§ 11. Quantitative Analysis of Hydrogen in the CFC Material Exposed to GAMMA 10 Plasmas by Means of Elastic Recoil Detection Technique

Nakashima, Y., Ishimoto, Y., Kobayashi, S., Yoshikawa, M., Yatsu, K. (Plasma Research Center, Univ. of Tsukuba)
Morita, K., Yuhara, J. (Department of Crystalline Materials Science, School of Engineering, Nagoya University)
Sagara, A., Shoji, M., Suzuki, H.

Control of hydrogen recycling is one of the most important issues for improvement of plasma performance such as density control and energy confinement. The first wall of plasma device is exposed to charge exchange fast neutral emitted form hot-ion plasma, and desorbed hydrogen from the wall induces hydrogen recycling. The aim of this research is control of hydrogen recycling by using carbon sheet pump (CSP) [1, 2] in actual devices. The pumping effect of CSP has already been confirmed with GAMMA10 hot-ion plasmas [3~5].

The purpose of surface analysis of carbon materials is to improve performance of CSP and to examine applicability to actual devices from a microscopic point of view. As shown in Fig. 1, we additionally installed the surface station to the CSP test module. Exposure conditions (e.g. exposure term and angle) can be arbitrary set because specimens can be replaced without opening the GAMMA10 vacuum chamber to air. Specimens were annealed at a steady temperature of 800 ˚C for 10 minutes before exposure. They were exposed to fast neutrals from hot-ion plasma in GAMMA 10 after that. The specimens were analyzed by elastic recoil detection (ERD) technique using several MeV He ion beam extracted from the Van de Graaff accelerator in Nagoya University.

Specimen is 2-dimensional CFC material (CX-270, Toyo-Tanso Co., Ltd). ^{3}He is used as a probe beam of ERD in order to measure the hydrogen depth profile in deeper region. Hydrogen depth profiles of exposed and annealed specimens are shown in Fig. 2. In order to estimate hydrogen density caused by the exposure, hydrogen density in the annealed specimen was subtracted from that of the exposed one. As shown in Fig. 3, the hydrogen depth profile caused by fast neutrals agrees with the calculation result of the Monte Carlo simulation TRIM (TRVMC95). In the calculation, Maxwell-distributed incident flux of 5 keV ion-temperature is adopted to simulate fast neutrals. The ion temperature of 5 keV also corresponds with a typical ion temperature of GAMMA10 plasmas.

Hydrogen surface density obtained by integrating the hydrogen density from 0 to 300 nm is estimated to be 3×10^{20} m^{-2}. The fluence of fast neutrals is also calculated to be 2×10^{20} m^{-2} in the plasma experimental campaign. The fluence roughly agrees with the hydrogen surface density in the carbon material taking account of the shot-by-shot variation of neutral atom density profile in the plasma and the dispersion of hydrogen density in the material. Above results are consistent with those of numerous ion-beam experiments. This enables us to estimate hydrogen retention in CSP and contributes the estimation of regeneration cycle of CSP.

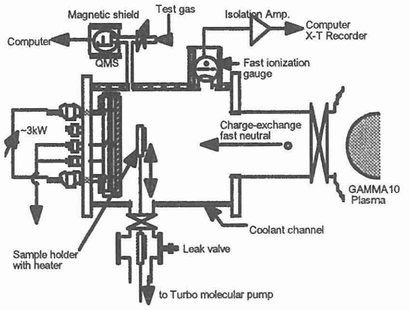

Fig. 1. Schematic of the surface station.

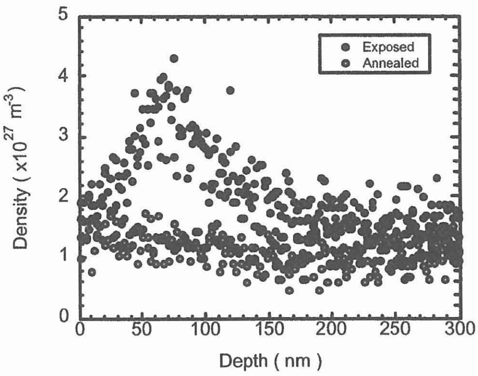

Fig. 2 Hydrogen depth profiles of exposed and annealed specimens.

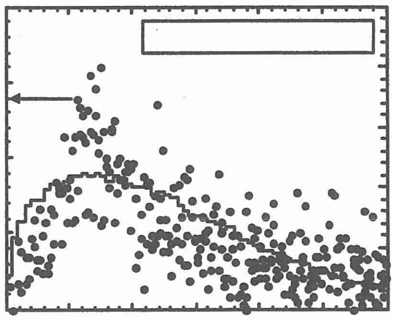

Fig. 3. Comparison between hydrogen depth profile measured by ERD and that calculated by means of TRVMC95.

References
1) Sagara, A. et al., J. Nucl. Mater. **220-222** (1995) 627.
2) Suzuki, H. et al., Trans. of Fusion Technol. **27** (1995) 523.
3) Nakashima, Y. et al., J. Nucl. Mater. **266-269** (1999) 901.
4) Ishimoto, Y. et al., J. Nucl. Mater. **313-316** (2003) 196.
5) Ishimoto, Y. et al., Fusion Eng. Des. **65** (2003) 429.