Testing of plasma-facing components of a fusion reactor

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The study of the effects of a steady-state plasma flow with the characteristics of the edge plasma of a fusion reactor on materials is of significant interest for simulating fusion reactor conditions and material surface modification. The required plasma heat flux density on plasma-facing components for modern fusion reactors is $10-40$ MW/m^2 with thermal stabilization at 300°C, dictating the need to develop and test heat transfer enhancement systems (both single-phase and two-phase) [1]. Testing structural materials requires a stationary magnetized plasma with characteristics similar to the peripheral plasma of a large tokamak: electron temperature from $1-50$ eV, plasma density $(1-10)\cdot 10^{18}$ m^{-3}. Such parameters are currently achieved only in a few unique linear plasma installations, one of which is the PLM-M stationary plasma installation developed at the NRU "MPEI". Samples made of VMP tungsten used for the lining of the ITER tokamak reactor divertor were tested in continuous discharges up to 9 h, with total exposure times of $50-100$ h. Power densities of 0.5–1 MW/m^2 were achieved at plasma electron temperature of 3 eV and electron density of 10^{-19} m^{-3}. Plasma exposure caused the initially smooth tungsten surface to form stochastic, highly porous "fuzz" nanostructures, uniformly filling the entire plasma-facing surface. The nanofiber diameter was 20–100 nm, and the layer thickness was approximately 1.5 μm.

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