§29. Natural Diamond Detector for Neutron and γ-ray Measurements in Laser Fusion Experiments

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In the GEKKO XII laser facility, a neutron time-of-flight detector called MANDALA has been employed to measure energy spectrum of neutrons produced by fusion reactions [1]. The neutron detection by use of the MANDALA is restricted in the fast ignition experiment due to huge flux of prompt X-rays. Because of this reason, an examination of different neutron detection method is required. Natural diamond detectors (NDD) have been applied to the Large Helical Device (LHD) to diagnose energy distribution of fast neutral particles originating from neutral beam heating and ion cyclotron resonance heating [2,3]. Because the diamond itself is known to be fast in time response, neutron and γ-ray may be detected separately in laser fusion experiments.

NDD with ohmic Au contacts and a DC bias can work as a radiation detector. Three NDDs having different area(ϕ2 mm, 2 mm × 2 mm) and thickness (0.1 mm and 0.2 mm) have been prepared for this purpose. The signal generation process is basically similar to that of a Si semiconductor detector. In the case of the high energy photons such as X-rays and γ-rays, electron-hole pairs are generated by photoelectric events inside the NDD. In the case of neutrons, a variety of nuclear processes such as elastic and inelastic scattering $^{12}C(n,n')^{12}C$, nuclear reaction $^{12}C(n,\alpha)^{9}Be$ and so on are involved [4]. In comparison with a Si detector, the primary advantages of NDD include a high band gap of 5.5 eV, short mean free drift time of ~10 ns, large saturation carrier velocity of 2.2×10^{7} cm/s for E of 10^{4} V/cm), high breakdown voltage of 10^{7} V/cm. Further detailed descriptions of NDD's properties are available in Ref. 4 and 5.

Because the time response of GHz range is required in the laser fusion experiment, the circuit used in LHD, so-called PHA, can not be used for this purpose. In order to improve time response as much as possible, a circuit shown in Figure 1 is used. A high voltage bias-T (Picoseconds Pulse Lab./Model : 5531) resistively couples the signal cable to a high voltage power supply and capacitively couples the signal cable to a GHz sampling oscilloscope. The total bandwidth is expected to be ~1 GHz by use of this electronics. As for photons and neutrons, a time to reach NDD from the target as a function of distance between target and NDD is shown in Figure 2. Since the total system bandwidth is about 1 GHz, NDD should be more than 15 cm away from the target to separate neutron signal from γ-ray signal. Figure 3 shows the diagnostic port on the target chamber where NDD is installed. In next fiscal year, we are going to apply NDD to fast ignition experiment to make sure of NDD's performance.

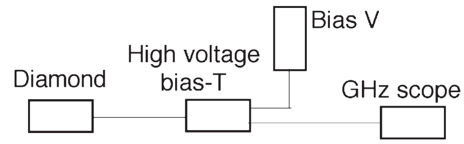

Fig.1 Electric circuit used for NDD in laser fusion experiment.

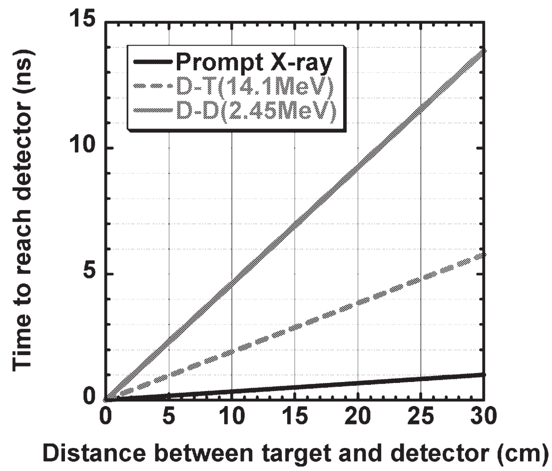

Fig.2 Time to reach NDD as a function of distance between target and detector.

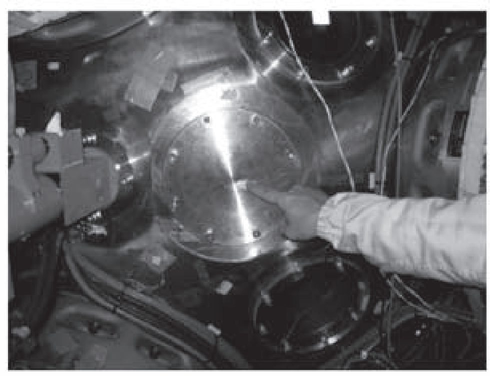

Fig.3 Diagnostic port on the target chamber for NDD installation.

References
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