§45. Development of Grain Boundary Strengthened Tungsten for Plasma Facing Material

Yabuuchi, K. (Kyoto Univ.),
Noto, H.

Introduction

Tungsten (W) is a promising candidate for plasma-facing materials for the divertor and blanket in fusion reactors because of its high melting point, thermal conductivity, and sputtering resistance. However, the recrystallization embrittlement is the major concern for use as plasma-facing materials. Plasma-facing materials will be subjected to heat flux as high as 10 – 20 MW/m^2 during the operation of the fusion reactor. The results of the cyclic heat load experiment using mock-ups of W divertor for ITER to evaluate their performance had been reported. These results showed the crack formation and loss of cooling capability of W during cyclic heat load. Heat removal is an important function of divertor, and the crack formation, which results in the loss of cooling capability, should be avoided. To avoid the loss of cooling ability by crack formation and propagation, improvement of the mechanical property in W is desired. The crack formation and propagation behavior will be affected by recrystallization of the grain structure in W. W for plasma-facing materials are fabricated by severe plastic working such as hot forging and rolling to retain a suitable amount of deformed substructures that carry toughness assurance. The fabricated W is known to recrystallize at much lower temperatures (1200 – 1300℃) than the anticipated ambience for plasma-facing materials to be exposed. The recrystallization decreases the mechanical properties of W and this phenomenon is called recrystallization embrittlement. The recrystallization embrittlement will accelerate the crack formation and propagation during cyclic heat load. Because the recrystallization would not be avoided, the different fabrication process from plastic working is attractive. In this study, we investigate the fabrication process to increase the strength of grain boundary of W using nano-scale fiber.

Experimental

Pure W powder, silicon carbide (SiC) fiber and carbon fiber were used for this study. 10 at.% SiC – W and 10 at.% C – W were prepared. They were mixed and milled by a mortar for 20 min. The mixed powder was sintered with hot press facility in Kyoto University (Fig. 1). The temperature was 1150 ℃ and the pressure was 60 MPa. After sintering, the density was measured by Archimede's principle.

Results and Discussion

Figure 2 shows the sintered specimen after hot press fabrication. The density of sintered pure W, sintered W-SiC, and sintered W-C were 16.8, 15.1, and 16.0 g/cm^3. The ratio from ideal density were 87, 78, and 83 %, respectively. To increase their density, sintering fabrication using HIP at NIFS will be scheduled.

Fig. 1. Hot press facility.

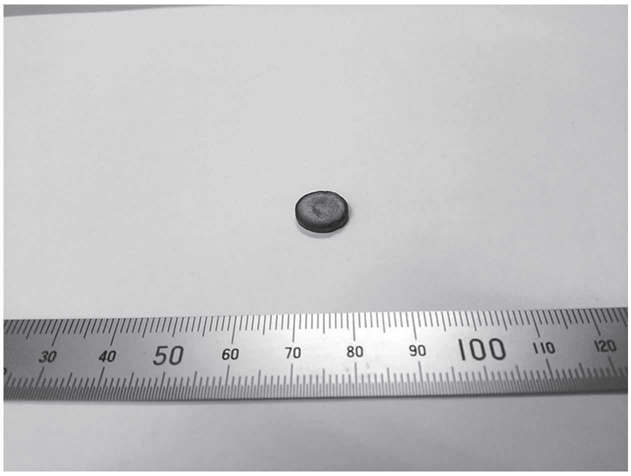

Fig. 2. Sintered tungsten.