§16. Increase of Neutral Beam Attenuation in High T_i Discharge Used a Carbon Pellet Injection

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Figue 1 shows the time evolution of high ion temperature (T_i) discharge of the shot number of 90982 sustained by NBI heating. A small carbon pellet with the diameter of $\phi = 1.4mm$ is injected at $t = 1.8s$. The averaged electron density measured by FIR is rapidly increased to $\langle n_e \rangle = 4.5 \times 10^{19} m^{-3}$, and it decay to $\langle n_e \rangle = 1.2 \times 10^{19} m^{-3}$ at $t = 2.5s$. At the plasma center ($R = 3.655m$), T_i measured by the CXRS increases to $5.4keV$ as decreasing $\langle n_e \rangle$ as shown in close circles in Fig. 1. We have observed beam emission Hα spectrum [1] which is emitted from neutral beam particles by the interaction of target plasma particles as shown in Fig. 2. Here, square marks and circle marks are observed at the upstream position and the downstream position, respectively. The beam emission signals have not observed before $t = 2.0s$. It is expected that there is strong beam attenuation caused by the carbon impurities. Then the beam emission signal increases as increasing penetration beam particles during discharge.

We have calculated the reconstructed beam emission intensity along the beam injection axis used the measured density distribution, the measured temperature distribution and the coefficients of beam stopping and beam emission by the Atomic Data and Analysis Structure (ADAS) [2] data base. The behavior in pure hydrogen plasma is different from the observed beam emission signals. The beam emission signal must be observed higher at both positions before $t = 2.4s$ in the case of pure hydrogen plasma written as thin lines in Fig. 2. Here, we also calculated the beam emission intensity taken into account the carbon impurity, because the number of penetration beam particles is close related with the beam stopping coefficient. The assumed fraction of the carbon impurity decreases after the pellet injection as show bold lines in Fig. 1. Fraction of carbon is 13% at $t = 2.1s$ and it rapidly decrease to 0.5% at $t = 2.4s$. The reconstructed beam emission intensity is fit well to the measured beam intensity as shown the bold lines in Fig. 2. Carbon particles are effective to increase the neutral beam heating power. At $t = 2.1s$, the beam particles are almost ionized (94%) into the plasma. Ionization rate is kept 76% at $t = 2.2s$ with the carbon fraction of 3%, which is 13% larger than the hydrogen discharge used same density profile as shown in Fig. 3. Strong beam attenuation is occurred by the carbon impurities during increasing of ion temperature. Beam attenuation decrease to 55%, which is almost same as the hydrogen attenuation rate, at $t = 2.4s$ with the carbon fraction of 0.5%. After that time, T_i keeps about $4keV$ with half beam attenuation same as the hydrogen discharge.

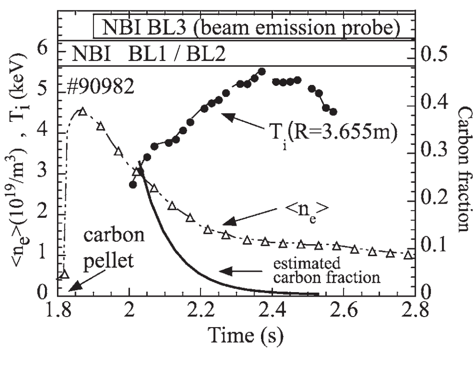

Fig. 1: Time evolution of the high T_i discharge used a carbon pellet and NBI heating.

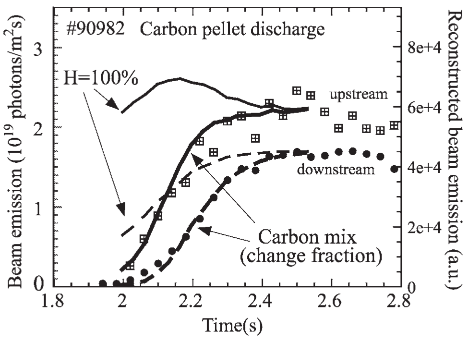

Fig. 2: Observed beam emission Hα intensities and reconstructed beam emission calculated by ADAS data.

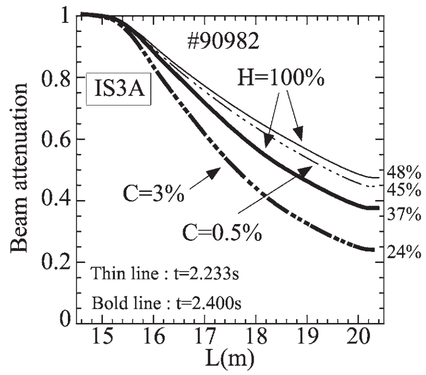

Fig. 3: Attenuation beam intensity along the beam injection axis of L from the negative ion source.

1) Ikeda, K. *et al.* : Transactions of Fusion Science and Technology **51**(2T) (2007) 283.

2) Summers, H. : ADAS manual 2.6 (2004) http://www.adas.ac.uk/manual.php