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High temperature microstructural stability of self-passivating W 10Cr-0.5Y alloy for blanket first wall application

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Tungsten is the main candidate material for the first wall (FW) armour of future fusion reactors. However, a loss of coolant accident with simultaneous air ingress into the vacuum vessel would lead to temperatures of the in-vessel components exceeding 1000ºC, resulting in the formation of volatile and radioactive tungsten oxides. A way to prevent this important safety concern is the addition to tungsten of oxide-forming elements, which, in presence of oxygen at high temperatures, promote the formation of a self-passivating layer protecting tungsten from further oxidation.
A W-10Cr-0.5Y alloy produced by mechanical alloying and hot isostatic pressing (HIP) has been recently developed, exhibiting a strong reduction of oxidation rate compared to pure W and high mechanical strength. After HIP at 1250℃ it shows a two phase microstructure, according to the W-Cr phase diagram, with a nanocrystalline structure of the W-rich phase due to the presence of a Y2O3 nanoparticle dispersion inhibiting grain growth. A heat treatment after HIP at 1550℃ results in a one-phase material with average grain size of ⊠250 nm and coarsening of the Y2O3 particles to ⊠50 nm. This material exhibits a high thermal shock resistance, as demonstrated by tests at the JUDITH facility consisting of 1000 ELM-like pulses, where the material showed a comparable performance to pure W. Nevertheless, the microstructure is metastable and its thermal stability under operational conditions has to be assessed.
In this work, results of thermal stability tests on heat treated W-10Cr-0.5Y alloy subjected to temperatures of 650, 700 and 1000℃ for times ranging from 50 to 3000 h are presented. After 100 h at 700℃ a slight growth of the Cr-rich phase is detected. After 100 h at 1000℃ a complete decomposition takes place with the formation of a uniform, fine-scale mixture of W- and Cr-rich phases, typical for spinodal decomposition.

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