PUB2003-1

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Diamond and Related Materials 12 (2003) 662–666

DIAMOND AND RELATED MATERIALS
www.elsevier.com/locate/diamond

Blue light sensitization of CVD diamond detectors

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Abstract

CVD diamond needs to be 'primed' or 'pumped' by X-rays or by high energy electrons in order to be qualified for nuclear detection. In this 'pumped' state, CVD diamond detector performances are reported to be more reproducible, homogeneous and averagely better. The pumping effect is usually attributed to filling of (hole) traps, which are responsible for the charge collection efficiency of the detector. In this work, the possibility of filling traps selectively by light has been systematically investigated, in order to find the kind of 'background light' in which the detectors could preserve their performances indefinitely in time. Irradiation by the blue light before or/and during the detection of nuclear particles seems to avoiding the large doses needed for pumping. Other wavelengths seem to be totally inefficient from this point of view. It turns out that electrons are responsible for charge transport during blue light priming, while holes give the largest contribution during X-ray priming. The results will be presented as maps of charge collection efficiency in CVD diamond detectors as obtained by IBIC (Ion Beam Induced Charge) carried out by using a proton microbeam.
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Keywords: X-ray priming; Homogeneity; Thermoluminescence

1. Introduction

Previous papers [1–3] indicated that light illumination at a determined wavelength interval could help in order to avoid polarization effects and to improve diamond nuclear detector performances.

Recently [4], during an investigation about the effect of light on the primed state of CVD diamond, we discovered that blue light illumination shows strong effects on transport properties of diamond. Apparently, light excitation in the region of blue A band ($\approx$2.9 eV) improves very sharply the charge collection efficiency (CCE) of electrons while reducing holes CCE to the values before priming. Blue light also almost erases thermoluminescence (TL) peak of CVD diamond at approximately 250 °C. Priming procedure is carried out by deposition of a determined amount of dose (10–20 Gy) of X-rays or of penetrating β-rays of an energy which could assure an homogeneous absorption along the depth of the detector, which is a few hundreds of micrometers thick. The priming effect is generally attributed to filling of traps: it is clear that by this method of priming there is no control both on excitation and on filling of levels. By blue light excitation there are at least two advantages, in principle: the former is due to the selective excitation and trap filling by light which is absorbed in the volume; the latter relies on the fact that it can be most simply carried out even in a cumbersome experimental apparatus like a track detector in an hadron collider (LHC) during the experiment by using blue LEDs or other simple forms of local filtered illumination.

Since our research group has been engaged in a long and pioneering work about homogeneity of response of CVD diamond nuclear detectors [5,6], we decided to investigate blue light priming from the point of view of homogeneity both of the response and of the detection efficiency. What turns out is that this new kind of priming is more effective and that the phenomenon is related to the more efficient transport of electrons with respect to holes.

2. Experimental

The measurements were carried out on a 5×5×0.6 mm^3 CVD diamond sample produced by DeBeers [7]. The sample thickness was obtained by cutting 'low

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0925-9635/03/$ - see front matter © 2003 Elsevier Science B.V. All rights reserved.
PII: S0925-9635(02)00327-8