§8. Spatial Distribution of Electron and H^- Ion Densities with and without Beam Extraction in the Beam Extraction Region of a NIFS-R&D Negative Ion Source

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Stable and beam extraction with high H^- current density is a common key issue on negative ion source for NBI. There are, however, many problems not understood clearly in formation and transport mechanisms of H- ions inside caesium (Cs) seeded ion sources. In order to investigate the mechanisms, a multi-diagnostic system has been installed to measure the dynamics of the charged particles and potential changes in so-called beam-extraction region of a R&D ion source [1]. We have found quite low electron density is included in the plasma near the plasma grid (PG) in the Cs seeded condition optimized for a ratio of extracted electrons to H^- ions. The charge neutrality is kept with positive and negative ions without beam extraction. On the other hand, the H^- density drops with a certain level during the extraction and decreasing density of extracted H^- ions are compensated with that of electrons [2].

The waveforms of negative saturation current, which includes H^- and electron currents, and H^- ions have been measured with Langmuir probe and cavity ring down (CRD) [3], and exchange of the H^- ions with electrons is shown in

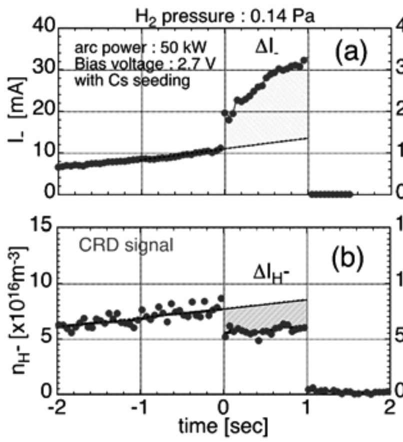

Fig. 1. Changes of (a) negative saturation current of Langmuir probe and (b) H^- density measured with cavity ring down. Extraction of H^- ions is applied at the origin of time. The measurement is done using Cs optimized plasma.

Fig. 1 (a) and (b), respectively. The extraction electrostatic field is applied at the origin of the time scale. The measurement is applied with Cs-optimized plasma in the extraction region at the position of 9 mm apart from PG, where H^- ions are produced on the surface. The increment of negative saturation current and decrement of H^- ion density during beam extraction are indicated as ΔI_- and ΔI_{H^-}, respectively. The next question is how the density distribution of the charged particles changes in the extraction region. The distribution of the saturation currents

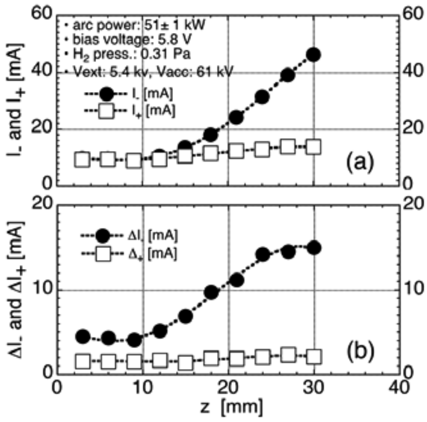

Fig. 2. (a) Spatial distribution of the positive and negative saturation currents (I_- and I_-, respectively) in the direction normal to the PG surface, where corresponds to the z origin (b) The distribution of the positive and negative current increments during beam extraction (ΔI_- and ΔI_-, respectively).

without beam extraction and increments of the current with and without beam extraction are shown in Fig. 2 (a) and (b), respectively. As shown in Fig. 1 (a), positive and negative saturation current have similar intensities in a region within a distance of ~10 mm from the z origin, where corresponds the PG surface. This indicates that the plasma includes very low electron density. In this region, relatively strong magnetic field of ~10 mT induced by a set of permanent magnets imbedded in the extraction electrode to sweep co-extracted electrons. As moving away from the PG, the negative current increases more than positive one because of the electrons are involved in the plasma. The increment of the negative saturation current (ΔI_-) has flat distribution near the PG as shown in Fig. 2 (b), while the intensity is much higher than that of ΔI_+. This current difference is interpreted as follows: by applying beam-extraction field, charge neutrality of the plasma near the PG cannot be held with positive and negative ions only, and electrons are involved in the plasma. This feature is reproduced with a numerical simulation using PIC method [4].

1) Tsumori, K. et al.: Super CCNB, Hida Earth Wisdom Centre (unpublished).
2) Tsumori, K. et al.: Rev. Sci. Instrum. **83** (2012) 02B116.
3) Nakano, H. et al.: AIP Conf. Proc. **1390** (2011) 359.
4) Kameyama, N. et al.: Rev. Sci. Instrum. **83** (2012) 02A721