§28. Analysis of Tritium Transfer Dynamics for Helical Prototype Nuclear Reactor System Design

Okuno, K., Oya, Y. (Shizuoka Univ.), Matsuyama, H., Hara, M. (Univ. Toyama), Hino, T., Yamauchi, Y., Nobuta, Y. (Hokkaido Univ.), Sagara, A., Tanaka, M., Ashikawa, N.

i) Introduction and appuratus

Tungsten will be used for plasma facing materials in future fusion devices and many studied were devoted to elucidate fundamental tritium retention and transport behaviors in tungsten under well-controlled condition. However, it is quite difficult to apply these data derived under well-controlled condition to actual and large scale plasma devices or fusion devices due to lots of uncertainties. Therefore, the key parameters should be acquired for the expansion of laboratory data (well-controlled condition data) to actual reactor design.

In this study, newly designed plasma experimental device, namely EXPRESS (Effluence and Exchange Probe for Recycling Estimation at NIFS and Shizuoka University) was established. Figure showed that overview of EXPRESS apparatus. This device has some futures as follows. The compact RF plasma device was installed and many samples can be placed in the exposure chamber. In addition, the sample stage size was 100 mm in diameter. The heating unit was installed beneath the sample stage and the temperature gradient of 200 K was arisen between the center and the edge of sample stage.

The preliminary experiment by deuterium plasma exposure to pure tungsten was performed at room temperature. Characterization of tungsten surface was done by XPS and hydrogen isotope desorption and retention behaviors were studied by TDS.

ii) Experimental

Polycrystalline tungsten (10 mm^{φ} x 0.5 mm^{t}) with stress-relieved conditions (heated at 1173 K) purchased Allied material Co. was used as samples. These were preheated at 1173 K for 30 minutes under ultrahigh vacuum to remove the impurities and damages introduced during the polishing processes. After preheating, the sample was introduced in the plasma exposure system of EXPRESS. The system was vacuumed at 1.0 x 10^{-5} Pa. The deuterium gas was supplied at a flow rate of 3.0 sccm and the pressure in the plasma exposure system was reached to be 3.5 Pa. Then, deuterium plasma was ignited. The ion energy was adjusted as 63 eV by applying a bias voltage and plasma exposure was performed at room temperature. The ion flux and fluence were 3.4 x 10^{19} D^+ m^{-2} s^{-1} and 1.0 x 10^{24} D^+ m^{-2}, respectively. After the plasma exposure, TDS measurements were performed from room temperature to 1173 K with a heating rate of 0.5 K s^{-1} to investigate the deuterium desorption and retention behaviors. The chemical states of tungsten were evaluated by XPS.

iii) Results and discussion

It was found by XPS that impurity deposition layer was formed on the sample surface with the thickness of 0.3 nm, which was mainly consisted of C-C bond and W-O bond. D_2 TDS spectra were consisted of three deuterium desorption stages, located at around 400 (Stage 1), 550 (Stage 2) and 750 K (Stage 3). From the previous studies, they were attributed to the desorption of deuterium adsorbed on the surface and trapped by dislocation loops (Stage 1), trapped by vacancies (Stage 2) and retained in the impurity deposition layer (Stage 3), respectively. The desorption stage of TDS spectra was quite different from that for LHD hydrogen plasma exposed tungsten, where thick impurity deposition layer was formed, indicating that thickness of the impurity deposition layer may control the hydrogen isotope retention.

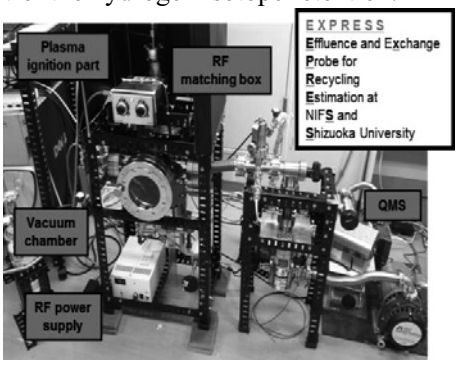

Figure Overview of EXPRESS apparatus