§22. Synthetic Diamond Radiation Detectors for Charged Particles

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1. Introduction

A diamond radiation detector has several merits in terms of high-temperature operation, high-radiation hardness, high-speed response etc. In the LHD, several applications, i.e., escaped charged particles measurement and DT neutron measurement based on the $^{12}C(n, alpha)^{9}Be$ reaction are expected.

A single crystal CVD diamonds suit for energy spectroscopy is usually obtained by a homoepitaxial growth on a single crystal high-pressure and high-temperature (HP/HT) diamond. In this study, aiming at application on the LHD, single crystal CVD diamonds were grown in several conditions of methane concentration and radio frequency power; influence of detector performance were evaluated.

2. Experimental

CVD diamond single crystals were grown on off-axis (001) surface of HP/HT type IIa substrates. A lift-off method was adopted to reuse of the HP/HT type IIa substrates. A micro wave assisted plasma CVD device (SEKITECHNOTRON, ASTeX AX5250) was used. After CVD growth, self-standing CVD diamond single crystals were obtained by electro-chemical etching. A typical growth condition is as follows, substrate temperature: 850 Centigrade, gas pressure: 110 Torr, methane concentration: 1%.

3. Experimental Results

CVD diamond single crystals were grown with methane concentration of 4, 2 and 1%. In this growth, substrate temperature and gas pressure were fixed. Typical size of substrate was 5 * 5 * 1 mm. RF power was changed around 1500 W and 1000 W by changing sample holders with other thermal-conductivities.

The best result in this study was obtained a growth condition of RF power:1000 W and methane concentration: 1 %.Figure shows induced charge distribution spectra obtained by a CVD single diamond grown in the above mentioned condition. Charge collection efficiencies were 101.1% and 97.5% for holes and electrons. These values were decided by comparison with a silicon surface barrier detector. In addition, energy resolution was 0.7 % and 1.1 %.Approximately, electrons of 6 % was trapped in this measurement; it was probably caused by nitrogen related trapping centers. To realize a practical detector reduction of these trapping center is indispensable.

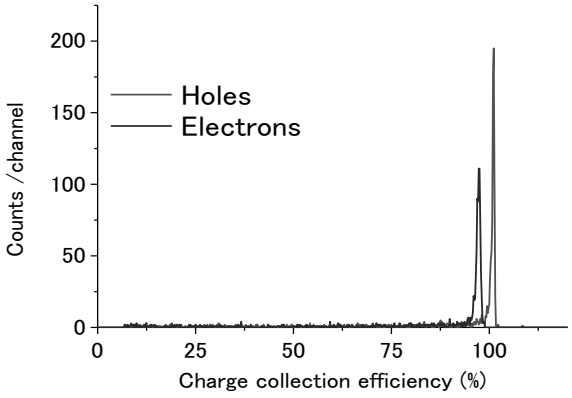

Fig. 1 Example of induced charge distribution spectra obtained with a CVD diamond single crystal grown with RF power of 1000 W and methane concentration of 1 %.