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Elemental interdiffusion in W-Ta composites developed for fusion applications

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Tungsten (W) was select for an extensive use in nuclear fusion devices due to its low neutron activation, high melting point and sputtering threshold [1] as well as low hydrogen inventory [2]. Nevertheless, W is brittle at low and moderate temperatures, which results in abnormal thermal stress, component fracture and extra erosion under reactor operation due to inherent thermal cycling events. An attractive way to solve these problems involves the addition of other refractory metals in the W matrix and tantalum (Ta) is a natural candidate. It has a high ductility, toughness and radiation resistance relative to those of W [1] and transmutes to W by high-energy neutron irradiation. Recently, IST proposed the production of W-Ta composite by mechanical synthesis [3].

The composite should reveal the individual properties of the pristine phases as long as the interdiffusion between the components is significantly avoided during the consolidation/sintering route of the final material. Sintering operations at temperatures higher than 1300ºC lead to significant improvements in the final densification and thermal conductivity of the composites, which is crucial for fusion applications [1]. However, W and Ta interdiffusion can be relevant above 1300ºC, mainly due to diffusion of W into Ta [4], and the aim of the present work is to control the mechanism.

W-Ta_f composites presenting 10 and 20 at.% of Ta where produced by alloying W powders and Ta fibres with a planetary ball milling route (MA) and by consolidating the mixture with spark plasma sintering (SPS) in the 1300-1600ºC temperature range. The final densifications remain fairly constant in both composites after sintering at different temperatures (83 to 87%) and the elemental interdiffusion remained low at 1300ºC. Nevertheless, the diffusivity of W in Ta became significant at 1600ºC, leading to the formation of a solid solution zone with a stoichiometry close to $W_{16}Ta_{84}$. The mechanism was followed by scanning electron and energy-dispersive X-ray spectroscopies (SEM/EDS; Figures 1 and 2, Table 1). Fabrication routes yielding high densifications and low interdiffusion are currently under investigation.

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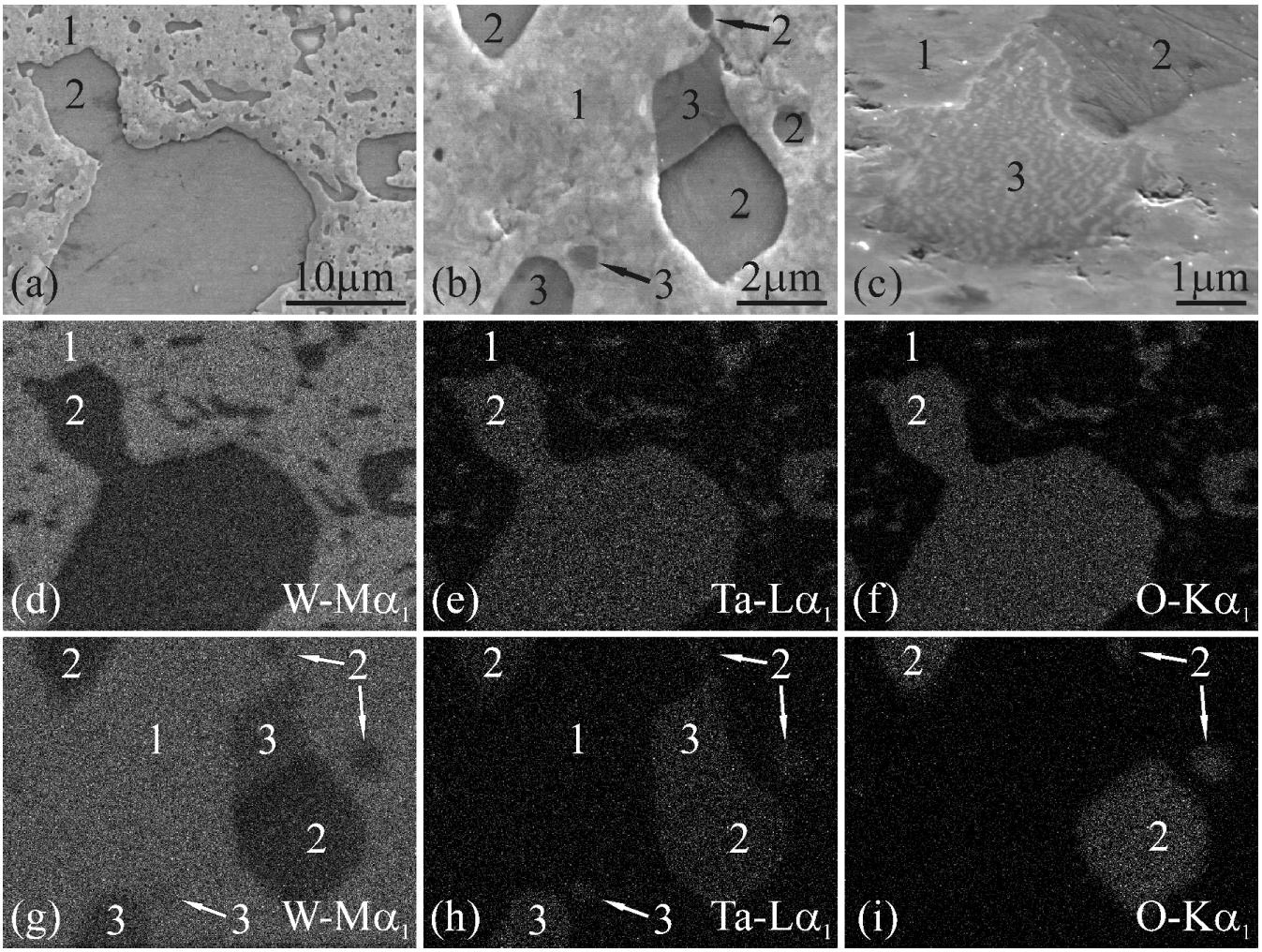

Figure 1. SEM images of W-Ta_f composites sintered at 1300 (a) and 1600ºC (b) showing the W and Ta phases and a WTa solid solution in zones 1, 2 and 3, respectively; lamellar growth in a WTa solution (c); EDS distribution maps for W (d), Ta (e) and O (f) in **figure 1.a**; corresponding maps in **figure 1.b** (g,h,i).

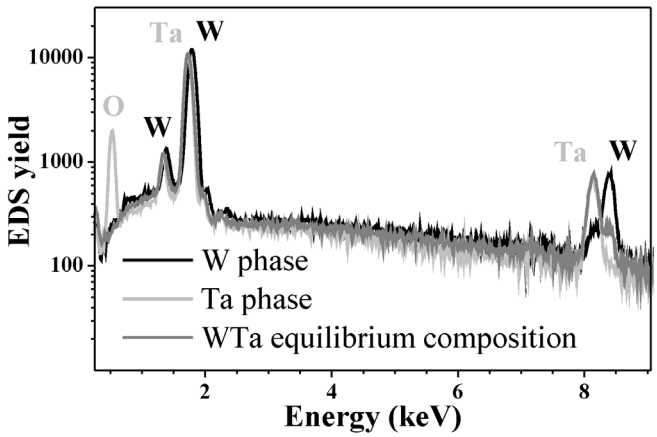

Figure 2. Representative EDS spectra of zones 1, 2 and 3 in the W-Ta_f composite sintered at 1600 ºC.

Table 1. Main composition in zones 1, 2 and 3 in the W-Ta_f composite sintered at 1600 ºC.

Zone	Element (at.%)		
	W	Ta	O
Zone 1	90.5	9.5	-
Zone 2	1.2	25.5	73.5
Zone 3	16.0	84.0	-

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