§12. Profile Measurement of Negative Ion Density with Cavity Ringdown Method in Negative-Hydrogen-Ion-Source Plasma

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A large-scaled negative-hydrogen-ion (H^-) source has been applied for the neutral beam injector (NBI) on Large Helical Device (LHD). For improvement of the source performance, it is important to understand the physical mechanism for the H^- production and extraction in the beam extraction region. We have directly measured the H^- density there with the half-size source used for the R&D of the LHD-NBI source.

The H^- density ($n(H^-)$) was measured with the Cavity RingDown (CRD) method. The CRD method is based on the optical absorption by the photo-detachment of the negative-hydrogen ions, and the absolute line-integrated $n(H^-)$ can be obtained. In the measurement, Nd-YAG laser with the wavelength of 1064 nm and the diameter of 7 mm is utilized for the CRD system, and the line-integrated $n(H^-)$ was measured along 9 mm from a plasma grid (PG) and above PG apertures with the time resolution of 50 ms [1].

The CRD system of a fixed path measurement [1] has been modified to that of a flexible path measurment, i.e. profile measurement [2]. In the modified CRD system (shown in Fig. 1 and Fig. 2), two dimentional drive units was installed between the high reflectvie mirrors and the source. By use of the drive units, both sides of high reflective mirrors of cavity can move in the plane perpendicular to laser axis. Adjusting input laser axis to the moved cavity axis, we can obtain the $n(H^-)$ profile. The area of profile measurement is 5 mm to 17 mm from PG, and -25 mm to 25 mm of vertical direction in Fig. 1 from the basing point (Fig. 2). Limitations of profile measurement area are caused by the configuration of the source and the movable range of the drive units. A space resolutin is experimentally confirmed as less than 2 mm, although it is ideally less than 1 mm which is derived from the cavity configuration.

A $n(H^-)$ profile perpendicular to PG above PG apertures is shown in Fig. 3. The profile was obtained in arc power of about 52 kW, introduced hydrogen gas pressure of 0.2 Pa, and bias voltage of 2 V, without beam extraction. In the H^- source for the NBI, cesium was seeded to a plasma generator. In such H^- source, it is considered that the negative-hydrogen ions in vicinity of the PG are mainly produced on the PG surface, transport to PG apertues, and extract as the beam. In Fig. 3, the $n(H^-)$ decreases as approaching to PG. This can be consistent with negative-hydrogen ions are produced on PG surface.

By use of the $n(H^-)$ profile measurement system, we promote the study of H^- production and extraction.

[1] NAKANO H. et al., 19th International Toki Conference, P2-67, Toki, Japan, December 8 - 11, 2009.
[2] NAKANO H. et al., 2nd International Symposium on Negative Ions, Beams and Sources, O-32, Takayama, Japan, November 16-19, 2010.

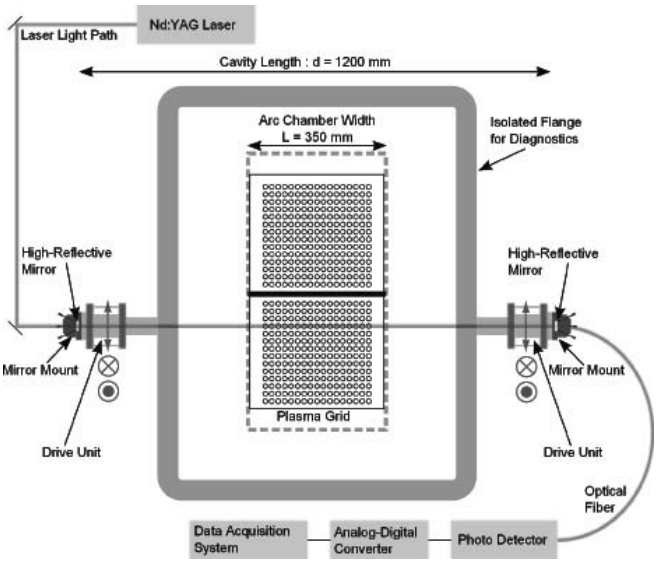

Fig. 1 A schematic view of a CRD system for the profile measurment on the ion source for development.

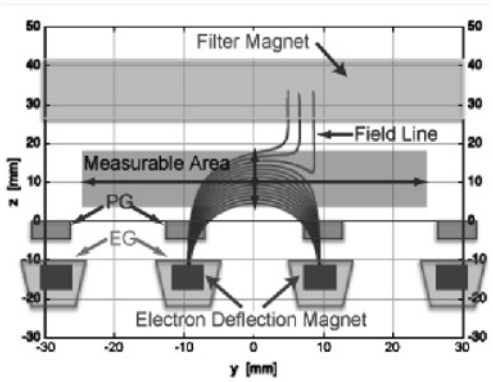

Fig. 2 A relation between area of the profile measurement and magnetic field in the vicinity of the PG.

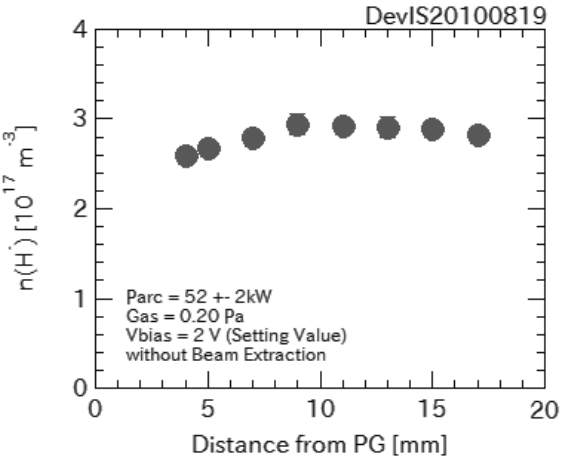

Fig. 3 A density profile of negative hydrogen ion on a line of sight above apertures of the plasma grid in cesium-seeded hydrogen plasmas.