§5. Impurity Behavior in IDB-SDC Mode

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In reduced recycling discharges in the Large Helical Device (LHD), a stable SuperDense Core (SDC) mode with an Internal Diffusion Barrier (IDB) is achieved both in Local Island Divertor (LID) and Helical Divertor (HD) configurations when a series of pellets are injected.[1] In such a high density regime like an IDB-SDC mode, the impurity behavior plays an important role to maintain or enhance the present regime. The impurity accumulation in the core region may bring about the disruptive collapse of the discharge.

Figure 1 shows time evolutions of (c) Fe Kα line emission measured with a pulse height analyzer (PHA) for X-ray emission, (d) total radiation power measured with a 2π-bolometer, (e) core and edge radiations measured with a poloidal bolometer array, together with (a) central electron density n_{e0} and (b) central electron temperature T_{e0}. It is found from Fig. 1 (d) that the total radiation increases gradually in the latter half of the discharge. Comparing Figs. 1 (d) and (e), it seems that the energy is mainly radiated from the core region. The time behavior of the total radiation well correlates to the core radiation depicted in Fig. 1 (e), especially from $t \sim 1$ s to 1.6 s. The Fe Kα line emission shown in Fig. 1 (c) also increases with the total and/or core radiation in the latter half of the discharge. It could surely be reasonable to consider that the Fe Kα line emission comes from the core region in this temperature range. However it does not always correlate to the core radiation, i.e. the Fe Kα line emission continues to increase while P_{rad} begins to decreases after t = 1.45 s. In fact, it seems Fe Kα line emission correlates to T_{e0}, rather than P_{rad}. Therefore it can be considered that the increase of Fe Kα line emission may be due to the increase of the central electron temperature, rather than the increase of Fe density itself. In other words, impurity contamination is not so serious in the IDB-SDC mode. Another qualitative explanation for the increase of the Fe Kα line emission may be possible, i.e. it is attributed to the increase of the Fe influx. The high density plasma in the IDB-SDC mode enhances the sputtering on the vacuum vessel wall which is made of stainless steel, through the high flux of charge exchange particles. The sputtered carbon released from the plasma facing components (PFCs), e.g. carbon tiles on the LID head, may also enhance the Fe sputtering on the vacuum vessel wall through the charge exchange process, since the sputtering yield by carbon is much higher than that by hydrogen.

Anyway the core radiation does not terminate the discharge. In view from the fact that the total radiation power is small (about 30 % of the total heating power), it is found that the radiation has nothing to do with the termination of the discharge. In fact, the discharge was actually terminated by switching off the NBs in this shot. Sufficient or crucial evidence has not been observed for the impurity accumulation in the core region yet, therefore further experimental and theoretical investigations should be necessary to reach the conclusion.

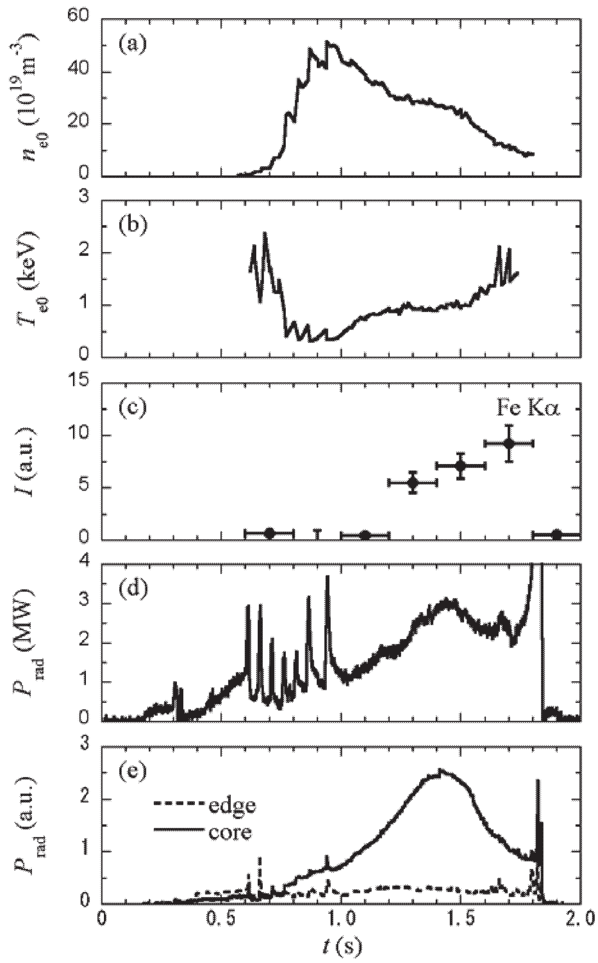

Fig. 1. Time evolutions of (a) central density, (b) central temperature, stored energy W_{dia}, (c) Fe Kα emission, (d) total radiation power and (e) edge and core radiation power in IDB-SDC discharge.

References

1) Morisaki, T. et al., Phys. Plasmas. **14**, (2007) 056113.