§40. Boronization Study with SUT

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Study of boronization has been continued using SUT (SUrface Modification Test-stand). A glow discharge in a gas mixture of 10 % O_2 and 90% He was continued for around 1 hour with and without boronization. The liner was made of stainless steel (SUS304). The boronization was carried out by a glow discharge in a gas mixture of 10% B_2H_6 and 90%He. The average thickness of the boron-coated layer was around 200 nm. The liner was kept at room temperature in the course of these processes, which corresponds to the operational condition expected to the LHD first wall. The partial pressure P_{32} of oxygen went down just after ignition of the glow discharge in O_2+He. It recovered gradually with time and came back to the original level later. The partial pressure P_{28}, mainly contributed by CO, occasionally increased at the initial phase of the discharge. Net oxygen P_{OX} absorbed to the surface was obtained as the sum of $-(P_{32} + 0.5P_{28})$. The RGA (Residual Gas Analyzer) was calibrated to obtain the absolute partial pressures of O_2 and CO gases by comparing its signal level to that with a diaphragm gauge. Using these absolute pressure, the total number of the absorbed oxygen atom can be calculated by integrating time behavior of P_{OX} . This was 1.5 x 10^{16} /cm^2 for a bare stainless steel surface, and 1.2x10^{17}/cm^2 for a boronized surface, respectively. Oxygen capacity was measured for a boronized wall with decaborane ($B_{10}H_{14}$). That is 1.6x10^{17} /cm^2, being similar to diborane case. Thus decaborane works same as diborane as far as oxygen gettering capacity is concerned.

The amount as large as 1x10^{17} /cm^2 indicates that oxygen is contained more than 100 monolayers in depth. This was confirmed by AES analysis. Figure 1 shows depth profile of the boronized film after oxygen saturation. In the most part of the boron film, oxygen and carbon concentration was less than 2-3 at.%. The oxygen concentration is around 40 % at the top surface. Considerable amount of oxygen can be found up to 50 nm in depth. Integrated oxygen surface density is close to 1x10^{17} /cm^2 which agrees with that obtained by RGA. The reason is not clear why oxygen is absorbed beyond the range of implantation depth with a glow discharge. Based on such large number of oxygen-saturation density, we can conclude that the oxygen-gettering ability of the boronized surface is likely to be maintained during one-day experiment of LHD.

From above result, we can expect that the thickness of ≈ 100 nm is sufficient for a boronized wall as an oxygen-gettering surface. Oxygen capacity was measured as a function of the B-film thickness and the result is shown in Fig. 2. The capacity is really saturated above 100 nm in thickness. In actual plasma experimental devices, non-uniform thickness is expected due to an arrangement of boronization system. Then the minimum thickness should be ≈ 100 nm in those cases.

These results were presented in 11th PSI conference held in May 1994 at Mito.

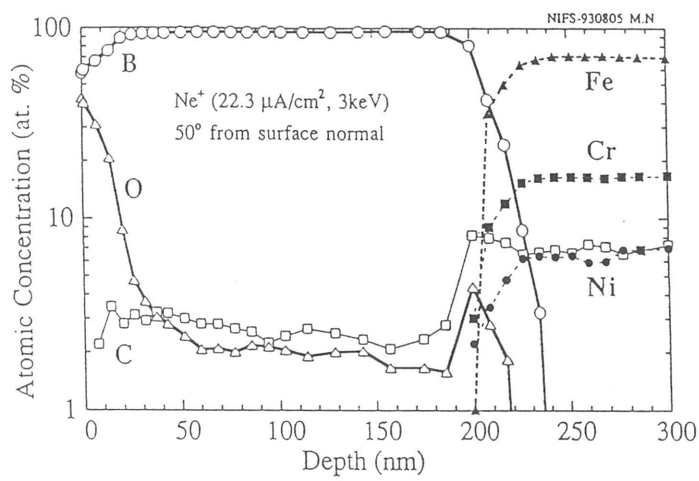

Fig. 1 Depth profile obtained with the in-situ AES analysis.

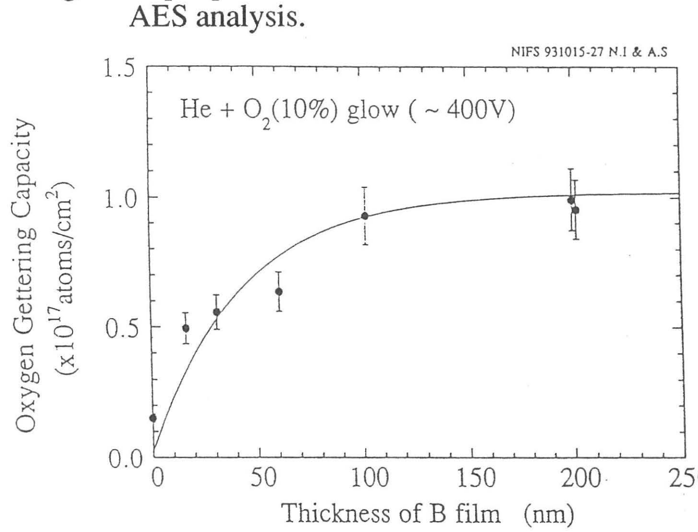

Fig. 2 Oxygen gettering capacity as a function of B-film thickness.