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Helium/Deuterium blistering in a W-Ta_{fiber} composite consolidated by pulse plasma sintering

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Tungsten is a promising candidate for fusion reactor applications since it has high melting point, good thermal conductivity and low sputtering yield, which minimize plasma contamination. The major disadvantage of tungsten grades for plasma facing and structural components in nuclear fusion reactors is the low fracture toughness associated with the high ductile-to-brittle transition temperature. A strategy to increase the fracture toughness of W-based materials for nuclear fusion applications lies on the development of suitable W-Ta composites through a powder metallurgy route [1]. Pure tantalum shows high toughness, low activation and high radiation resistance and, moreover, transmutes to W under high-energy neutron irradiation. This tends to retard the formation of the brittle sigma phase originating from transmutation of W to Os and Re [2]. Therefore, dispersions of ductile Ta fibers in a W matrix have been proposed as a novel approach for the development of suitable plasma facing materials [3].

In the present study tungsten-tantalum composites (W-Ta) with W powder and 10 of at.% of Ta fibers were produced by pulse plasma sintering (PPS) at 1500ºC. Pure W and Ta plates as well as W-Ta_{fiber} composites were implanted with of He^+ (pre implantation step) and D^+ ion beams at room temperature with fluencies in the 10^{20}-10^{21} at/m^2 range. The W-Ta_{fiber} composites were studied by scanning electron microscopy (SEM) coupled with energy dispersive X-ray spectroscopy (EDS) and focused ion beam (FIB), X-ray diffraction (XRD), Rutherford backscattering spectrometry (RBS) and nuclear reaction analysis (NRA). The microstructure observations revealed that after consolidation the W/Ta interface reflects internal oxidation of Ta without W/Ta interdifusion as presented in Figure 1. Results have shown that the W matrix remains essentially unaltered with the implantations. However, blistering occurred in the Ta_2O_5 and TaO_x regions (Fig. 2 (a)) with single He^+ implantation and a more severe effect was observed after sequential He^+ and D^+ implantation. The blister cavities evidence the formation of a nanometer-sized foam structure (Fig. 2 (b)).

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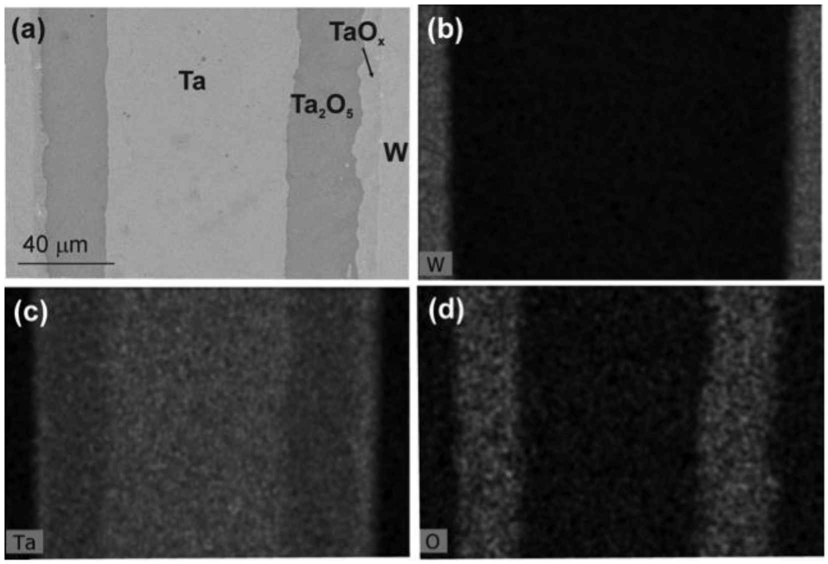

Figure 1 - SEM image showing (a) low magnification of W-Ta_{fiber} composite evidencing the fibers, and (b), (c) and (d) corresponding elemental maps for the W-Lα_1 Ta-Lα_1, and O-Kα_1 X-ray emissions, respectively.

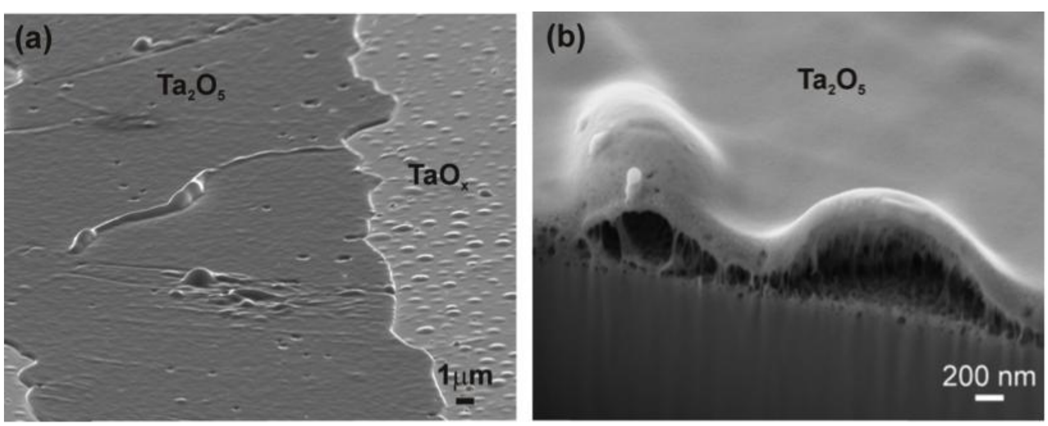

Figure 2 - SE images showing microstructures observed in W-Ta_{fiber} implanted sequentially with He^+ and D^+ ions evidencing (a) blistering in Ta_2O_5 and TaO_x regions and (b) blister profile in Ta_2O_5 region.

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