Memory effects in CVD diamond detectors

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I. INTRODUCTION

CVD diamond, as other wide energy gap semiconductors or insulators, is known to present polarization effects when used as a nuclear particle detector, which are due to the building up of an internal space-charge electric field and are responsible for "memory" effects if the polarization is not erased. A strong trapping induced on both carriers, i. e. priming or pumping [1], is used in order to try to stabilize diamond before its use as a nuclear detector. Polarization effects are larger when the thickness of the sample is longer than the drift length of carriers and give rise to a shortening of the electric field region inside the sample. In this work, IBIC (Ion Beam Induced Charge) measurements with 1 and 2 MeV proton beams have been carried out on a relatively thin CVD diamond sample with the conclusion that no memory or hysteresis effects were present even by switching from one polarity to the opposite one in subsequent measurements. However, it resulted that the values of the charge collection efficiency (cce) did depend on counting rate and the lowering at large counting rates was attributed to a local polarization due to trapping.

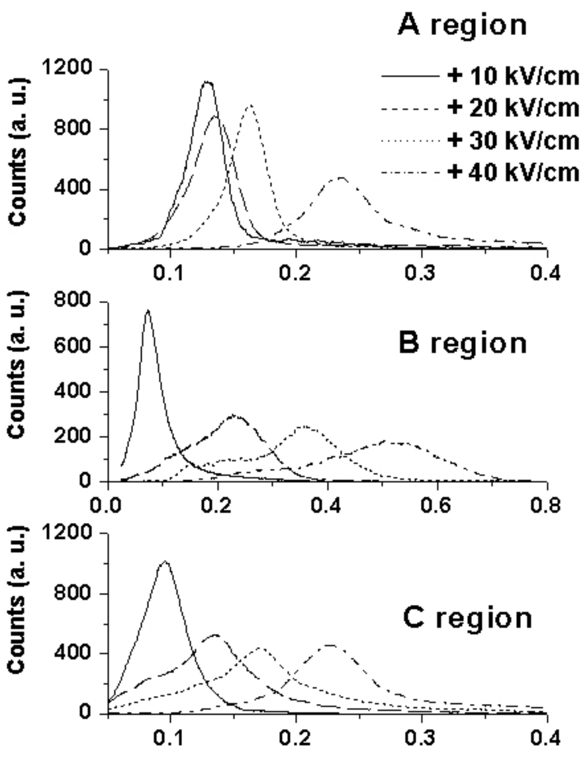

FIG 1: Three series of pulse height spectra obtained in three different regions of the sample (35 μm x 35 μm wide). Proton energy is 2 MeV. Bias voltages are positive and applied to the exposed surface.

II. EXPERIMENTAL SET-UP

The investigated detector was 50 μm thick, as measured by SEM, and it was equipped with standard evaporated Au/Cr contacts on both sides about 0.5 cm in diameter and 100 nm in thickness (70 nm Au + 30 nm Cr). The I-V characteristic displayed an ohmic behaviour up to 160 V with very low dark currents (below 10^{-11} A/cm^2).

The detector was placed in a scattering chamber equipped with standard charge sensitive electronics and acquisition apparatus. The detector was exposed to proton microbeams of 1 and 2 MeV at counting rates from 1800 to less than 100 cps. The penetration depth in diamond is 8 μm at 1 MeV and 25 μm at 2 MeV. In the former case, the main contribution to pulse height and to cce is given by electrons (negative polarity to front electrode) or to holes (positive polarity to front electrode) In the latter case, this preferential contribution cannot be assumed, but, because along the track electron-hole recombination is larger, maybe it maintains still some meaning. Bias voltage was applied to the face of the sample exposed to the proton beam. Multichannel spectra were acquired by scanning proton microbeam over surface electrode areas from 35 μm x 35 μm up to 75 μm x 75 μm. The charge collection efficiency (cce), i.e. the fraction of generated charge contributing to the charge pulse, was evaluated by comparison with a silicon barrier detector with 100 % cce, taking obviously into account the different pair creation energies (3.6 eV for silicon and 13.2 eV for diamond) and the different electronic signal amplifications. Time constant was kept routinely at 8 μs.

III. RESULTS AND DISCUSSION

Some multichannel spectra taken at increasing positive bias voltages in three different regions of the sample, 35μm x 35 μm wide, are shown in Fig. 1: the peak efficiencies (η) are varying from 10 % up to more than