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The primed state of CVD diamond under blue light illumination

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Abstract

The primed state of a detector grade CVD diamond sample has been investigated with respect to light illumination during alpha particles (5.5 MeV) detection. The measurements have been carried out as a function of elapsed time after beta-rays priming both in short term (1 h) and in long term (33 h) conditions. The contribution of holes and electrons to the average charge collection efficiency and to total number of counts above a threshold has been qualitatively separated by selecting bias polarity. The behaviour of electron collection after X-ray priming during blue light or UV illumination is improved while the hole one is worsened, confirming previous data. Linearity of the average collection efficiency for alpha particle is observed only at very low doses and in the hole case. Long term stability of both collection efficiency and of total number of counts is observed both in the primed state for holes and during blue light illumination for electrons.

Keywords: CVD diamond; Priming; Illumination; Stability

1. Introduction

There are several controversies about the effect of light illumination on the primed state of CVD diamond as obtained by X- or beta-rays irradiation at doses around 20–30 Gy: according to different authors, the effect could be either positive or negative, i.e. it can be used in order either to improve the performances of CVD diamond as nuclear detector [1] or to erase the improvement obtained by priming [2]. According to our experience, blue light illumination (around 400 nm) transfers the main contribution to charge collection from holes to electrons, and this conclusion has been largely demonstrated by using alpha particles in order to discriminate between electrons and holes contribution simply by changing bias polarity [3,4]. Illumination below 550–600 nm has been proved not to give rise to any effect on the primed state or at least to any improvement in holes and electrons collection. The investigation of primed state can be carried out also by Below Gap PhotoCurrent (BGPC) measurements [3] which can give some insight into transient or dynamic phenomena. In effect, the primed state is not stable under illumination for photon energies below 2.7 eV, but it decays probably because of an optically stimulated detrapping of trapped holes generated by priming, which are responsible [5] of what has been called Persistent PhotoConductivity (PPC). As a matter of fact, the integrated photocurrent is linearly proportional to the cumulated priming dose, as it was the case of ThermoLuminescence (TL) which starts to be used to measure X-ray doses. What is very strange, at least in our case, is that the linearity [5] is restricted to very low doses (below 1 Gy for instance) with respect to TL. Above 2.7 eV the situation changes because probably the main contribution to photocurrent is given by electrons and a good long_term stability is reached.

In order to throw some light on all these phenomena, we started a much longer investigation by using alpha particles spectra in the same way as BGPC as a function of time after priming and blue light illumination, which is a quite long and difficult task, but which gives a better understanding of electrons and holes behaviour. In order to follow the time behaviour, we extracted from alpha multichannel spectra both the centroid or the average value of charge collection efficiency (cce) and the total number of counts (ci), after subtracting the background. This latter parameter can in effect decrease in time because of polarization effects due to trapped charges that locally lower electric field and may cause charge pulses to fall below the electronic threshold. As a consequence, this

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