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Ion Beam Induced Charge characterization of epitaxial single crystal CVD diamond

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Abstract

IBIC (Ion Beam Induced Charge) technique has been used in order to characterize single crystal epitaxial CVD diamond film with respect to homogeneity and stability of the response (in terms of charge collection efficiency, cce) as a function both of counting rate and of the number of counts per unit surface area. The maximum shift of cce peak, under a 1.2 MeV proton microbeam, is 1.5% for counting rates from 43 to 4330 Hz, while the homogeneity, evaluated as the standard deviation with respect to the average value of cce over strip-like regions 60–100 μm wide and 800–1200 μm long, is 0.5%. Counting rates per unit surface area were between 30 and about 15,000 Hz/mm^2. A total number of counts per unit area up to 9 10^6 counts/mm^2 was reached without noticing any polarization effect due to trapped charge. Moreover, the functionality of a new kind of bulk electrode, realized by a boron doped buffer layer laterally contacted with Ag paste, has been checked by measuring cce at different proton ranges.

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

1. Introduction

In the past, selected natural diamond nuclear detectors [1] were found to display very nice performances both in terms of speed and energy resolution, together with well known properties of resistance to radiation damage. This was not the case of artificial diamond, which, as deposited by CVD, was polycrystalline and, as obtained by HPHT, was strongly doped. However, because of the relatively weak radiation resistance of Si, CVD diamond started to be investigated for nuclear applications. In fact, from 1995, CVD diamond was tried to be used as a track detector in large collider experiments such as LHC [2] and this challenging application contributed a lot to improve its detector quality [3]. Nevertheless, due to its polycrystalline nature, the performances of CVD diamond in terms of homogeneity of response and consequently of energy resolution were very poor [4].

The situation changed suddenly with the advent of homo-epitaxial CVD diamond, which displayed superior properties in terms of carrier mobilities and trapping times [5]. However, even if it was documented that energy resolution was now very good [6], no report appeared concerning : 1) the homogeneity of the charge collection efficiency (cce) over relatively large areas of the detector; 2) the stability of the detector as a function of counting rate and of the total number of counts; 3) the presence of polarization effects and 4) the need of priming or pumping [2], largely used for the initial stabilization and improvement of diamond response.

Recently [7], we reported about preliminary measurements on energy resolution and of homogeneity over relatively large areas by using alpha and proton microbeams, with the indication of no need of priming, of the relative absence of polarization effects and of a good stability up to counting rates of about 700 Hz. In the meantime, the material quality has been continuously improved and this work is a progress report mainly dedicated to the homogeneity of cce up to surface areas more than 1 mm^2 and to the stability of the full energy peak up to counting rates as high as

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