surface modification of fusion materials under the effect of plasma flows and high-energy particles

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Complex experimental research of plasma effect on fusion materials is being conducted for the last few years at NRC Kurchatov Institute. Steady-state deuterium plasma is generated on the LENTA linear plasma machine and the near wall and divertor plasma of a tokamak-reactor is simulated at total plasma flux on the surface of 1022–1023 cm–2 thus providing research conditions corresponding to a stationary regime of a fusion reactor.

The neutron effect on the first wall materials is simulated with high-energy ions [1]. In few hours’ irradiations of materials by MeV-range ions to the total fluence of 1021–1023 ion/cm2 conducted on the cyclotron at Kurchatov Institute the samples have been obtained at high level of radiation damage characteristic for durable operation of reactor from 0.1 to 80–100 dpa. Considerable experience has been gained in damage production in materials with accelerated ions. Ions of Helium, Carbon, Nitrogen and protons having quite different damage production capabilities have been used.

The research is focused on tungsten as candidate for coating of tokamak-reactor which is to be used in the ITYER divertor (Plansee, Austria; POLEMA, RF). The surface response to plasma exposure at elevated temperatures has been also tested. Experiments have been conducted at 600–1100 °C on the surface. Data has been obtained on erosion of the irradiated and unirradiated materials in plasma (erosion rate, erosion yield), on swelling and changes in microstructure of the damaged layer (profilometry, SEM). The damaged layer depth was ~50 mcm in irradiations with 10 MeV protons. Deuterium retention in irradiated tungsten has been measured for evaluation s of tritium factor in a fusion reactor.

Recently, experiments were performed on silicon carbide SiC suggested as a low activation structure material. Changes were found in the irradiated material microstructure under deuterium plasma impact.

Tungsten surface has been explored under helium plasma at high temperature (1100 °C). Fundamental change in the micron depth surface layer has been revealed with nanostructured features of ~20 nm in size, “nanofuzz”.

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References

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