MANUFACTURING OF SELF-PASSIVATING W-CR-SI ALLOYS BY MECHANICAL ALLOYING AND HIP

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Tungsten is presently the main candidate material for the plasma exposed areas of the divertor and the blanket first wall of future fusion reactors (DEMO) due to its low erosion yield by sputtering with plasma particles and its good thermo-mechanical properties [1]. However, the use of tungsten as first wall material implies an important safety concern in case of an accident with loss of coolant and air ingress into the reactor vessel. In this situation, the high temperatures achieved in the in-vessel components within 10 to 30 days due to the decay heat [2] would lead to a strong exothermic reaction owing to tungsten oxidation with the release of volatile radioactive tungsten oxides.

A possible way for avoiding this important safety issue would be the addition to tungsten of alloying elements forming stable oxides, in such a way that at high temperature in the presence of oxygen a self-passivating layer is formed protecting the material from further oxidation. In previous works, in which tungsten alloys have been manufactured via magnetron sputtering, it have been demonstrated that tungsten alloys containing 10 wt.% Si and 10 wt.% Cr exhibited the best self-passivating behaviour when exposed to air at temperatures up to 1000°C, obtaining an oxidation rate three orders of magnitude lower than for pure tungsten [3]. However, the PVD route is not industrially relevant because for the first wall of DEMO coatings or tiles with a thickness of several mm are required.

Powder metallurgy is a suitable route for the production of alloys of complex composition with the desired microstructure, while being a route of relatively low cost. In this work, first results on the manufacturing and characterization of W-Cr-Si alloys by powder metallurgy (mechanical alloying (MA) + hot isostatic pressing (HIP)) are presented. Different MA parameters were studied both at a SPEX and at a planetary ball mill, and several alloys with different Cr and Si amount were produced. After HIPing, densification >90% was achieved. The microstructure and the existing phases were observed by SEM (with cross sectioning by FIB), EDX mapping and XRD, and the mechanical properties were explored by micro- and nano-indentation. Furthermore, the thermal conductivity of some samples was measured as a function of temperature. Finally, first results of oxidation tests up to 1000°C are presented.

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