Comparison of Optical Emission Spectroscopy and Cavity Ring Down Spectroscopy in Large-Scaled Negative Ion Source

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Production of H\textsuperscript{-} ions and its dynamics near the surface of the plasma grid (PG) are important subjects in cesium (Cs) assisted H\textsuperscript{-} ion sources for stable operations of the neutral beam injectors (NBI). An optical emission spectroscopy (OES) and a cavity-ring-down spectroscopy (CRDS) systems have been installed in the 1/3-scaled NIFS H\textsuperscript{-} source to investigate H\textsuperscript{-} and Cs behaviors. The plasmas are produced by filament-arc discharge, and magnetic filters are equipped in the H\textsuperscript{-} source to reduce electron energies near the PG. A bias insulator has been replaced the thickness from 16 mm to 40 mm to install quartz windows for OES, optical mirrors for CRDS, and Langmuir-probe ports. All the diagnostic positions are 10 mm apart from the PG and parallel to its plane.

In the OES measurements, atomic hydrogen lines (H\textalpha{}, H\textbeta{}, H\gamma{}), oxygen lines (O I 777 nm), and Cs\textsuperscript{0} lines (Cs I 852 nm) have been observed. Although Cs\textsuperscript{+} lines (Cs II 460 nm) are strongly observed in the driver region in the previous experiment [1], the intensity of the lines are below the measurable limit in the extraction region. The electron temperature measured by the Langmuir-probe is at most 1 eV. According to the numerical calculation of the emission rate coefficient of hydrogen Balmer lines, an emission line ratio H\textalpha{}/H\beta{} relates to H\textsuperscript{-} density in a negative ion source [2]. The H\textsuperscript{-} density can be estimated in the condition of $T_e > 1$ eV. At the present plasma parameters near the PG, it is difficult to obtain H\textsuperscript{-} density from the ratios of Balmer-line intensities using only OES analysis, because dissociative recombination of molecular hydrogen ions contributes significantly to the Balmer line radiation. So the correlation approach is employed in OES measurement for H\textsuperscript{-} estimation.

We set the constant discharge conditions (arc power, bias voltage and pressure) in the Cs experiment. Just after Cs seeding, H\textsuperscript{-} beam current immediately jumps up. Then the signal intensity of neutral Cs and H\textsuperscript{-} beam current increase shot by shot. We have also observed increasing of H\textalpha{}/H\beta{} ratio by OES and H\textsuperscript{-} density by CRDS near the PG due to enhancement of H\textsuperscript{-} production. The linear correlation between the inclination of H\textalpha{}/H\beta{} and the H\textsuperscript{-} density allows for benchmarking the OES measurement with the CRDS experimentally, which is then being used for estimation of H\textsuperscript{-} density by OES in these ion sources.