H diffusion in nanoestructured as compared to massive W

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One of the challenges in the design of the future nuclear power plant is to develop materials capable to resist in the hostile environment of a fusion reactor. Because of its low sputtering yield, low-activation with a high melting point, high thermal conductivity, and low thermal expansion, tungsten is one of the most attractive materials proposed for first wall applications in the nuclear fusion reactors [1-3]. Even when W is assumed to be the best candidate as plasma facing material (PFM), some limitations have been identified that have to be defeated in order to fulfil specifications i. e one of the important point of concern is the light species behaviour. Light species (mainly H, D, T and He), which are present in the plasma in magnetic confinement fusion (MC) and which result from the explosion in inertial confinement fusion (IC), are implanted in the near surface region of PFM. The concentration of light species in W can lead to formation of bubbles which notably degrade its mechanical properties [4] and heat load performance. Moreover, the degradation is enhanced by the fact that ion implantation is accompanied by the production of thermal vacancies in MC and ion-induced damage in IC. In particular, in IC reactors with direct drives (HiPER), the mayor threats comes from the simultaneous arrival of a great diversity of energetic particles (mainly D, T, He and C) short time after the explosion and the subsequent arrival of a high neutron flux (with energies of up to 14 MeV/neutron).

In this work we focus on the study of hydrogen behavior in nanoestructured films (see N. Gordillo et al. contribution to this conference) as compared to massive W. For this purpose resonant nuclear reaction (RNRA) experiments are carried out by using the $^{1}H(^{15}N,\alpha\gamma)^{12}C$ nuclear reaction in nanoestructured and massive W samples implanted with (i) H at an energy of 170 keV and (ii) sequentially implanted with C at an energy of 665 keV and H at 170 keV. Implantations were carried out at a fluence of $5x10^{16}$ at/cm^2 and at two different temperatures RT and 400ºC. RNRA data evidence that the highest H retention is observed for the samples sequentially implanted with C and H, being the lower one measured for the massive samples implanted only with H. In general, the H retention is higher for nanoestructured than for massive samples. Moreover, increasing the irradiation temperature up to 400ºC drives the H to completely out diffusion in nanoestructured as well as, in massive samples. The role of microstructure and radiation-induced damage on light species behaviour will be discussed.

References

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