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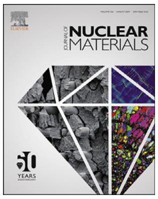

New WC-Cu composites for the divertor in fusion reactors

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ABSTRACT

The requirements for the divertor components of future fusion reactors are challenging and therefore a stimulus for the development of new materials. In this paper, WC-Cu composites are studied for use as thermal barrier between the plasma facing tungsten tiles and the copper-based heat sink of the divertor. Composite materials with 50% vol. WC were prepared by hot pressing and characterized in terms of microstructure, density, expansion coefficient, elastic modulus, Young's modulus and thermal diffusivity. The produced materials consisted of WC particles homogeneously dispersed in a Cu matrix with densifications between 88% and 98%. The sample with WC particles coated with Cu evidenced the highest densification. The thermal diffusivity was significantly lower than that of pure copper or tungsten. The sample with higher densification exhibits a low value of Young's modulus (however, it is higher compared to pure copper), and an average linear thermal expansion coefficient of $13.6 \times 10^{-6}\,°C^{-1}$ in a temperature range between 100 °C and 550 °C. To estimate the behaviour of this composite in actual conditions, a monoblock of the divertor in extreme conditions was modelled. The results predict that while the use of WC-Cu interlayer leads to an increase of 190 °C on the temperature of the upper part of the monoblock when compared to a pure Cu interlayer, the composite will improve and reduce significantly the cold-state stress between this interlayer and the tungsten.

1. Introduction

The heat generated in nuclear fusion reactors will be extracted by the first wall of the blanket and in the water-cooled divertor. It is intended to perform a heat collection without losses, which requires materials that can withstand intense neutron irradiation and very high heat fluxes, without compromising their physical integrity. The present design for the water-cooled divertor consists of tungsten monoblocks crossed by a CuCrZr pipe where the coolant circulates. Tungsten was chosen to be the plasma facing component due to the low sputtering [1], high melting point and a low tritium retention at high temperatures. However, the tungsten grades presently available are associated with relatively high ductile-to-brittle transition temperature and therefore show a high probability of failure at room temperature during, for instance, repair/cleaning operations after high temperature service [2]. The CuCrZr alloy is the most promising heat sink material due to its high conductivity and ductility, allied to high strength and microstructural stability [1]. The service temperature of CuCrZr, however, is relatively low and the material suffers embrittlement under irradiation [3]. Therefore, there is a thermal operation gap as well as a thermal strain mismatch between the two materials, induced by the dissimilar values of coefficient of thermal expansion (CTE) [3,4].

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