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XPS ANALYSIS OF THE COMPONENT AND STRUCTURAL CHANGES IN MOLYBDENUM AND TUNGSTEN DURING INTERACTION WITH HIGH-TEMPERATURE PLASMA *)

Afanas'ev V.P., Lobanova L.G., Fedorovich S.D., Semenov-Shefov M.A., Zavgorodnaya A.M.

National Research University "MPEI", Moscow, Russia, v.af@mail.ru

Transition metals molybdenum and tungsten are widely used as in-vessel materials in fusion devices. When polycrystalline molybdenum and tungsten interact with plasma conditions expected in a fusion reactor, they undergo a series of fundamental changes in the samples. Plasma exposure leads to heating, implantation, sputtering, re-deposition, radiation-induced defect formation, etc. The cyclic nature of experimental fusion devices necessitates analyzing the processes occurring on the surface of molybdenum and tungsten at fundamentally different times during tokamak operation. During plasma discharges, the samples experience conditions that sharply contrast with those observed in the absence of discharges. In the absence of discharges, conditions for oxidation of molybdenum and tungsten are created due to the relatively high amount of H_2O in the tokamak chamber. Carbidization of the molybdenum and tungsten surfaces prevents their corrosion.

In this work, the surface composition of molybdenum and tungsten samples irradiated with high-energy steady-state hot plasma in the PLM plasma device [1] (magnetic field 0.01 T, up to 0.2 T in cusps, plasma discharge current up to 15 A, plasma density up to $3 \cdot 10^{18}$ m^{-3}, electron temperature up to 4 eV with hot electron fraction up to ~30 eV, steady-state discharge over 200 min, plasma-thermal load on test samples 1-5 MW/m^2, ion flux up to $3 \cdot 10^{21}$ $m^{-2}s^{-1}$, working gas - helium) was investigated using X-ray photoelectron spectroscopy (XPS). The XPS spectra were measured on a Kratos Axis Ultra DLD system using the Al Kα line with a monochromator in the magic angle geometry. Samples of molybdenum and tungsten foil, both unprocessed and treated with helium plasma, were studied.

The results of the XPS experiments showed that a 1-minute hold at 700°C leads to the removal of MoO_3 and WO_3 oxides from the sample surfaces. The tungsten samples showed the appearance of 12% WC carbide. The molybdenum samples exhibited a clear growth of the Mo_2C layer with increasing plasma treatment duration. The photoelectron spectra analysis (PES) of the tungsten samples did not show any change in the allotropic form of tungsten in the "foil-like" formations.

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References

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