Optical measurement of the cesium behavior in large H^- ion source for neutral beam injector

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Hydrogen negative ion (H^-) source is an indispensable instrument for high power and high-energy neutral beam injector (NBI) in fusion facilities. We have operated large negative ion sources for three high energy NBI in the Large Helical Device. In the hydrogen negative ion source, cesium (Cs) vapor is effective to increase H^- production on a plasma grid surface. It is much better to decrease Cs consumption though increasing negative ion densities. To investigate Cs behavior inside of the negative ion source, an optical view ports are installed at both arc discharge area and magnetic filter field area near the plasma grids.
According to the probe measurement in an $80kW$ arc power discharge without beam extraction, the electron density and the electron temperature is $n_e = 3 \times 10^{18} m^{-3}$ and $T_e = 5eV$ at discharge area, respectively [1]. In the magnetic filter area, the electron density and the electron temperature hold down to $n_e = 0.5 \times 10^{18} m^{-3}$ and $T_e = 2eV$ by the filter field, respectively. In the 20 sec beam operation with $78kW$ arc discharge power, the acceleration drain current of $16.5A$, which is almost constant during discharge, is extracted from the ion source with the beam energy of $111keV$. The intensity of hydrogen Balmer line emission ($H\gamma$) is also constant during discharge, so the electron temperature and density are presumed constant condition during beam extraction. We have found the difference behavior between the Cs light emission at discharge area and at magnetic field area. At the arc discharge area, Cs^+ ion light emission is strongly observed during beam extraction due to sputtering Cs from the back plate of the arc chamber surface by the impact of back streaming H^+ ions with an acceleration potential. Cs particles are almost ionized in the discharge area, and its density increase continuously during 20 sec beam extraction. Cs^+ light emission is also observed at the magnetic filter area, but it is very weak signals because of decreased the emission coefficient by low electron temperature. On the other hand, Cs^0 neutral light emission have been clearly observed, and it also increase during beam extraction. We have also observed the rapid increasing of Cs^0 signal after 13 seconds from beam extraction. It is thought that the neutral Cs particles evaporate hot area around PG other than the back plate. From the estimation of the Cs particle fraction, neutral Cs at the PG area is 100 times larger than neutral Cs at the discharge area. The neutral Cs around the PG area estimated from the optical emission intensity is ten times smaller than Cs ions at the discharged area. Neutral Cs with thermal energy is likely to contaminate the extraction area, but this is not large amount.

[1] K. Ikeda, U. Fantz, K. Nagaoka et al., J. Plasma Fusion Res. **2** (2007) S1047