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SURFACE LAYERS FORMED ON THE SURFACE OF TUNGSTEN BY THE DEPOSITION OF ATOMS SPUTTERED BY PLASMA IONS FROM THE SURFACE OF BORON *)

Ashaev L.B, Begrambekov L.B., Zakharov A.M., Sidorov V.D.

NRNU MEPhI, Moscow, Russia, lbbegrambekov@mephi.ru

Boron deposition (boronization) is performed on tokamaks (ASDEX – Upgrade, WEST (formerly Tore Supra) and other fusion facilities, routinely using diborane as the precursor material. It has been reported that deposition of a 100 nm layer (ASDEX – Upgrade) was sufficient to conduct up to 100 discharges of 5-10 second duration [1]. Sputtering of the coating in areas of maximum irradiation, it may occur much earlier [1].

Boron coating is also expected for the first wall of ITER. According to calculations, the lifetime in the Q=10 mode of a layer up to 100 nm thick will be equal to several 10^4 seconds, during which a protective layer 100 nm thick on 20% of the wall surface retains 20% of the boron.

This circumstance served as an incentive to study the properties of surface layers formed during the deposition of boron on the tungsten surface. It is proposed to conduct an analysis of the adhesive properties, composition and structure of the formed surface layer, the capture and retention of plasma ions and residual gas atoms in it. The patterns of layer erosion during sputtering and thermal exposure will be identified depending on the plasma composition, the temperature of the tungsten substrate, the amount of deposited boron, the presence of re-deposited tungsten atoms in the layer, etc

The paper presents the first results of this study. The experiments were conducted in a setup that simulated, to a certain extent, the conditions on the first wall of modern tokamaks. The gas discharge was initiated between the heated cathode and the anode. Boron atoms were deposited on the tungsten surface, sputtered from the surface of the boron target by ions of deuterium, argon and D+5%Ar plasma. The surface layers formed on the tungsten were analyzed by SEM, EDS and TDS methods. Before and after the TDS analysis, the samples were weighed.

It was shown that oxygen; deuterium and hydrogen were deposited on the tungsten surface together with boron. Their trapping significantly exceeded the capture of boron. It was noted that the capture of hydrogen, relative to its concentration in the plasma chamber during the deposition process, exceeded the similar ratio for deuterium by several tens of times. At the first stages of deposition, boron, oxygen and hydrogen penetrated the surface layer and were retained there in chemical compound with tungsten until its decay in the range of 1200-1400 K.

As deposition continued, the increase in the thickness of this layer slowed down and stopped. It can be assumed that the reason for this was the inhibition of oxygen penetration through this layer into the depth of tungsten, and the consequence was the development of a new layer on its surface, including deuterium in addition to the components listed above. The new layer continued to grow until the end of the experiment. Its decay occurred in the range of 400-600 K, indicating a difference in the structures and concentrations of the components of both layers. We note the absence of features in the TDS spectra that could indicate the presence of a boron structure in the surface layers of tungsten.

References

[1]. ITER Council Science and Technology Advisory Committee (STAC). 30 Meeting. St. Paul-lez-Durance, 13 – 16 May 2024., p. 73.

*) abstracts of this report in Russian