§1. Simulation Analysis of Carbon Deposition Profiles in the Closed Helical Divertor in LHD

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Long pulse plasma discharges were often terminated by emission of the large amounts of dusts from a closed helical divertor region in the previous (17th) experimental campaign in FY2013. The plasma termination processes induced by the dusts exfoliated from carbon-rich mixed material deposition layers accumulated in front of divertor plates were observed with a fast framing camera. The position of the dust source was tightly enclosed by a dome structure, divertor plates and the vacuum vessel, which enhanced the deposition of carbon-rich layers by physical and chemical sputtering on the divertor plates. Before the last (18th) experimental campaign in FY2014, the configuration of divertor plates (target plates) installed near lower and upper ports near the dust source was changed such that the front side of the target plates directly face to the main plasma for reducing the formation of the deposition layers.

For investigating the effect of the change of the divertor configuration, the profiles of the carbon deposition density were calculated using a three-dimensional peripheral plasma simulation code (EMC3-EIRENE). Figure 1 shows a three-dimensional model of a LHD plasma and the vacuum vessel including the components of the closed helical divertor for before and after the change of the configuration of the target plates. In this simulation, the deposition profiles are calculated by counting the number of carbon atoms sticking to the surface of the dome structure per unit of area (total number of the atoms is ~100 millions). It is assumed that carbon atoms are released by chemical sputtering from strike points with a thermal energy (600K) with a cosine angle distribution, and a sputtering and sticking coefficients of carbon atoms are 0.02 and 0.5, respectively.

The calculated density profiles of the carbon deposition on the dome structure are presented in Figure 2, which clearly shows the reduction of the density of the carbon deposition by change of the configuration of the target plates. This simulation is consistent with the experimental fact that the termination of long pulse plasma discharges induced by dust emission due to the exfoliation of the deposition layers near the target plates was not observed in the last experimental campaign and the traces of the exfoliation of the deposition layers were not identified on the dome structure near the target plates after the change of the configuration.

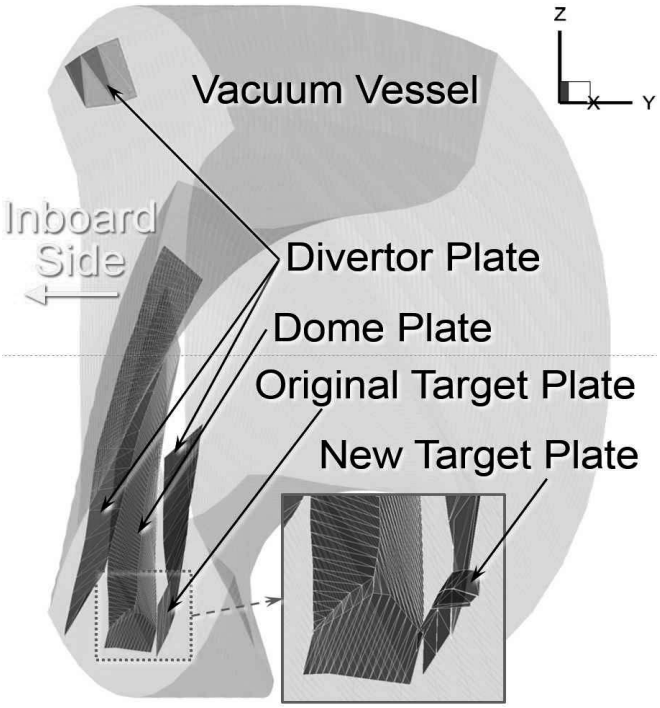

Fig. 1. A perspective view of a three-dimensional model of the LHD vacuum vessel and the closed helical divertor components for before and after the change of the configuration of the target plates.

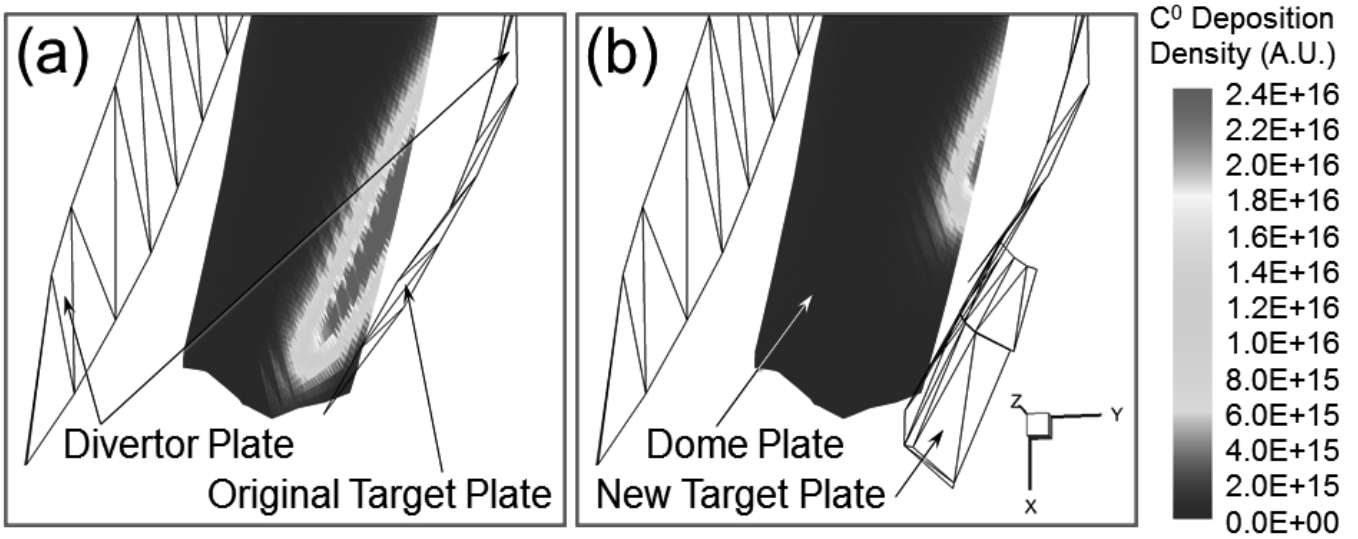

Fig. 2. Top view of the calculated carbon deposition density profile on the dome structure for before (a) and after (b) the change of the configuration of target plates installed near a lower port.