§14. Characteristics of a Pyroelectric Detector for Neutral Particle Beam Measurements

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Behavior of α (He^{2+}) particles in a fusion plasma is important as it affects the plasma confinement. A neutral He (He^0) beam can be used to diagnose the α particles[1). He^- beam is considered to be a good candidate to produce the H^0 beam because of the low neutralization efficiency of He^+ to He^0 in the MeV energy region. We have been developing a beam transport system for feasibility test to produce He^- and He^0 beams through charge exchanges from He^+ beams. Detection of the He^0 beam is essential to quantify the charge exchange efficiency from He^+ to He^- beam, as well as the auto-electron detachment efficiency of He^- to required He^0 beams. We have designed and built a pyroelectric detector to measure both neutral and charged particle beams with a single system. The pyroelectric detector has advantages of high sensitivity in the low current of microampere region and large detection area[2). This property is most desirable for the test stand experiment with the beam current ranges from 10 to 100 μA. Here we report fundamental characteristics of the pyroelectric detector.

A pyroelectric disk made of sintered $BaTiO_3$ is placed at the bottom of a cylindrical Faraday cup. Irradiation of particles onto the disk produces temperature gradient, and changes the polarization of electrical charges induced between the top and the bottom layers of the disk. Thus the neutral particle intensity is detected as the change of the voltage caused by the pyroelectric effect. The detection system can be used as both pyroelectric and faraday cup modes. The signals from the two modes can be measured independently by a simple change in the electrical connection. Figure 1 shows an example of the modulated pyroelectric and the Faraday cup signals for 2 keV He^+ beam injection.

Figure 2 shows the relation between the lock-in signal in the pyroelectric mode and the ion current measured by the Faraday cup mode. The calibration curve show the linearity in the Faraday cup current range to a few tens μA. The pyroelectric signal depends on the incident beam energy, or the incident beam power, but neither on the mass nor the kinds of beams. The lower detection limit was less than 0.2 μA of the ion beam current, showing that the pyroelectric detector has capability to detect the produced He^0 beam in the test stand for He^- beam production.

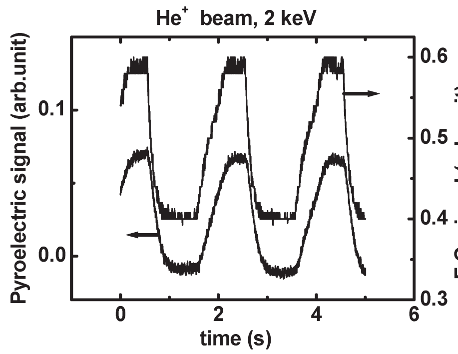

Fig.1. Modulated Faraday cup (F. C.) and pyroelectric signals for 2 keV He^+ beam injection.

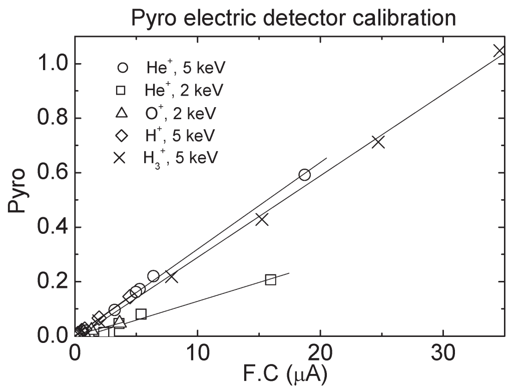

Fig. 2. Calibration curves of the pyroelectric signal for the ion current of H^+, He^+, H_2^+ beams of 5 keV and O^+, He^+ beams of 2 keV.

References

1) N. Tanaka *et al.*, 16th International Toki Conference, Gifu, Japan (6, Dec, 2006), to be published.

2) M. W. Geis *et al.*, J. Phys. E **8** (1975) 1011