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Consolidation of W–Ta composites: Hot isostatic pressing and spark and pulse plasma sintering

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HIGHLIGHTS

- Consolidation of W–Ta composites using three techniques: HIP, SPS and PPS.
- Comparison of consolidation methods in terms of W–Ta interdiffusion and densification.
- Microstructure analysis in terms of oxides formation.

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ABSTRACT

Composites consisting of tantalum fiber/powder dispersed in a nanostructured W matrix have been consolidated by spark and pulse plasma sintering as well as by hot isostatic pressing. The microstructural observations revealed that the tungsten–tantalum fiber composites consolidated by hot isostatic pressing and pulse plasma sintering presented a continuous layer of Ta_2O_5 phase at the W/Ta interfaces, while the samples consolidated by spark plasma sintering evidenced a Ta + Ta_2O_5 eutectic mixture due to the higher temperature of this consolidation process. Similar results have been obtained for the tungsten–tantalum powder composites. A (W, Ta) solid solution was detected around the prior nanostructured W particles in tungsten–tantalum powder composites consolidated by spark and pulse plasma sintering. Higher densifications were obtained for composites consolidated by hot isostatic pressing and pulse plasma sintering.

1. Introduction

The selection of suitable first wall materials is one of the major challenges associated with the development of components for fusion power plants. Requirements for first wall materials include high radiation resistance and low neutron activation together with high thermal conductivity and appropriate mechanical properties [1,2]. Tungsten possesses high melting point, high sputtering threshold, great corrosion resistance and high tensile strength, that turn this material into a strong candidate for plasma facing applications in nuclear fusion devices [3–5]. Nevertheless, the use of W in armor components is limited by its high ductile-to-brittle transition temperature [6]. Pure tantalum shows high toughness, low activation and high radiation resistance and, moreover, transmutes to W under high-energy neutron irradiation. However, Ta is a scarce commodity and its use as a predominant high heat-flux material cannot be envisaged for large devices. A strategy to increase the fracture toughness of W-based materials lies on the development of W–Ta composites through a powder metallurgy route [7]. The presence of a ductile secondary phase may enhance the toughness of brittle matrices by two mechanisms: (i) suppression of crack propagation through the ductile phase and (ii) crack deflection at the interfaces and consumption of elastic energy via interfacial decohesion [8]. In the present work a dispersion of ductile Ta fibers in a W matrix is studied as an approach to the development of tough armor materials [9].

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