§8. Edge-plasma Interactions with Low-activation Ferritic Steel Alloys

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It is widely recognized in the fusion research community that the extensive use of low-activation alloys is of critical importance for the constructions of future DEMO, such as FFHR. Worldwide efforts on the evaluation of candidate materials are currently in progress because the successful candidate is envisaged to be used for the first wall to maintain vacuum as well as for the plasma-facing side of the blanket structure. However, it is also true that little has been known about edge-plasma interactions with these alloys, including surface modifications, particles retention.

In the present work a ferritic steel alloy, F82H (89at%Fe, 8at%Cr, 2at%W, 0.1at%C), has been bombarded with steady-state hydrogen and helium plasmas under some of the conditions relevant to the first wall environment, using the VEHICLE-1 facility [1]. The plasma density is of the order of 10^{10} cm^{-3} and the electron temperature is a few electron volts, resulting in the ion flux of the order of 10^{16} ions $s^{-1}cm^{-2}$. The ion bombarding energy is set at 100eV by applying a negative DC-bias onto the target assembly. Exposed samples are then analyzed with Scanning electric microscope (SEM), Energy Dispersive X-ray spectroscopy (EDX), X-ray photoelectron spectroscopy (XPS) and Atomic Force Microscope (AFM) for surface characterization and also subjected to Thermal desorption spectroscopy (TDS) for particle retention measurements.

Figure 1 shows a surface morphology of F82H target after exposed to H2 plasma and it was observed by SEM. Surface roughness still remained about a few microns, but a few ten nm was eroded by H2 plasmas and erosion rate was measured by spectroscopy and a weight loss measurements.

For this surface of F82H target, a chemical binding of iron was measure by XPS as shown in Fig.2. At before target exposed to plasma, a principal peak is iron-oxide which locates about 712 eV. After a target exposed to H2 plasma, an iron-oxide layer was removed by sputtering and and a peak of iron binding energy was shifted to lower energy region. And then main peak energy locates about 708 eV.

Figure 3 shows a comparison of atomic concentrations before and after exposed to H2 plasma measured by XPS. At before exposed to H2 plasma, impurities contained on the top surface and then oxygen and carbon show high atomic concentrations. At after exposed to H2 plasma, these impurities were removed and then oxygen and carbon concentrations changed only a few % and iron and chromium concentrations increased. At after exposed to H2 plasma, a surface roughness is not smoothly as shown in Fig.1, and at un-exposed areas on this surface are remained and iron –oxides are also remained on these areas.

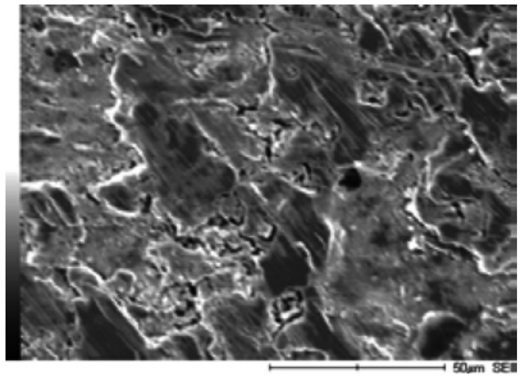

Fig.1 Surface morphology of ferritic steel after exposed to hydrogen plasma in VEHICLE-1

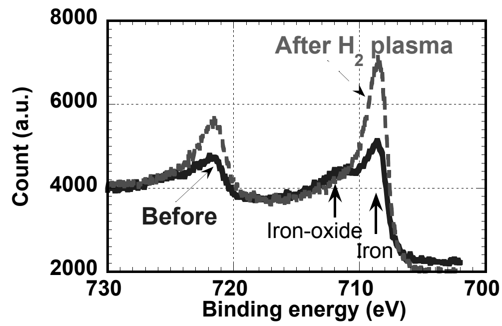

Fig.2 Chemical binding of iron at before and after exposed to hydrogen plasma.

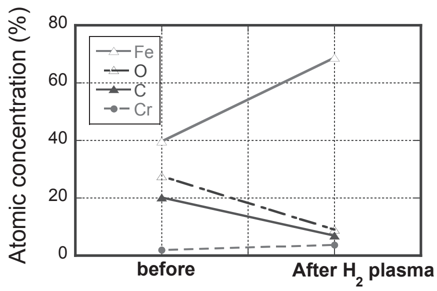

Fig.3 Atomic concentrations at before and after exposed to hydrogen plasma.

1) Y. Hirooka et al., J. Nucl. Mater. **337-339** (2005) 585-589.