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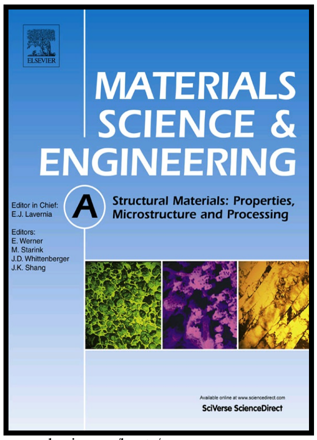

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Evolution of mechanical performance with temperature of W/Cu and W/CuCrZr composites for fusion heat sink applications

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Abstract

Power exhaust and materials lifetime have been identified as key challenges for next-generation fusion devices. A water-cooled monoblock divertor, consisting of tungsten as the plasma facing material and copper-based composites as the heat sink, has been proposed as the baseline material. However, there is a large mismatch in the coefficient of thermal expansion and the elastic modulus between these metals, which requires the development of new materials.

The goal of this study is the mechanical and microstructural characterization of two composites materials, W-30 wt%Cu and W-30 wt%CuCrZr, produced using liquid infiltration in an open porous tungsten preform. To reproduce the most adverse in-service conditions, materials were characterized under high vacuum atmosphere up to 800 °C. From the measured mechanical properties, a remarkable temperature dependence can be assessed, since it is noticeable that for both materials, tensile and flexural strength equally decrease as the measurement temperature increases. However, the fracture behaviour of W-30CuCrZr is on average 25% higher than that of W-30Cu (21 MPa.m$^{1/2}$ versus 17 MPa.m$^{1/2}$ at RT) although this gap is narrower at higher temperatures; at 800 °C, the contribution of the Cu-based phase is quite low, thus fracture is primary controlled by the W initial skeleton. From these values, it can be inferred that the the yield strength and fracture toughness of W-30CuCrZr composite are superior, whilst it presented lower elastic modulus and rupture strain values than the W-30Cu composite.

As a result, the metal matrix composites presented in this article could effectively dissipate heat while overcoming the thermal stresses produced during operation, since a decent thermomechanical performance was observed at relevant reactor temperatures. This is of vital importance to enhance the performance, life cycle, and reliability of the component.

Keywords: Tungsten; copper; CuCrZr; heat sink; thermo-mechanical properties