§7. Comparison of a Reduction Value between H^- Density and H_α Emissions at Extraction Region in a Negative Ion Source

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We have reported a spectrally selective imaging system for a negative hydrogen ion source in the last NIFS annual report[1]. This system have been performed well to understand distribution of H_α emissions which is caused by the variation of excited hydrogen population. It is low electron temperature ($\sim$1 eV) near the plasma grid surface where is the birth area of the hydrogen negative ions. Main excitation mechanisms for H_α emission are dissociative recombination between an electron and H_2^+, and the mutual neutralization between H^+ and H^- in this area. We have also observed the ionic plasma condition which maintained by H^+ and H^- ions. As the percentage of negative ions is increased, H_α emission caused by the mutual neutralization process becomes dominant. Figure 1 shows the typical waveform of a hydrogen negative ion density (n_{H^-}) and a H_α emission intensity in the extraction region. These signals decreased by extraction voltage applied between the plasma grid and the extraction grid. We have defined the reduction vale of ΔH_α and Δn_{H^-} subtracting the value acquired before beam extraction from during beam extraction as shown in Figure 1. Figure 2(a) shows a plot of the extraction current (I_{ex}), the absolute value of the reduction H^- density ($|\Delta n_{H^-}|$) and the reduction in the H_α intensity ($|\Delta H_\alpha|$) against the absolute value of the extraction voltage ($|V_{ex}|$). The extracted current density for I_{ex} is reached 10 mA/cm^2 at $|V_{ex}|$= 8 kV, here the I_{ex} is the drain current (i.e. mixed H^- ions and electrons) in the circuit between the EG and a direct current extraction voltage power supply; it is linearly depended on the V_{ex}. The reduction density of $|\Delta n_{H^-}|$ observed at 2 mm from the PG surface also depend linearly on the extraction voltage. As the extraction current is 10 mA/cm^2, the $|\Delta n_{H^-}|$ is 3.4×10^{16} m^{-3}. The current density J is the product of the charged particle density n and the drift velocity v. The drift velocity $v = J/n = 1.85 \times 10^4$ m/s when we assume the extraction current is carried by $|\Delta n_{H^-}|$. The flow energy of the negative ion is estimated as 1.8 eV that is nearly value to the election temperature in the extraction region of this source. We also found the linear increase on the reduction value for $|\Delta H_\alpha|$ measured at $z = 4$ mm, where is as close as possible to the position of H^- measurement. The linear dependence is appeared between $|\Delta H_\alpha|$ and $|\Delta n_{H^-}|$ as shown in Figure 2(b). This result indicates the reduction in the intensity of H_α is the result from a reduction in the H^- ion density by way of mutual neutralization process in ionic plasma with rich H^- ions after Cs conditioning.

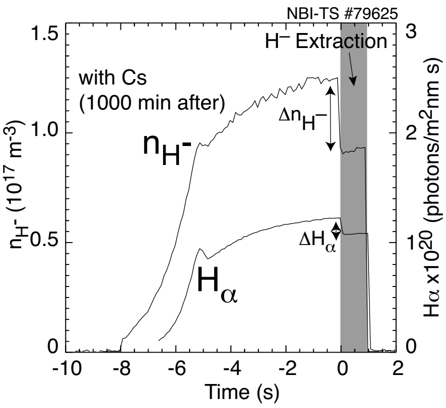

Fig. 1: Typical example of the waveform of H^- density and H_α intensity in 38kW arc discharge after 1000 min Cs conditioning. Both signals decreased by the extraction voltage during 1 sec.

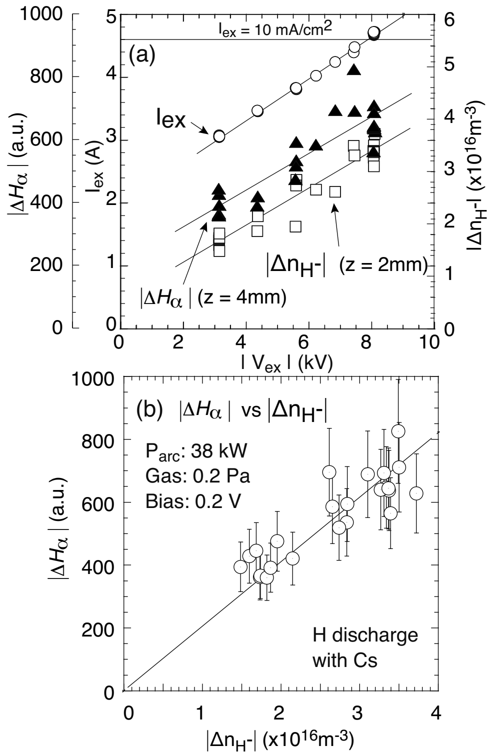

Fig. 2: (a) Extraction drain current I_{ex} and the absolute value of the ΔH_α and Δn_{H^-} linearly increase by the strength of applied extraction voltage. The line for 10 mA/cm^2 is represented. (b) There is a linear relationship between the $|\Delta H_\alpha|$ and the $|\Delta n_{H^-}|$ in the optimal Cs condition.

1) IKEDA, Katsunori "Observation of Reduction Structure of H^- Ions at Extraction Region in a Hydrogen Negative Ion Source", Annual Report of National Institute for Fusion Science April 2012 - March 2013, (2013), pp200.