



Neutron irradiation hardening across ITER diverter tungsten armor

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Abstract

In this work, we have performed neutron irradiation and sub-sequent hardness measurements on a series of tungsten grades to screen the irradiation-induced hardness as a function of irradiation temperature reaching up to 1200 °C. The selected irradiation temperatures were chosen by performing temperature analysis of the expected irradiation temperature on tungsten monoblock during the steady state operation in ITER, where 1200 °C corresponds to the surface temperature at 10 MW/m² flux density expected during normal operational conditions. The applied neutron fluence and flux (using BR2 material test reactor, up to 1 dpa) is representative of ITER irradiation conditions except the neutron spectrum. However, the measures were taken to reduce the thermal neutron flux to limit the transmutation closer to the fusion conditions. The irradiation-induced hardness measured in single crystal after irradiation at 600–800 °C agrees very well with the earlier data reported after HFIR irradiation experiments. The new irradiation data obtained in the temperature range 900–1200 °C show that even at one third melting point the neutron exposure raises the hardness by 40% to 70%, depending on the selected grade. Screening measurements by transmission electron microscopy, applied to clarify the origin of the hardening at 1200 °C, have proven the presence of the dislocation loops and high density of voids. The presence of those defects should imply the reduction of thermal conductivity, fracture toughness as well as alteration of hydrogen isotope permeation and trapping.