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Studies on deuterium retention in W-Ta based materials

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The high melting point, high sputtering threshold and low tritium inventory rendered W as a potentially suitable material in fusion devices [1-4]. The major problem associated with presently available tungsten grades as structural materials is its brittleness at lower temperatures. This is further worsened by irradiation embrittlement. A strategy for ductility improvement is producing a composite, with the brittle W matrix being reinforced by short fibres of tantalum [5]. As Ta is more ductile than W it can therefore divert or stop cracks propagating in the W matrix. In the present research Ta short fibres and powder were used as reinforcement component for W [6] by alloying Ta short fibres or powder in a W powder matrix. The composites were subsequently irradiated with deuterium to assess the retention of this hydrogenic species in the materials.

The irradiated composites, with Ta contents of 10 or 20 at%, were produced from pure elemental powders (W-Ta powder composites), and pure W powder and Ta fibre (W-Ta fibre composites) with 100 μm in diameter by low energy ball milling in argon atmosphere. These materials were consolidated via spark plasma sintering (SPS) in the temperature 1200 to 1600 ºC range. Pure W and Ta plates (controls) and W-Ta composites were irradiated with He^+ ions (optional pre-implantation step) and D^+ ion beams at room temperature with fluences in the 10^{20}-10^{21} at/m^2 range. Blistering and deuterium retention in W and Ta plates and in W-Ta composites were studied with scanning electron microscopy (SEM), X-ray diffraction and thermal desorption analysis. The deuterium concentration was evaluated trough nuclear reaction analysis (NRA) using 0.75 to 2.1 MeV $^3He^+$ beam and the D(^{3}He,p)α reaction.

The investigations showed that deuterium irradiation induced microstructural modifications producing blistering in Ta plates as well as in W-Ta composites (Figure 1). These effects increased substantially in the Ta and W-Ta materials with the He pre-implantation step, while blisters have not been observed in the W plates either for D^+ or He^+ plus D^+ implantation. Higher deuterium retention was observed by thermal desorption for the composites than for the W plates. Moreover the present study revealed that D^+ trapping in the composites is dependent on the microstructure with higher retention observed for fibers than for powder.

References

1. Baluc N. *et al*., Nucl. Fusion, 47:S696-S717, 2007.
2. Sugiyama K. *et al*., Nucl. Fusion, 50:035001, 2010.
3. Nygren R.E. *et al*., J Nucl. Mater., 417:451-456, 2011.
4. Wright G.M. *et al*., Nucl. Fusion, 50:055004 (9pp), 2010.
5. Livramento V. *et al*., Proceedings of the 1st International Conference on Materials for Energy, A 268.
6. Cottrell G.A., J. Nucl. Mater., 334:166-168, 2004.

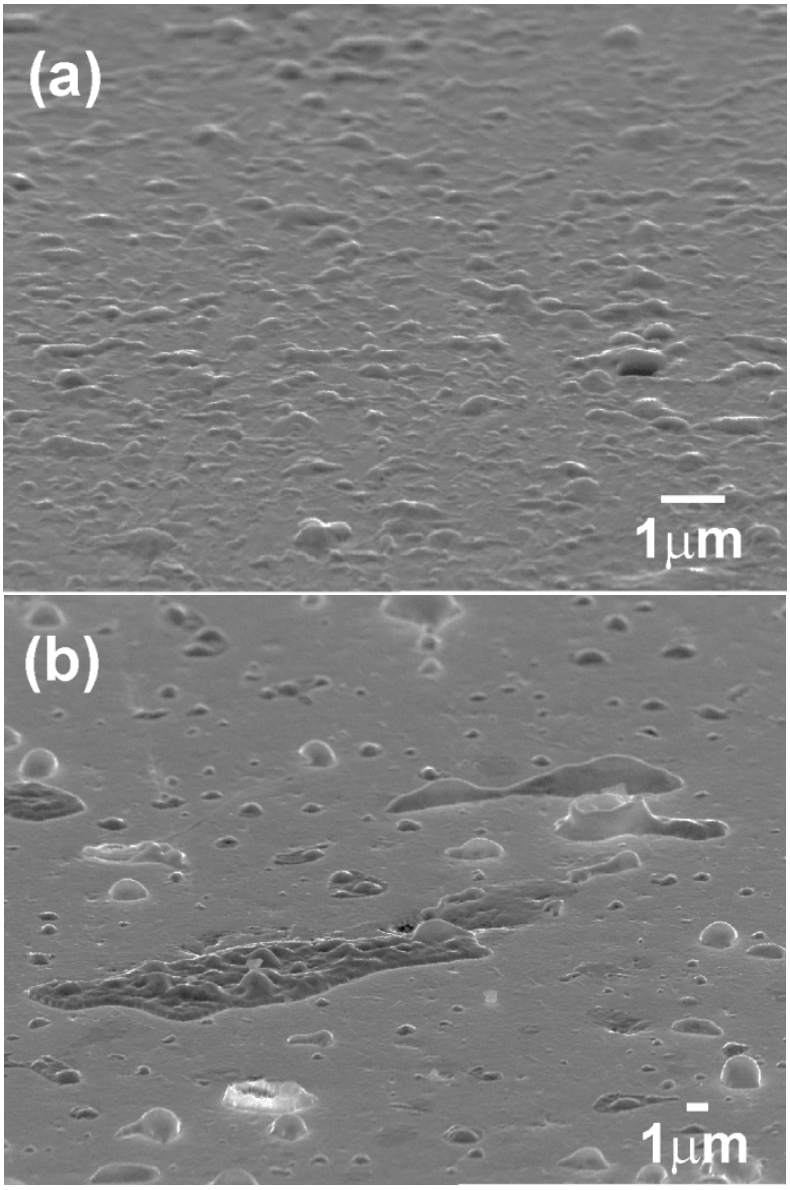

Figure 1 - BSE images showing microstructures observed in (a) Ta and (b) W-Ta_f 20 at% composite, both pre implanted with $^4He^+$ (15 keV and fluence of $5x10^{21}He^+/m^2$) and D^+ (30 keV and fluence of $5x10^{21}D^+/m^2$) at room temperature.

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