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Ion and X-ray micro-beam induced charge collection and their applications in CVD diamond detector characterisation

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Abstract

We have used a micrometer size X-ray beam generated from a synchrotron light source at the European Synchrotron Radiation Facility (ESRF) in Grenoble and a 2 MeV proton micro-beam at the Italian National Laboratory (LNL) of Legnaro to image the electronic transport properties of a CVD diamond detector developed within the CERN RD42 collaboration. The focused X-rays or protons are scanned over the device surface, and the induced current or charge pulse is measured and plotted on two dimensional maps. Due to the polycrystalline nature of the material, the maps are not homogeneous and both the techniques show structures ascribable to diamond grains. It was found that the uniformity of the maps depends on the lateral scale (binning) and on the analytical depth of the micro-probes.

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Keywords: CVD diamond detector; X-ray induced photocurrent; Electronic properties; IBIC

1. Introduction

Ion beam induced charge collection (IBIC) technique has been extensively used to image the transport properties of semiconductor devices [1]. Polycrystalline samples, homogeneous monocrystals, Schottky and p–n junction diodes as well as integrated circuits have been successfully analyzed to get two dimensional maps of charge collection efficiency (CCE), to evaluate the effect of ion induced damage and to measure carrier diffusion lengths and depletion layer thickness. The main advantage of IBIC stems principally from its large penetration depth and low lateral spread which allow CCE maps and profiles to be evaluated with reasonable lateral resolution. However, IBIC technique suffers some limitations due to ion induced damage and to the high density of charge carriers along the ion path which produces charge funneling and promotes plasma recombination. Moreover, the generation of charge carriers in a small volume can produce polarization effects in highly resistive and defective materials.

In order to avoid such drawbacks, we have experienced another micro-beam induced current

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