NUCLEAR PARTICLE DETECTION AS PROBE FOR DIAMOND DEFECT CHARACTERIZATION

Cristina Tuvè*, V. Bellini, R. Potenza, C. Randieri, C. Sutera
Università di Catania, Corso Italia 57, I-91124 Catania, Italy
INFN – Sezione Catania, Corso Italia 57, I-91124 Catania, Italy

G. Pucella, M. Marinelli, E. Milani, A. Paoletti, A. Tucciarone, G. Verona-Rinati
INFM - Dipartimento di Ingegneria Meccanica,
Università di Roma "Tor Vergata", Via di Tor Vergata 110, I-00133 Roma, Italy

ABSTRACT

Diamond was shown to be a suitable material for application in high energy particle detection due to its striking electronic proprieties, such as high carrier mobility, wide band- gap, good radiation hardness and very high breakdown voltage.
Recently high quality diamond films could be deposited by microwave plasma enhanced chemical vapor deposition (CVD).
However, the polycrystalline nature of CVD diamond and the presence in it of a high concentration of crystallographic defects still constitute a severe limitation to most of the applications as nuclear detectors and a large amount of work is still needed.
We have extensively studied the transport properties of synthetic diamonds grown in Roma Tor Vergata Laboratory.
In particular, we were able to separate the electron and hole contributions to the diamond carrier dynamics to determine the correspondent defect distribution inside specimens. This is achieved through a systematic investigation of the signals obtained from properly biased diamonds irradiated with differently penetrating nuclear particles. To this purpose ^{12}C ions produced by the 15 MV TANDEM accelerator of the Southern National Laboratories (LNS) of INFN in Catania (Italy) are used as a probe. The ion beam energy is varied in the 22-91 MeV range (penetration depth from 10.5 μm to the thickness of the used samples, deposited energies from 22 MeV to 62 MeV and mean energy densities from 0.8 MeV/μm to 2.1 MeV/μm respectively). The sample responses are studied as a function of the ^{12}C energy and penetration depth, both in the positive and negative bias polarization.
The measurements using ^{12}C probe energetic beam allow scanning the detection properties of the whole sample thickness. The experimental results clearly show that, when the detector is previously driven in the so-called pumped state by ^{90}Sr β-particle irradiation, a different behavior of signals is observed in the positive and negative polarization states.

The data are analysed in the framework of a properly modified Hecht model where the different behavior of carriers and influence of the variation in the ionization density along the path of the incident particles are considered. As a novelty the inhomogeneous distribution of defects is taken into account. By fitting the experimental curves with the model, a quantitative estimate of the defects distribution and of the correlated mean drift distance for electron and holes can be obtained. A good agreement is observed, thus allowing a better understanding of the details of the diamond growth. The nuclear particle detection results in a powerful technique to finely adjust the parameters of the reactor for an improved deposition.