§56. Study on Hydrogen Recycling and Particle Control in the Spherical Tokamak QUEST

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A stable steady state operation is a critical issue for a future fusion device. The issue contains not only subjects related to the core plasma such as confinement, heating and current drive but also those related to the plasma-wall interaction (PWI) such as hydrogen recycling. An objective of this research is to study hydrogen recycling and particle control for better understanding of PWI phenomena.

In this time, preliminary experiments on hydrogen recycling were carried out in the spherical tokamak QUEST. Figure 1 shows plasma current I_p, RF power P_{RF}, H_α line intensity $I_{H\alpha}$ and variation of neutral pressure due to the plasma production ΔP, which is estimated from the difference between the neutral pressure with and without plasma to eliminate influence of magnetic field on an ionization gauge. The plasma was produced by ohmic heating and electron cyclotron heating (ECH) with the frequency of 8.2 GHz. The plasma-wall interaction seems to be enhanced during ECH, since $I_{H\alpha}$ was increased in that period as shown in Fig.1(c). ΔP was also increased during ECH. It decreased to almost zero when P_{RF} was switched off, and then became negative in the latter phase of the discharge. This suggests that hydrogen desorption from the wall occurred due to enhancement of PWI during ECH and hydrogen absorption in the wall occurred in the latter phase of the discharge without ECH.

In order to study PWI phenomena from the microscopic viewpoint, long-term samples were installed on the plasma-facing wall of QUEST. The samples were SUS316L coated by Au and those shown in Fig.2. Those were analyzed after an experimental campaign. Figure 3 shows analysis results by using a Rutherford back scattering (RBS) method and a elastic recoil detection (ERD) method for the sample of SUS316L coated by Au. The RBS and ERD methods were simultaneously carried out using 2.8 MeV $^4He^{2+}$ beam. From RBS analysis it is found that thickness of unexposed area of Au coated layer was 100 nm and it was almost the same as that of plasma-exposed area. This means that sputtering or erosion did not take place during the experimental campaign. From the analysis of X-ray photoelectron spectroscopy (XPS) it is found that there exist carbon and oxygen on the surface. And only carbon was detected after elimination of the top most surface. This means that carbon deposition occurred during the discharge. An ERD analysis indicates that hydrogen was absorbed beneath the surface. The hydrogen seems to be codeposited with carbon. In QUEST, carbon was not used for the plasma-facing components. The reason of the carbon deposition is now under investigation.

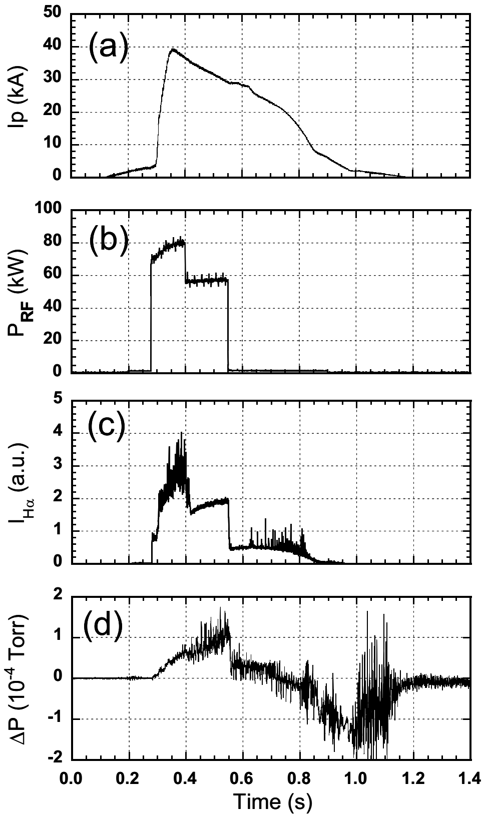

Fig.1 Time evolution of (a) plasma current, (b) RF power, (c) H_α line intensity and (d) variation of neutral pressure due to the plasma production. The plasma was produced by ohmic and RF heating.

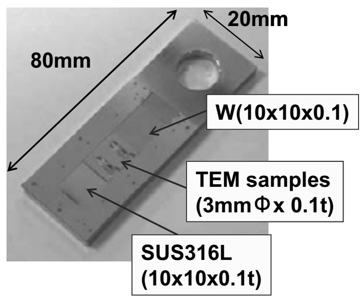

Fig. 2 Picture of a long-term sample installed on the plasama-facing surface in QUEST.

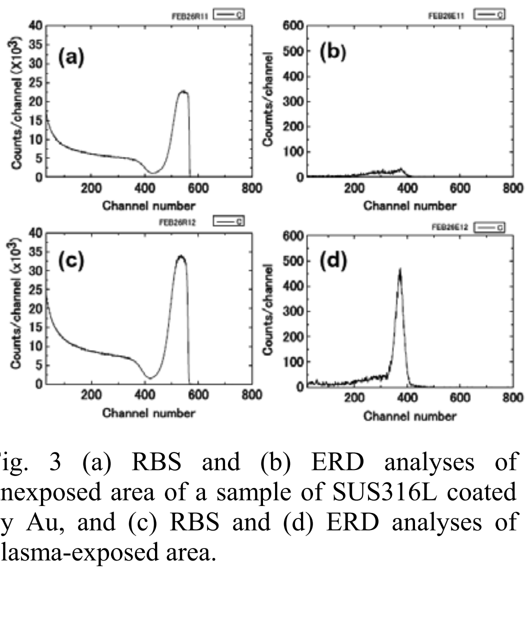

Fig. 3 (a) RBS and (b) ERD analyses of unexposed area of a sample of SUS316L coated by Au, and (c) RBS and (d) ERD analyses of plasma-exposed area.