Are Nanostructured materials more resistant to irradiation?: Grain boundaries and hydrogen in Tungsten

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Abstract

Irradiation of solids with energetic particles, such as neutrons or ions, normally gives rise to formation of atomic defects in the target and modifies the material properties. Moreover, neutron irradiation leads to nuclear reactions, in which light species, such as He, H and D, are generated. These changes in the physical (electrical resistivity, exfoliation, swelling,..) and chemical (phase segregation) properties of the irradiated material is highly undesirable when dealing with functional materials. Therefore, research on radiation resistant materials is crucial when facing, among others, the development of large facilities (fusion reactors) focused on alternative ways (nuclear fusion) of massive energy production such as: the International Thermonuclear Experimental Reactor (ITER) [1], the European High Power laser Energy Research facility (HiPER) [2] and the Laser Inertial Fusion Energy (LIFE) in U.S.A [3].

Currently, nanostructured materials have been proposed to exhibit higher radiation resistant than their massive counterpart. The large density of grain boundaries in these materials may favor the annihilation of radiation-induced damage [4-5] and may increase the area to accommodate light species delaying swelling to higher radiation fluences. However, one remaining question is how the light species accumulation affects the material properties. In particular how does it affect the material mechanical properties? Such knowledge is needed to define the operational windows for functional materials.

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 [6]. In this contribution the role of grain boundaries in the hydrogen behavior in nanostructured W are discussed. The effect of the presence of hydrogen on a tungsten grain boundary on the mechanical properties is addressed. The radiation resistant of nanostructured W is discussed within this framework.

References

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