Analysis of radiative mantle formation by impurity seeding in ITER

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In fusion reactors, the divertor and the other plasma facing components get some interactions with hot plasma, by ion backscattering, chemical and physical sputtering processes, and then produce impurities. Especially heat loads on divertor plates are predicted to be very large, and high-Z materials such as tungsten will be used in such parts because of its high heat conductivity and low erosion rate. However, resulting high-Z impurity tends to accumulate into plasma core due to strong inwardly directed drift velocities caused by neoclassical convection and cause large radiation loss. Besides they displace reacting ions by the large number of electrons produced by them and cause fuel dilution. In order to check the access to ignition regime, it is important to clarify the plasma radial profile and the local energy balance including impurity effects in burning plasmas. On the other hand, it is considered that the reduction of heat load on divertor plates to tolerable level is one of the most critical issues. For the solution of this problem, impurity-seeded radiative mantle formation have been suggested. It depends on atomic processes to disperse the heating power in plasma periphery over the large surface area of plasma facing components such as first wall and the divertor chamber wall by impurity seeding into plasma. In this study, we investigate the possibility of radiative mantle formation to reduce the power flux to the divertor plates in ITER device. Figure 1 shows the radial profile of the radiation power density for various impurity and Fig.2 shows radiation fraction versus impurity concentration for Molybdenum impurity. These results indicate that medium-Z impurity can create radiative mantle effectively. The detail analysis will be shown in the conference. For the prediction of ITER plasmas, transport analysis has been carried out by using the 1.5D (1D transport / 2D equilibrium) toroidal transport analysis linkage code TOTAL [1] coupled with NCLASS. NCLASS code is utilized for the calculation of the neoclassical impurity fluxes for arbitrary aspect ratios and collisionalities. In this code, multi-species of impurity ions can be treated including neoclassical transport and radial electric field effects. For the impurity charge-state dynamics, the rate equation and diffusion equation are solved by using IMPDYN code with ADPAK atomic physics package.

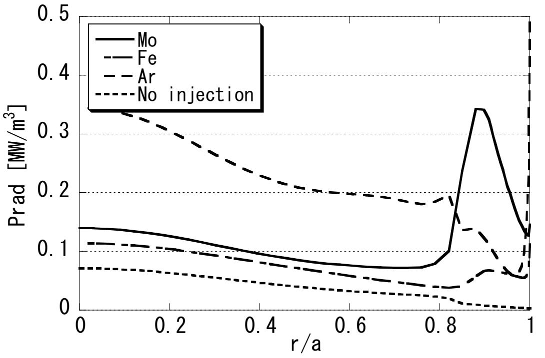

Fig.1 Radiation power density profiles for different impurity species at maximum concentrations.

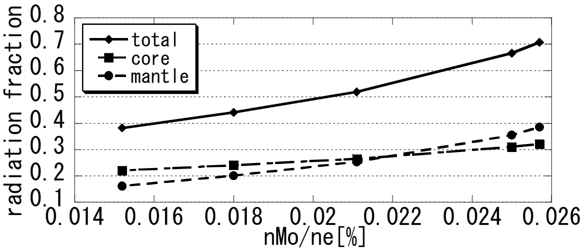

Fig.2 Radiation fraction versus Mo impurity concentration.

[1] K. Yamazaki, T. Amano, Nucl. Fusion **32** (1992) 633.