3 - 2 Microstructure and Mechanical Properties of Tungsten at Elevated Temperatures*

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Because of its advantages of high neutron yield, high melting point, high thermal conductivity and low sputtering yield, tungsten is proposed as solid target material in many spallation neutron source facilities and even accelerator driven sub-critical system (ADS) device in future. Microstructural and mechanical properties of powder-metallurgy pure tungsten material, which is prepared with two different production methods of hot rolling and forging process, have been investigated in this study. Because of anisotropic structure induced by different thermal treatments, specimens in different orientations were cut from the hot forged and rolled materials. Metallography observation was performed in order to identify the grain structure of the forged and rolled tungsten materials. Considering surface effect on mechanical properties of tungsten, the tensile test of all hot rolled samples with two different surface conditions of as-machined and electro-polished were also performed in the temperature range of 25∼ 500 °C.

Fig. 1 shows typical microstructures of different planes in hot rolled and forged tungsten. The grain size of hot forged is larger than that of rolled, and the grain along rolled direction has the biggest size due to the hot rolled thermal treatment. As shown in Fig. 1(f), the pore located on grain boundary was only observed in forged samples. The tensile test (Fig. 2) indicated that tungsten has good ductile properties at above 350 °C. According to the com-

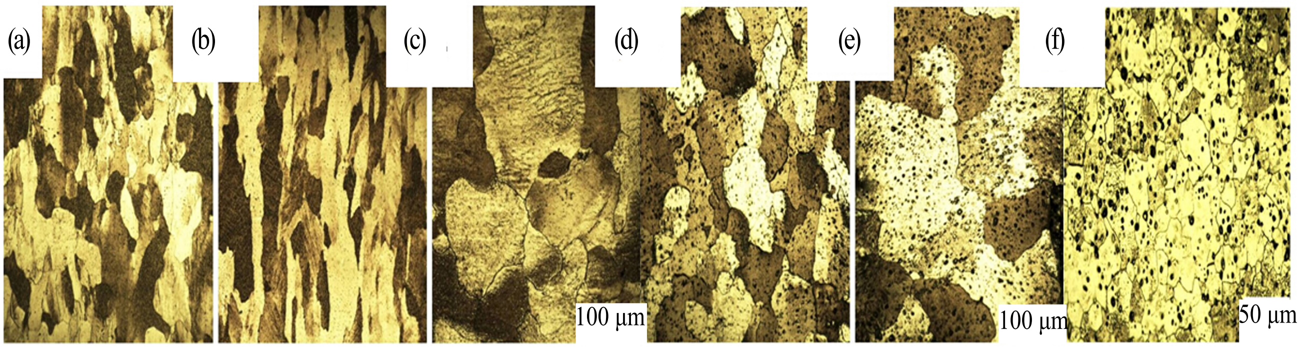

Fig. 1 (color online) Typical microstructures of different planes in hot rolled and forged tungsten: (a) a-plane rolled; (b) b-plane, rolled; (c) c-plane, rolled; (d) a or b-plane, forged; (e) c-plane, forged; (f) smaller grain area, forged.

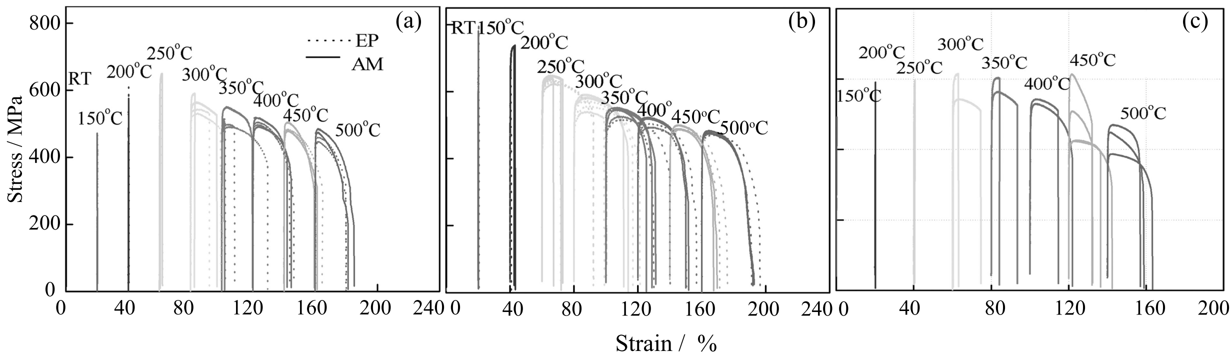

Fig. 2 Tensile curves of different orientations samples at temperature range from 25 to 500 °C rolled- X direction; (b) rolled- Y direction; (c) forged- X direction.

