INVESTIGATION OF THE INFLUENCE OF THE STRUCTURAL AND SURFACE PROPERTY CHANGES OF TUNGSTEN AFTER INTERACTION WITH THE PLASMA FLUX ON THE DUST FORMATION PROCESS

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In this work, the experimental results of studying the structural and surface property changes of tungsten after interaction with the plasma flux and their influence on the dust formation process are presented [1].

It is known that the dust of plasma-facing materials negatively affects the steady-state operation modes of fusion facilities. They are radioactive, chemically toxic, and explosive. Therefore, fusion facilitiesâ€™ candidate materials are subject to strict "dust safety" requirements [2].

The intensity of dust formation depends on the structure and properties of the surface of plasma-facing materials. Moreover, it also depends on the energy of the plasma beam and on the duration of exposure. It was observed that after several plasma pulses, the mechanical and surface properties of materials deteriorate, and defects, such as micro-cracks, melting pools and craters could form on the surface. The analysis of parameters such as dust size, morphology, shape, and density were performed. Approximately, 200 dust particles are vaporized from the surface of the tungsten target only during the 38th plasma pulse. Dust particles from the molten surface of the target are ejected as droplets. In addition, it was observed that sharp edges of micro-cracks developed on the surface of the tungsten target could also be the sources of hard dust.

Peak intensities at Bragg angles of 40.2, 58.2, 73.2 and 87 were used to study the structure of the irradiated tungsten target. These well oriented with respect to JCPD reference number 00-004-0806 W angles correspond to planes (110), (200), (211), and (220) respectively. After interaction with the plasma flux, tungsten diffraction peaks shift to higher angles; as the pulse dose increases, the peaks shift back to lower angles. This indicates structural changes caused by compressive and tensile stresses in the crystal lattice (lattice deformation). In addition, the decrease of peak intensity was observed, which indicates recrystallization of the tungsten target. The compression stress (Î”d/d) of the intense peak (110) can be estimated. The value of $\Delta d/d$ was 0.004474. The compression stress was estimated from the elasticity constant k for tungsten ($3.45 \cdot 10^{11}$ N/m^2) and was equal to 1.5 GPa. Due to the small depth of X-ray penetration on the target surface, the estimation is approximate.

1. M.K. Dosbolayev, A.B. Tazhen, T.S. Ramazanov, Y.A. Ussenov, “Investigation of dust formation during changes in the structural and surface properties of plasma-irradiated materials”, Nuclear Materials and Energy, vol. 33, 101300, 2022. l
2. M.K. Dosbolayev, A.U. Utegenov, A.B. Tazhen, T.S. Ramazanov, “Investigation of dust formation in fusion reactors by pulsed plasma accelerator”, Laser Part. Beams, vol. 35, 741-749, 2017.