

§27. Development of CVD Diamond Detector for Particle Detector

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1. Introduction

Triton burn up measurements by neutron is necessary for alpha-particle diagnostics. Diamond detector, which has small size and excellent particle energy resolution, is expected to use Triton burn up measurement. Natural diamond detector has already installed for a Neutral Particle Analyzer (NPA) at Tokamak e.g. Large Helical Device (LHD), JT-60U, NSTX.

Hokkaido University have been synthesized CVD diamond and developed detector which is superior to natural diamond.

In this paper, we report charge carrier transportation property obtained by suppress of nitrogen impurities in diamond. Then influence of charge up was examined by use of 3MeV protons.

2. Experimental

CVD diamond was homo-epitaxial grown using a microwave plasma chemical vapor deposition (MPCVD) reactor (ASTEX AX5250). Type IIa HPHT diamond was used as a substrate. The substrate includes nitrogen < 1ppm and off axis treatment with 3 degrees on (100) for <110> direction was conducted to suppress abnormal growth. Growth condition was listed in Table 1. To suppress nitrogen contamination from air leakage, a door of a sample chamber was covered by a gas bag filled with argon gas.

Grown single crystal 100µm thick diamond film was removed by chemical etching, 1.6 µm thick, at the bottom of the epitaxial layer was removed using ion beam etching. The substrate was reused for crystal growth.[1]

Diamond film was oxygen- terminated using dichromic acid. Ti/Au Ohmic contact and Al Schottky contact were fabricated by evaporation method. After fixing the diamond film on an Al detector mount, the contacts were connected to a receptacle and were grounded by gold wire and silver paste. Charge collection efficiency was evaluated using Am-241 radioactive source described detail in Ref[2]

Relation between Charge trapping and Number of incident particle was evaluated under 3MeV proton irradiation. It was conducted at pelletron accelerator in RIKEN Nishina RIBF center.

Table 1 Growth condition

Substrate Temperature	Gas Pressure	CH ₄ /(CH ₄ +H ₂)	Thickness
850°C	110Torr	1%	102µm

3. Experimental results

Figure 1 shows effect of nitrogen reduction; step bunching, i.e., wrinkle caused by impurity, disappeared. However, charge carriers collection efficiency was not improved. Especially Charge collection efficiency for electron decreased from 97% to 92% at three sample average. This result indicated that there is other trapping center(s) for electrons other than nitrogen.

Figure 2 shows Peak channel number dependence on Number of incident particles. A count rate of diamond detector was set to 1.5~7.0 kcps.

Diamond Detector which synthesized ex-growth (without suppress of nitrogen) condition was tested.

The vertical axis is normalized by the channel number obtained when irradiation starts. Peak channel number decrease was observed as a result of a few percent of charge trapping of both hole and electron. However, polarization effect was cancelled by reverse bias voltage and pulse height recovered again. The diamond detector working under incident proton of 2.5×10^{12} ion/cm² was confirmed.

For the future works, we reveal charge trapping center in diamond, reduce it and apply detector to LHD.

- 1) Mokuno. Y. et al. : Diamond and Related materials 17(2008).
- 2) Kaneko J.H. et al.: Nuclear instruments and Methods A 505(2003).

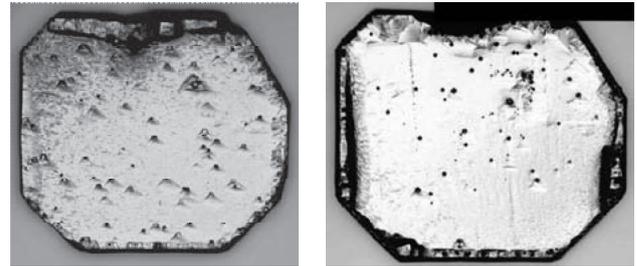


Fig.1 Surfaces of grown diamond taken by a differential interference microscope (Left: Before nitrogen reduction, Right: After nitrogen reduction)

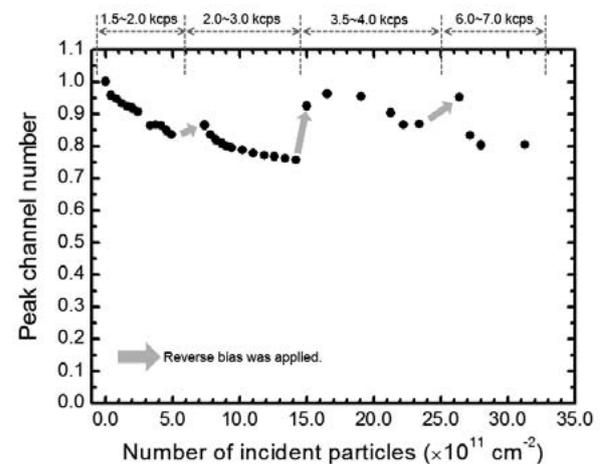


Fig. 2 Peak Channel Number dependence on Number of incident particles. Arrows show the timing of the applying reverse bias voltage.