§12. Long-pulsed Operation of an Negative Hydrogen Ion Source

Ando, A., Matsuno, T., Funaoi, T., Tanaka, N. (Dept. Electrical Eng. Tohoku Univ.),
Oohara, W., Tauchi, Y. (Dept. Eng. Yamaguchi Univ.),
Takeiri, Y., Tsumori, K., Nakano, H.

Neutral beam injection (NBI) system is one of the powerful and fruitful heating tools in fusion researches. A high power hydrogen negative-ion (H^-) source has been successfully developed for a beam source and operated as a major heating device in LHD.[1),2)] For a long pulse or continuous operation, it is requisite to develop radio-frequency (RF)-driven H^- sources. They have no electrode like a filament, usually used in arc-discharge-driven sources, which limits a source lifetime by its erosion and fragility.

Our purpose of this research is to develop a compact RF-driven H^- ion source by using a FET-switching inverter power supply with a frequency of 0.3-0.5MHz as a RF source and to operate it for long time duration. The small ion source consists of a cylindrical driver region and an expansion region. In the driver region a multi-turn loop antenna was wound around a cylindrical ceramic tube (inner diameter: 70 mm, outer diameter: 80 mm, length: 170 mm). Axial magnetic field can be applied in order to enhance plasma production. Electron density attains to 10^{19}cm^{-3} at the driver region and to more than 10^{18}cm^{-3} at the expansion region.[3),4)] Cesium vapor can be injected to enhance the H^- production. It is necessary to clarify temporal behavior of heat influx to electrodes, cesium behavior in the plasma and beam currents during long pulse operation.

H^- beam was extracted from acceleration electrodes through a single hole with single aperture of 9mm in diameter attached on the source. An extraction current I_{ext} and an acceleration current I_{acc} were measured as a function of the filling pressure as shown in Fig.1. With adding a small amount of cesium vapor, I_{acc} increased more than twice, while I_{ext} decreased. The source can be operated with the pressure of 0.3Pa and I_{acc} and I_{ext} were almost constant to the pressure.

Figure 2 shows temporal behavior of several parameters measured after cesium injection. When cesium vapor were added at t=30min, I_{acc} and I_{ext} decreased. Optical emission of CsI lines started to increase, while H_α and H_β decreased as shown in the figure. Temperature of the plasma grid was gradually raised by using a sheath heater. I_{acc} and I_{ext} increased as the temperature increased, while the ratio of (I_{ext}- I_{acc}) to I_{acc} decreased, which corresponds to the ratio of electron to H^- currents. These data were taken shot by shot, and duration of each pulse was 5ms. We have tried to elongate pulse length from several ms to sec by arranging cooling system of isolation transformer, RF transmission line and the ion source.

We are going to increase pulse length to CW operation and to investigate plasma parameters, cesium behavior and H^- beam extraction.

1) Y.Takeiri, et al.., Nuclear Fusion, **46** (2006) S199.
2) K.Tsumori, et.al., Rev. Sci. Instrum., **79** (2008) 02C107.
3) A.Ando, et al., Rev. Sci. Instrum., **81** (2010) 02B107.
4) A.Ando, et al., AIP conf. Proc. **1390** (2011) 322.

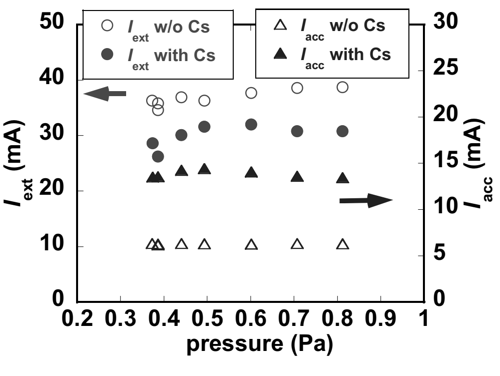

Fig.1 Dependences of the extraction current (Iext) and acceleration current (Iacc) on filling gas pressure. V_{ext}= V_{acc}=7kV, P_{RF} ~ 15kW. f=0.32MHz. B_z=14mT.

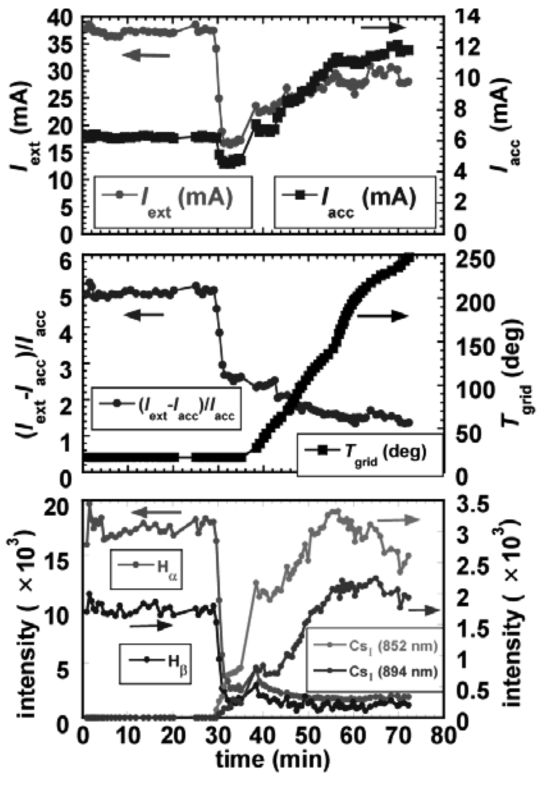

Fig. 2 Temporal behavior of beam currents and optical emissions from the RF ion source. V_{ext}= V_{acc}=7kV, P_{RF}=14kW. P=0.6Pa, f=0.32MHz. B_z=14 mT.