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Recent IBIC measurements on epitaxial CVD diamond

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Abstract

Frontal IBIC (Ion Beam Induced Current) mesurements have been carried out on new single crystal epitaxial CVD diamond. The sample consists of about 100 μm synthetic diamond grown by microwave CVD on a 300 μm thick, low cost, HPHT diamond substrate (see Balducci et al.–this conference). Both proton and alpha microbeams of energies 3 and 4.5 MeV have been used, with a beam diameter spot of about 1.5–3 μm. Scanned areas varied from 450 μm × 450 μm down to 150 μm × 150 μm and the homogeneity of charge collection efficiency (cce) was suitably monitored. At voltage bias of 80–100 V, the average cce was in the range 42–50%. Depending on the scanned surface area and on the beam type, energy resolutions FWHM from 1.3% to 4.1% FWHM have been obtained, even at counting rates as high as 700 cps.

Keywords: Single crystal CVD diamond; IBIC; Homogeneity; Energy resolution

1. Introduction

CVD diamond polycrystalline material, even of detector grade, is known to present, in many cases, strong polarization effects during detection of heavy particles like protons or alphas. These effects may make frontal IBIC (Ion Beam Induced Charge) measurements [1] almost impossible to carry out, particularly when cce is lower than 20%–30%. Another important point refers to homogeneity of charge collection efficiency (cce), which may present larger values [2] in correspondence with grains of good electronic quality and very low values in disordered and defective regions. What commonly happens is that these regions where heavy carrier trapping occurs become more and more affected by space-charge. The main effect of space-charge is to reduce locally the electric field, with the result of increasing the amount of trapping. In a crystalline material of good electronic or detector quality, such as the best or selected natural diamond, the above phenomena do not occur commonly. However, being the natural samples always doped with nitrogen, is not that easy to find large values of cce. This drawback has been recently overcome with the growth of single crystal homoepitaxial CVD diamond samples of suitable thickness, which present high values of cce and which are also relatively homogeneous in this respect. The only way to measure with a suitable confidence level cce homogeneity is of course IBIC and this work will present the first results obtained on a homoepitaxial CV diamond sample by this technique. We will show that crystalline samples are very homogeneous over areas of the order of 400 μm × 400 μm and that this property leads to very good values of energy resolution for protons and alpha particles of 3 or 4.5 MeV energy. The effects due to some residual electrical polarization and of large counting rates will also be discussed to some extent.

2. Experimental

The diamond sample investigated in this work was epitaxially grown by MW-CVD on a 315 μm low cost HPHT diamond substrate, which had a nominal N concentration of 1016 cm^{-3} and which was electrically conducting because of B doping [3]. The thickness of this epitaxial layer of was evaluated to be 110 μm. Circular Al electrodes, 2 mm in diameter, were deposited on each surface, i. e. bottom HPHT surface and top epitaxial growth surface.

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