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FTP/P7-11: Development of W Based Materials for Fusion Power Reactors

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Due to the superior thermophysical properties, tungsten (W) materials are candidates for plasma facing applications for ITER and DEMO. W-base materials are being developed on the basic idea that alloys and nano-grained materials should be more ductile than pure W and standard grain-sized materials, and that oxide or carbide dispersion strengthened materials should be more radiation resistant than pure W and standard grain-sized materials. A variety of materials are being produced using standard powder metallurgy (PM) methods including mechanical alloying (MA), hot isostatic pressing (HIPping) and thermo-mechanical treatment.
The goal of this work is to develop W-base materials by standard PM, which include mostly pure W and W-Y, W-Y2O3, W-TiC, W-Ta and W-Re-TiC alloys. For instance, W-(0.3-1.0-2.0)Y, W-(0.3-1.0-2.0)Y2O3, and W-(0.3-0.9-1.1-1.5-1.7)TiC (in wt.%) were produced by MA followed by HIPping. From X-ray diffraction and scanning electron microscopy studies on one powder with different milling time, it was shown that the particles are uniformly distributed in the W matrix and crystallite size decreases with time. All the materials are made of small grains, 20 and 500 nm, and contain a high density of nano-sized Y2O3 or TiC particles. For W-Y materials, Y transformed into Y2O3 during MA, due to the high amount of O present in the milled powders. All the materials contain a residual porosity of a few percents (1-3%). They exhibit high strength but they show no ductility. In collaboration with the Plansee Company, a more promising W-2Y2O3 material was produced by sintering and hot forging. The density of the ingot was 99.3%. The material appears to be composed of grains with a mean size around 1 μm and also contains nano-sized Y2O3 particles. Three-point bending (3PB) tests showed that the material is brittle at 25℃ and ductile above 400℃. The bending stress shows that the mechanical property is improved in W-2Y2O3 material with respect to pure W and W-1Y2O3. 3PB tests also show that the increase in the grain size improves the ductility of the material. This improvement outbalances the degradation of the fracture properties due to the increase of the particle size. Correlation between the mechanical properties and their respective microstructures resulting from various production routes will be discussed.

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