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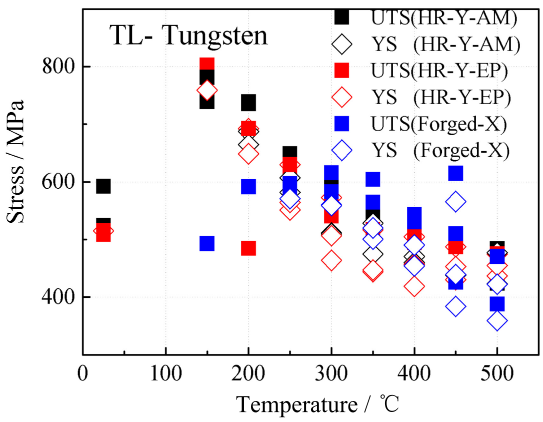

Fig. 3 (color online) Ultimate tensile strength and yield strength comparison at different temperatures.

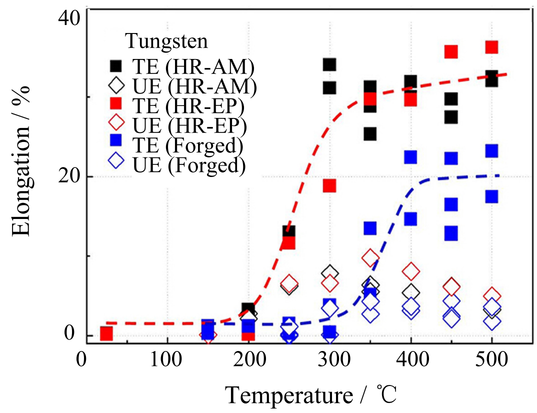

Fig. 4 (color online) Elongation comparison of different tungsten at different temperatures.

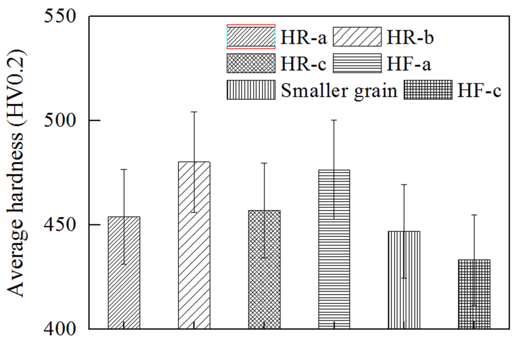

Fig. 5 The average hardness depending on different planes of both hot rolled and forged samples.

parison between rolled and forged sample, the hot rolled sample has larger ultimate tensile strength than that of forged. It is found that the transition temperature from brittletoductile fracture for forged tungsten is higher than that of rolled tungsten (Fig. 4), whereas the total elongation of the rolled tungsten is significantly larger than that of the forged tungsten at the temperature range of 250~ 500 °C. The hardness values of both rolled and forged samples are almost the same (Fig. 5). Only some difference was observed in different directions due to thermal mechanical treatment.

3 - 3 Microstructure Evolution in EC316LN Austenitic Stainless Steel Irradiated in STIP-Ⅱ *

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Austenitic stainless steels are a class structural material applied in current nuclear reactors and spallation targets as well as future nuclear devices. It is well known, the migration and interaction of defects and their clusters and small dislocation loops caused by irradiation induce changes in mechanical properties of materials and result in radiation hardening and ductility loss of materials. In the present study, microstructure evolution in EC316LN austenitic steel irradiated with mixed spectra of high-energy proton and spallation neutrons has been investigated by using Transmission Electron Microscopy (TEM).

The EC316LN austenitic steel was irradiated in the second experiment of the SINQ Target Irradiation Program to the dose ranged from 5.8 to 19.5 dpa at temperatures between about 112 and 375 °C. Carefully TEM observation (Fig. 1) shows that dense dislocation loops with sizes of about 2 nm in diameter are visible at lower doses, and the density of these smaller loops (black dots) is very high. In the low temperature regime, the loop density reaches a saturation level whereas the loop size distribution changes with increasing dose. At damage level above 16.5 dpa, corresponding irradiated temperature 283 °C, the average size of loops increases significantly with increasing the damage level, while the density of smaller loops decrease rapidly. It should be noted that the density of smaller loops (cluster) saturates and keeps the value of around 3×10^{23} m^{-3}, whereas, the mean size of larger loops increases and the density decreases with increasing of dose according to the results obtained from weak beam dark field images.