§33. Trail on a ToF Measurement of Gamma-rays and Neutrons by a Diamond Radiation Detector with Fast Time Response

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Ion temperature measurement has been carried out by a ToF measurement of neutrons using multi channel fast plastic scintillator system, i.e., MANDALA, at ILL 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 ILL. In this stage, obtaining of basic data required for developing real diamond ToF spectrometer for gamma-rays and neutrons was main objective.

This year, CVD diamond single crystals were grown in Hokkaido University by a micro-wave assisted plasma CVD device. A HP/HT type IIa diamond single crystal with off-axis (001) surface, 5×5 mm, was used as a substrate in this crystal growth. The lift-off method was adopted for reuse of the substrate.

Typical growth condition was as follows, substrate temperature: 850 ℃, gas pressure: 110 Torr, methane concentration: 1 to 4 %, growth time: 48 hours. Strong free exaction recombination luminescence were observed in cathode luminescence (CL) spectra obtained with grown single diamond crystals. An aluminum Schtokky contact and a Ti/Au ohmic contact were fabricated on the crystal by evaporation technique.

Charge collection efficiency of one CVD diamond single crystal was 100 % for holes, 97 % for electrons. An example of response function for 213 nm UV pulsed laser is shown in figure 1; time width of the pulsed laser was approximately 100 ps.

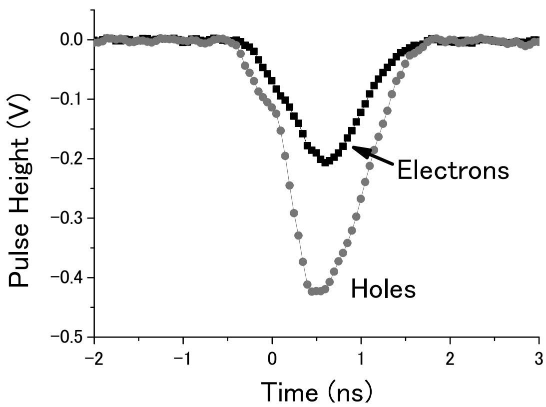

Fig. 1. Examples of time response for 213 nm pulsed laser obtained by a CVD diamond single crystal grown in Hokkaido Univ. Methane concentration was 4 %.

To suppress RF noise to the diamond radiation detector, an isolated measurement port was used. The detector was settled at 10.2 cm from the target. The detector was connected with a digital oscilloscope, analog bandwidth: 600 MHz, with double shielded SMA cable. The detector and cable was covered by aluminum foil.

The neutron yield was approximately 1×10^7 n/shot. Gamma burst was estimated arrived at 137 ns from the trigger signal, however no obvious signal caused by neutron or gamma-rays was not observed. From this result, it was reviled that electrical isolated measurement port did not work well. Then the detector was isolated by polyethylene sheet in the measurement port. It succeeded to suppress RF noise shown in Figure 2. Complete RF noise reduction should be done in the next step.

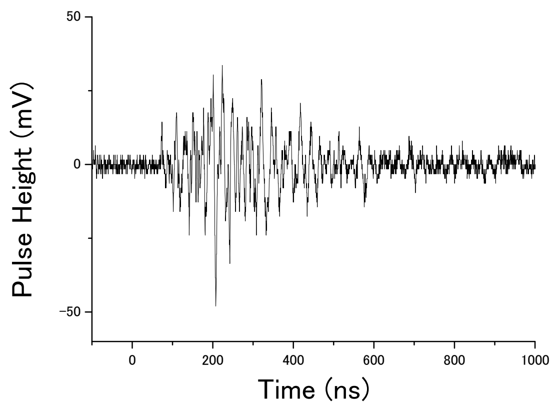

Fig. 2. Examples of output signals from the diamond radiation detector at Gekiko XII laser shot.