§13. Cs Density Measurement in Arc Driven Negative Ion Source by Means of Laser Absorption Spectroscopy

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The Cs has an important role on the hydrogen negative ion sources because it enhances the negative ion production significantly by reducing the work function on the plasma grid (PG). On the other hand, the maintenance interval for the ion source is limited by the Cs consumption rate and the Cs could cause the electrical breakdown when it enters the gap between the PG and the extraction grid (EG). Hence, it is important to understand the Cs behavior and optimize the Cs consumption. One of the key parameters to explore the Cs behavior in the negative ion source is the Cs density in the extraction region.

The optical emission spectroscopy (OES) is a powerful diagnostic technique for monitoring the Cs behavior and that is routinely operated in our experiments. However, the signal from the OES strongly depends on the condition of plasma discharge, and it is difficult to know the Cs behavior quantitatively. Then, we have installed the laser absorption spectroscopy (LAS) system to the 1/3-scaled negative ion source (NIFS-RNIS), where the plasma is produced by the arc discharge with filaments, in order to measure the Cs density in the extraction region. Figure 1 shows the schematic illustration of the experimental apparatus. The laser beam is ejected from the wavelength-tunable diode laser and guided to the NIFS-RNIS with the multimode optical fiber. The optical fiber is attached on the diagnostic flange as the laser beam can pass through the central region of the ion source. In this experiment, the wavelength of the laser beam was modulated by 2 Hz, and the Cs density measurement was performed during the plasma discharge.

Figure 2 shows the typical absorption spectra of the cesium D_2 line. In this study, the cesium D_2 line is chosen to estimate the Cs density because of the higher transition probability than the D_1 line. The cesium D_2 line consists of six hyperfine lines and only two peaks are observed because of the Doppler broadening of the individual lines[1]. The Cs density was obtained in the same manner as written in Ref. 1.

Figure 3 shows the time evolutions of the Cs density and the plasma discharge power. In the vacuum phase (before the plasma discharge) the Cs density stays constant and rapidly increases as the plasma discharge power increases because the Cs is evaporated from the wall which receives the heat load from the plasma. After the plasma discharge the Cs starts to be adsorbed on the wall surface as the wall temperature starts to drop, and the Cs density gradually decreases. This result implies that the Cs recycling from the wall plays an important role on the Cs effect for enhancement of the negative hydrogen ion production. As a future work, we have a plan to control the wall temperature actively in order to enhance the Cs recycling and to optimize the Cs consumption.

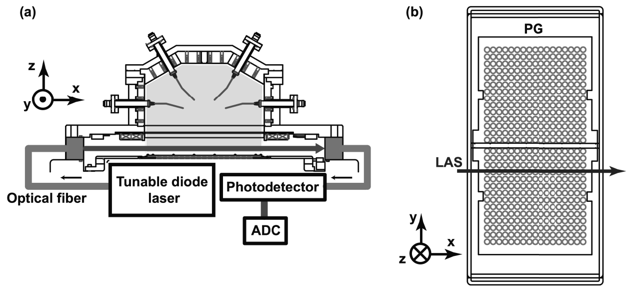

Fig. 1. Schematic illustration of experimental setup.

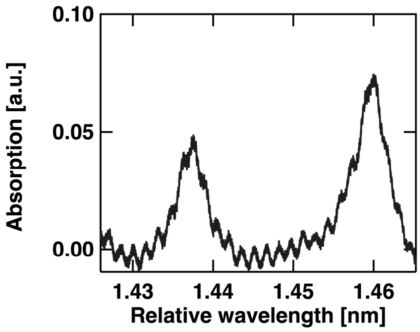

Fig. 2. Typical absorption spectra of Cs.

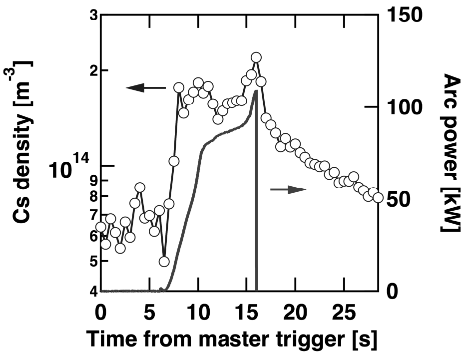

Fig. 3. Time evolutions of Cs density and arc power.

1) Fantz, U., Wimmer, C.: J. Phys. D: Appl. Phys. **44** (2011) 335202.