Studies of the formation and distribution of cracks and various defects on the surface of candidate materials of thermonuclear reactors during the influence of a pulsed plasma flux

M. K. Dosbolayev[1], A. B. Tazhen[1], T. S. Ramazanov[1],
[1] Institute of Experimental and Theoretical Physics, al-Farabi Kazakh National University, Almaty, Republic of Kazakhstan
e-mail (speaker): merlan@physics.kz:

A detailed understanding of the interaction of the plasma edge region with the first wall in current magnetic plasma confinement facilities is extremely important for improving the overall efficiency of fusion devices. The materials of the first wall can be significantly damaged by highly concentrated energy fluxes escaping from the edge region of the plasma [1]. This can be caused by plasma disruptions and edge localized modes (ELM of the order of ~1 MJ/m2 for ~0.5 ms with a frequency above 1 Hz) [2].
The paper will present the results of studying the impact of a plasma beam during the interaction of divertor candidate materials in a coaxial plasma accelerator, where tungsten and boron nitride plates were used as candidate materials. The studies were carried out on a PW-7 pulsed plasma accelerator [3]. The surface of the candidate materials was exposed to a pulsed hydrogen plasma flux. Plasma flux parameters: maximum energy density about 1.1 MJ/m^2, pulse durations up to 200 µs. The authors consider the contribution of surface defects (cracks, craters, bubbles) and structural changes (recrystallization) in candidate materials to dust formation under the action of a plasma beam. Scanning electron microscopy (SEM), elemental and X-ray diffraction analysis (XRD) were used to study the material surface morphology, chemical composition, and crystal structure. The authors also consider some undesirable effects revealed after irradiation of divertor candidate materials. The obtained experimental results will be useful for evaluating the prospects for further application of these materials in existing and future fusion reactors (e.g., in the international fusion reactor ITER).
The process of interaction of a plasma beam with a tungsten target for each pulse was recorded by a high-speed camera (10000 fps). The sample photo images are shown in Figure 1.
Our most important recent results on this topic have been presented in [4, 5] in open access.
This work was supported by the Ministry of Education and Science of the Republic of Kazakhstan (project no. IRN AP23490402).

References
[1] M. Reinhart *et al*, Nucl. Fusion **62** 042013 (2022)
[2] J. Linke *et al*, Fus. Sci. Technol. **46** 142 (2004)
[3] M.K. Dosbolayev *et al*, Laser and Particle Beams **35(4)** 741-749 (2017)
[4] M.K. Dosbolayev *et al*, Nuclear Materials & Energy **33** 101300 (2022)
[5] Dosbolayev M.K. *et al*, Nuclear Materials and Energy **37** 101540 (2023)

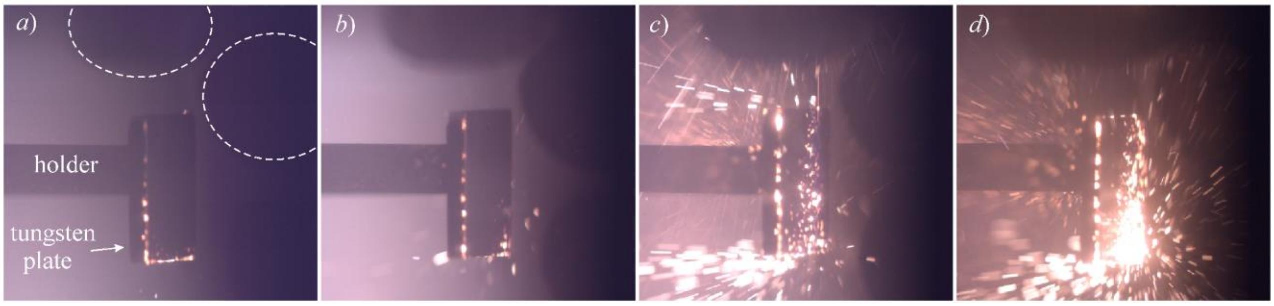

Figure 1. Photo images of erosion of the surface of a tungsten plate after interaction with a) 9, b) 18, c) 25, and d) 38 plasma beam pulses. The plasma beam is directed from right to left along the normal to the surface of the tungsten plate (15x15 mm). White dotted circles highlight the contours of the dust collectors located around the tungsten plate. Recording speed is 10000 frames/s [4].