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The effect of surface and bulk microstructure on deuterium transport in displacement damaged tungsten

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Implantation of energetic hydrogen, charge exchange neutrals and helium (He), as well as displacement damage creation by neutron irradiation will occur simultaneously during operation of a real fusion reactor. All this will have to consequences on crystal structure, hydrogen isotope (HI) retention and transport which we do not understand sufficiently in order to predict tritium retention in future fusion devices.

In this study we have addressed the influence bulk and surface microstructure on hydrogen isotope transport in displacement damaged tungsten (W).

In the first aspect, we have continued the study of the effect of grain size on the deuterium transport, where larger grain size showed reduced D uptake [1]. There the studied samples had minimum grain size of few micro meters. Now we extended that study to nanograined samples, where W films with grain size of few nm, hundred nm and few μm were deposited on W substrate. The samples were produced at Polytechnico Milano, Italy. After that they were irradiated by 20 MeV W-ions and then exposed to thermal D atoms at 600 K. The transport through the material was studied by measuring D depth profiles during the exposure. We have observed that in nanograined samples D populated the damaged region more than two times faster than in samples with grain size of hundred nm and few micro meters.

The second aspect that we have addressed was how surface microstructure created by irradiation with 3 keV He ions with different He fluences (3×10^{20} and 3×10^{21} He/cm^2) affects transport deeper into the material and trapping into defects present under that layer. After the He irradiation the recrystalized W samples were irradiated by 20 MeV W-ions to create traps under the He layer and to be able to observe the difference in the uptake. One sample was as a reference irradiated only by W ions. Samples were afterwards all exposed to D ions with energy of 300 eV/D for 24 h, yielding approximately a D fluence of 2×10^{21} D/m^2. In the no-He irradiated sample, D populated the whole damaged layer down to 2 μm. On the other hand, in the surface He irradiated samples D was retained only near the surface with more than 5 times lower retention than in only W irradiated sample. This study shows that the local D retention in He layer is very high but at the same time He prevents D to penetrate deeper in the layer. This is in agreement with the studies performed with He on the surface [2] but opposite to what is observed when He is implanted deep in the bulk [3].

References:
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