DEVELOPMENT OF ODS W ALLOYS PRODUCED BY HIP

J. Martínez, B. Savoini, M.A. Monge, A. Muñoz, R. Pareja

Departamento de Física, Universidad Carlos III de Madrid, 28911, Madrid, Spain

Corresponding author: angel.munoz@uc3m.es

W and its alloys are very promising materials for making plasma facing components in the future fusion power reactors. In particular, these materials are being considered candidate materials for high heat flux components with structural functions in the divertor [1,2]. The properties that make W a suitable material for use as a plasma facing material are its high melting point, good thermal conductivity, high thermal stress resistance, low tritium retention and high temperature strength. The ductile-brittle transition temperature (DBTT) for W is the temperature range 373-673 K and its recrystallization temperature (RCT) around 1500 K [3]. These features limit the operating temperature range of those W components with structural functions. On the other hand, pure W is brittle at room temperature, what makes the fabrication of W components be very difficult. Nevertheless, the DBTT and RCT for W can be improved by addition of some impurities. For instance, the addition of Re to W lowers the ductile-brittle transition temperature (DBTT) and enhances its fabricability and mechanical characteristics at high temperatures. However, W-Re alloys have been excluded for fusion applications because they suffer severe embrittlement induced by neutron irradiation due to the Re transmutation [4–6]. Also, it appears that the operating temperature window for W can be modified via a uniform dispersion of oxide nanoparticles as such ThO_2, La_2O_3 or Y_2O_3. Then, the current He-cooled divertor designs are considering a thermal armor of sintered W tiles joined to thimbles of oxide dispersion strengthened (ODS) W alloy. These ODS alloys have to be properly joined to sintered W tiles, besides having a low DBTT and a high RCT. This requires the development of ODS W alloys containing an element that enhances the joining using a metal interlayer. In fact, joining between pure W and W-1%La_2O_3 (WL10) is successfully accomplished by a Ti interlayer [7].

The goal of the present work has been the development of different ODS W-V and W-Ti alloys containing Y_2O_3 or La_2O_3. The alloys have been fabricated by a powder metallurgy technique, which consists of the following steps: 1) blending of the starting powders; 2) mechanical alloying of the powder blends in a planetary ball mill; 3) encapsulation and degassing; and 4) sintering by hot isostatic pressing (HIP) for 2 h at 1573 K and 195 MPa. The microstructural characteristics of these alloys have been investigated by X-ray diffraction, scanning electron microscopy and atomic force microscopy. The results indicate that the addition of Ti or V enhances the W sintering and favors the formation of a dispersion of oxide nanoparticles.

[1] J.W. Davis, V.R. Barabash, A. Makhankov, L. Plöchl, K.T. Slattery, J. Nucl. Mater. **258-263** (1998) 308-312.

[2] H. Bolt, V. Barabash, W. Krauss, J. Linke, R. Neu, S. Suzuki, N. Yoshida, ASDEX Upgrade Team, J. Nucl. Mater. **329-333** (2004) 66-73.

[3] I. Smid, M. Akiba, G. Vieider, L. Plöchl, J. Nucl. Mater. **258-263** (1998) 160-172.

[4] F.W. Wiffen, Proceedings of Symposium on Refractory Alloy Technology for Space Nuclear Power Applications, August 1983, Oak Ridge, TN, USA, p. 252.

[5] M. Schuster, I. Smid, G. Leichtfried, Physica B **234-236** (1997) 1224.

[6] R. K. Williams, F.W. Wiffen, J. Bentley, J.O. Siegler, Metallurgical Transactions **14A** (1983) 655.

[7] P. Norajitra, A. Gervash, R. Giniyatulin, T. Ihli, W. Krauss, R. Kruessmann, V. Kumetsov, A. Makhankov, I. Mazul, and I. Ovchinnikov: Fus. Eng. Des. **81** (2006) 341.