Processing and Characterization of W-2Y Material for Fusion Power Reactors

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W-2Y material has been produced by powder metallurgy techniques including mechanical alloying of W and 2 wt.% Y elemental powders in an argon atmosphere followed by hot isostatic pressing of the milled powder at 1320°C under a pressure of 200 MPa for 2 hrs. The mechanical alloying time was optimized by means of X-ray diffractometry. It was found that it should not exceed 50 hrs in order to obtain a homogenous size distribution for the powder particles and to limit WC carbide formation due to C contamination by the jar's and the milling balls' material. The density of the obtained ingots was found to be 97% of the theoretical one. The microstructure and mechanical properties of the ingots have been characterized by means of scanning, transmission electron microscopy and scanning transmission electron microscopy (STEM) observations and Vickers microhardness measurements, tensile, 3-point bend and Charpy impact tests, respectively. It was observed that the microstructure of the compacted material is composed of grains having a bimodal size distribution, with mean sizes around 50 and 150 nm (Figure 1). In addition, the material contains an inhomogeneous distribution of oxide particles with a mean size ranging from 2 to 20 nm (Figure 2). In situ TEM chemical analyses revealed that the entire content of yttrium reacted with oxygen to form nanometric oxides whose composition corresponds to Y_2O_3. Charpy impact tests revealed that the material is brittle up to the maximum investigated temperature of about 1000°C. Tensile tests confirmed that the material is brittle at 1000°C but ductile at 1300°C, indicating that the ductile-to-brittle transition temperature should lie between 1100 and 1200°C.

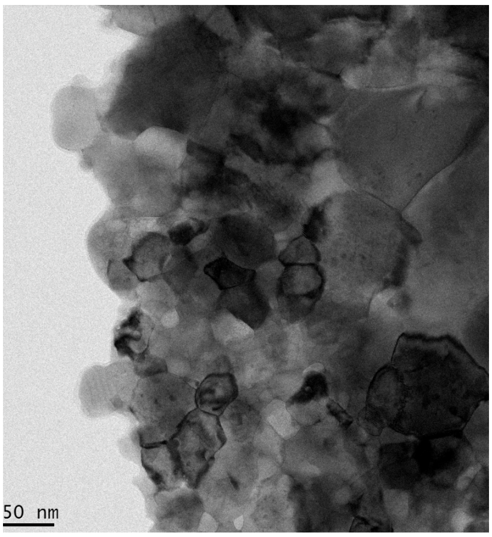

Figure 1: Typical bright field STEM image of W-2Y, revealing a nanostructured material

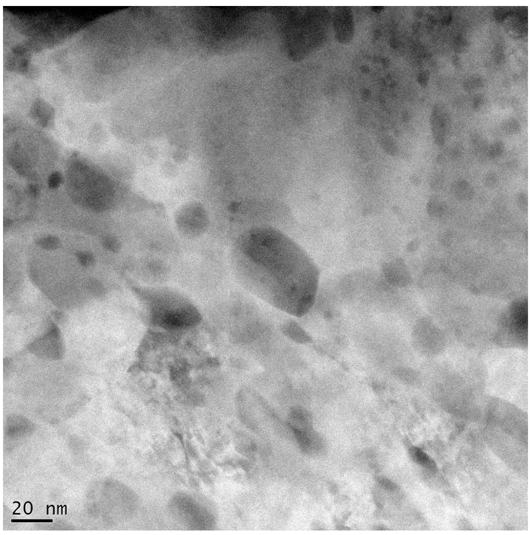

Figure 2: Typical dark field STEM image of W-2Y, revealing nanometric Y_2O_3 particles (dark areas)