§39. Traial on a ToF Measurement of Gamma-rays and Neutrons by a Diamond Radiation Detector with Fast Time Responce

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1. Introduction

Ion temperature measurement has been carried out by a ToF measurement for neutrons using a multi channel fast plastic scintillator system, i.e., MANDALA, at the Institute of Laser Engineering (ILE) of Osaka University. In a fast ignition ICF experiment, a ToF measurement for neutrons was sometimes disturbed by intense gamma-rays because scintillator had residual luminescence caused by the gamma-rays. By use of a diamond radiation detector with a fast time response, there is a possibility to measure accurate ToF spectrum of neutrons. In this development, diamond single crystals for radiation detectors were synthesized, then diamond radiation detectors were adapted in ICF experiments at ILE. In this stage, obtaining of basic data required for developing real diamond ToF spectrometer for gamma-rays and neutrons was main objective.

2. Diamond radiation detectors

At first, to obtain high detection efficiency, a large size polycrystalline diamond crystal synthesized by the Element Six was evaluated. Unfortunately, charge carrier's drift velocities were very slow and not sufficient for the ToF measurement in ILL. Last fiscal year, to resolve issue on diamond crystals, diamond single crystals grown by a chemical vapor deposition (CVD) method in AIST were evaluated. These self-standing CVD diamond single crystals were fabricated by a lift-off method; typical size of the CVD diamond single crystal was 1cm*1cm*0.1mm. For holes, drift velocity and charge collection efficiency were sufficient for the ToF measurement. For electrons, it should be improved by brushing up synthetic conditions. This fiscal year, CVD diamond single crystals synthesized by several growth conditions were evaluated.

3. Experimental Results

Growth conditions and evaluated results are summarized in Table 1. As shown in figure 1, five diamond radiation detector were fabricated, and then responses for alpha particles and UV pulsed laser with pulse width of 150 ps were carried out. Although, there were not superior detector than the previous one in charge correction efficiency, two detector had fast time response enough for ToF measurement.

4. Conclusions

Concerning to time response, it should be pay attention that fast trapping on charge carriers sometimes result in false fast time response. It means that a detector has charge trapping, and it is not ideal in practical use; time response changes depend on quantity of trapped charge. In the case of the Fire-X, there is a time interval of several hours between each shot; thus if release of trapped charge occurs satisfactory in this interval, there is a possibility to use these diamond radiation detector in practice. A matter of course, to obtain reliable and traceable ToF date, a diamond radiation detector with perfect charge collection and fast time response should be realize.

As the next step, to improve crystal quality, information on growth conditions investigated using high quality type IIa single diamond substrate in Hokkaido University will feed back to AIST. A preparation experiment for DT shot in the two next year will be carried out in the Fire-X

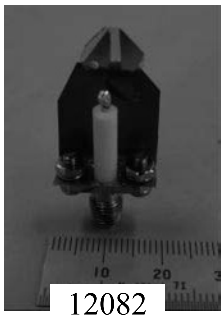

Fig. 1 An example of fabricated diamond radiation detectors.

Table Growth condition and evaluated results of CVD diamonds

Sample I.D.	Sub. I.D.	Thickness (mm)	CH_4/H_2	Sub.Temp. (℃)	Pressure (Torr)	ΔE/E (electron)	ΔE/E (hole)	Elect. Field (V)/(V/cm)	UV (electron)	UV (hole)
120823	A	0.095	10 %	900	160	4.4 %	0.73 %	200(21k)	several 10ns	5ns
290519	A	0.08	10 %	940	160	13 %	1.0 %	200(25k)	not yet	not yet
280730	A	0.2	10 %	940	160	15 %	3.3 %	100(5k)	not yet	not yet
290708	B	0.1	10 %	910	160	sensitive	4.5 %	40(4k)	～5ns	～5ns
290722	C	0.4	10 %	930	160	21.7%	13.2 %	250(6.25k)	～5ns	～5ns