the surfaces are hydrogen terminated [1]. Hydrogenation of the surface is necessary but not sufficient for inducing the hole accumulation layer at the surface [1]. A number of electronic applications proposed for diamond are based on the effect, however the surface conducting state is not very stable and surface stabilisation is essential for the future exploitation of this property of diamond [2].

The incorporation of hydrogen in bulk diamond grown by chemical vapour deposition (CVD), during growth or via post growth treatment (plasma processing, implantation etc) has received less attention, but has important consequences for the properties of the material. We will differentiate between hydrogen incorporation in polycrystalline diamond films and single crystal CVD diamond. Differently prepared polycrystalline diamond films exhibit considerable differences in the shape of the C-H stretch infrared absorption band, and the observed vibrational frequencies coincide with those measured in amorphous hydrogenated carbon (a-C:H), suggesting that the C-H stretch absorption predominately originates from a-C:H incorporated in the film [3]. EPR studies on the H1 defect in polycrystalline diamond films indicate that this defect, incorporating a hydrogen atom, is located on grain boundaries or in inter-granular material rather than in the bulk diamond, and that this defect only accounts for a small fraction of the total hydrogen [4,5].

Infrared studies on single crystal have shown that hydrogen is incorporated into single crystal CVD diamond [6]. It has been shown that hydrogen can compensate the boron acceptor in bulk diamond, and studies suggest that hydrogen diffuses readily only in the positive charge state [7]. A nitrogen-hydrogen complex has been observed using electron paramagnetic resonance (EPR) studies on as grown single crystal CVD diamond, and characterised in detail [8]. These data will be reviewed and new data on hydrogen incorporation in bulk CVD diamond will be presented.

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