Characterization of material properties of Tungsten exposed to Tokamak plasmas in central Divertor region

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As the plasma facing material of divertor target for ITER and next Fusion reactor, material properties of tungsten under high heat flux and plasma exposure are of primary importance to estimate the performance of the tungsten armor of divertor target in tokamak.

In this study, we investigated the material properties of pure and dispersion strengthened tungsten materials fabricated by spark plasma sintering (SPS) exposed in divertor plasmas and compared the results with those of a specimen from commercial tungsten. We measured the microstructure, hardness, and surface state of the investigated materials before and after the tokamak plasma exposure experiment. Specimens with small amount of Y2O3 dispersion showed finer grains and higher hardness than pure tungsten while thermal conductivity was decreased with the particle addition. The tungsten specimens were placed into test tiles and the test tiles were installed in the central divertor region of KSTAR tokamak along the toroidal direction. The KSTAR plasma campaign lasted for three months and the plasma exposures were accumulated on the specimens during the 2018 KSTAR campaign. Rough estimate of the total exposure time and deuterium flux was about 10,000 sec and 10^{26} m^{-2}. The effect of heat flux exposure was traced by the change of microstructure and hardness measurement results. Large defects ranging 200 nm ~ 500 nm generated by deuterium irradiation was clearly visible on the surface and to the depth of a few μm after the exposure. The D retention after the plasma campaign was measured by thermal desorption spectroscopy (TDS). A notable feature from the experimental results is the deuterium retention in tungsten is greatly influenced by the exposure temperature on the tungsten surface.