§14. Material Migration Study in LHD

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Understanding of the material migration in the vacuum vessel in present fusion devices is necessary to make a prediction of that in future fusion reactor. It is also necessary for the estimation of the plasma facing components life time in future fusion reactor. In the heliotron/stellarator devices which are non-axisymmetric system, the migration is more complicated than that in tokamaks. In LHD, to understand the migration, erosion and deposition measurement using Quartz Crystal Microbalance (QCM) and quantitative measurement of the first wall color were conducted.

QCM is a method to know the deposition amount on it position. The change of the resonant frequency of the crystal is monitored, and the decrease/increase of the frequency indicates the increase/decrease of the mass of the crystal. That means deposition/erosion at the position. In LHD, a QCM system (Inficon) was installed in the 1.5U port. The position of the crystal was R~1.6m, the first wall position. Figure 2(a) shows that erosion was dominant during glow discharge, and erosion and deposition were balanced during boronization at the position. Figure 2(b) shows the change of the frequency between before and after plasma experiment. It shows erosion is dominant during plasma experiment at the position.

As a result of plasma-surface interactions, the colors of the plasma facing components are changed. To investigate the plasma-surface interactions in the LHD vacuum vessel, 30 material probes for the color measurement were installed on the first wall as shown in Fig. 1. The difference of the color between before and after experiment campaign was quantitatively measured by a color analyzer (Satotech RGB1002) with an integrating sphere (developed by Dr. Matsumoto, Honda R&D). Figure 3 shows the RGB intensities before and after the experiment campaign at the positions shown in Fig. 1. At almost all positions, the probes colors were changed probably by deposition. The changes of the colors at #11, 12 (around torus outboard side equatorial plane in a vertically elongated cross-section) and #17 (torus inboard side) were much smaller than that at the other positions (in the red circles in Fig. 3). It is considered that erosion was dominant at these 3 positions.

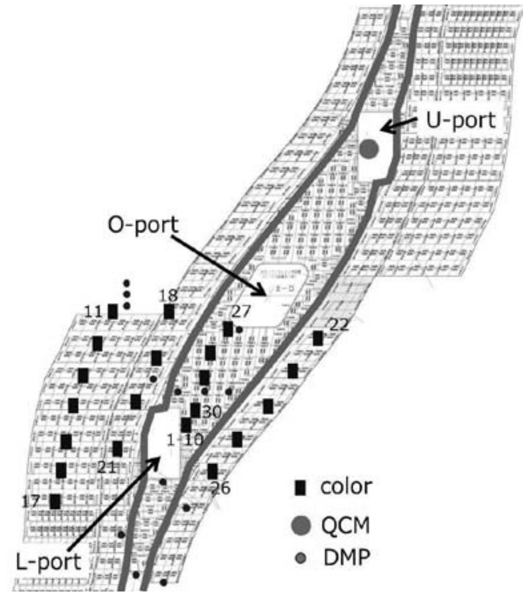

Fig. 1. Positions of the material probes and QCM on the development of the first wall. "1-30" indicate the color probes number.

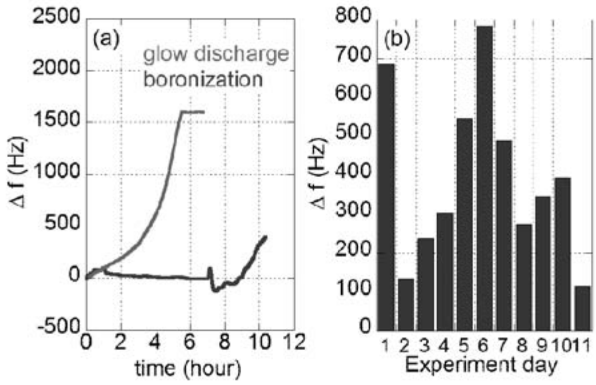

Fig. 2. Change of the resonant frequency of the QCM as a function of the glow discharge time (a) and experiment day (b), respectively. In (a), boronization was conducted about 7 hours, and He glow discharge was conducted after the boronization.

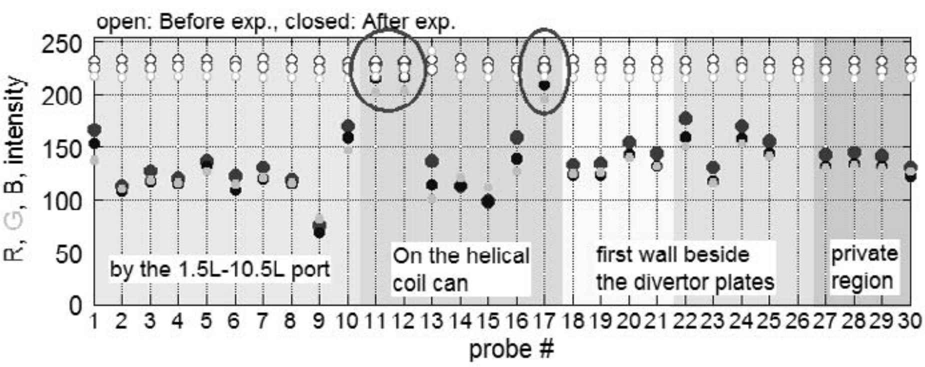

Fig. 3. RGB intensities of the material probes at 1-30 positions.