§27. W-coating on Low Activation Structural Materials

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Tungsten (W) coating R&D on low activation structural materials, such as reduced activation ferritic steels (RAFS), oxide dispersion strengthened steels (ODSS) and vanadium alloys, has been considered to be essential for the fabrication of blanket first wall and diverter components of fusion DEMO reactors. The vacuum plasma spray (VPS) process is practical for coating a large area because of its relatively high coating rate. Solid state diffusion bonding (SSDB) technique is desired for ODSS of which the high performance depends on the dispersion morphology of the oxide particles. In the present study, W coatings were fabricated on various low activation materials by the VPS process and the W-ODSS joining were conducted for bulk-W and an ODSS. The objective of this research is to characterize the coated materials and joints from the view of the microstructure and mechanical properties. In this short report, a part of the research on W/ODSS joints is reported.

The materials used for joints were high-Cr ODS ferritic steel (Fe-15Cr-0.3Ti-0.3Y_2O_3) and pure W. The fabrication of ODS ferritic steel is described in the literature. Insert material for brazing was a Fe-based amorphous alloy with a thickness of 25μm, called ALLOY 2605S-2 (Fe-3B-5Si), which contains 3wt. % B and 5wt. % silicon as a melting point depressant of Fe. The melting point of the insert materials was measured to be 1423K by means of differential calorimetric analysis. Brazing was performed in a vacuum less than 10^{-3} Pa, for 1h. SSDB was also performed to compare the joint performance with brazing. The temperature of both the brazing and SSDB was 1453 or 1473K, which are slightly higher than the melting point of insert material.

Figure 1 shows the hardness distribution across the joint boundary of SSDB and brazing, indicating an abrupt change in the hardness at the boundaries. In SSDB, a peak in the hardness was observed at the boundary. A specific bright feature in the vicinity of the boundary in ODSS is a sort of diffusion affected zone (DAZ) that is due to W diffusion into ODSS during SSDB processing. The hardness distribution at the boundary of brazing is rather homogeneous, indicating no remarkable change in the hardness. It is surprising that the hardness of insert material is almost same with ODSS, although the grain size is much larger than the ODSS.

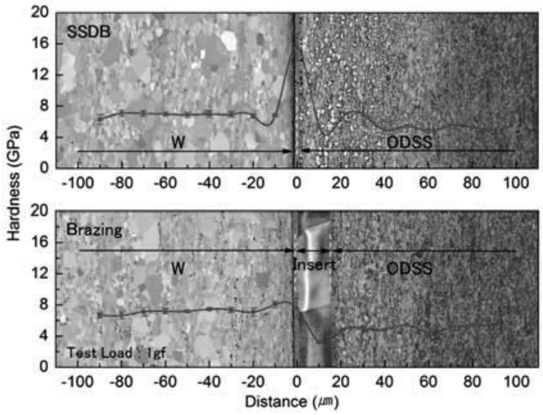

Fig. 1: The hardness distribution across the joint boundary of SSDB (upper) and brazing (bottom).

Joint strength was measured by means of torsional shearing test method developed in Kyoto University, and load-strength curves were shown in Fig. 2. The maximum strength is the fracture shear strength of the joints, and the strength is higher for brazed joints than that of SSDB. An FEM analysis indicated that thermal residual stress was smaller for brazed joint, which was considered to be due to stress relaxation at the joint boundary by the presence of insert material in brazed joint.

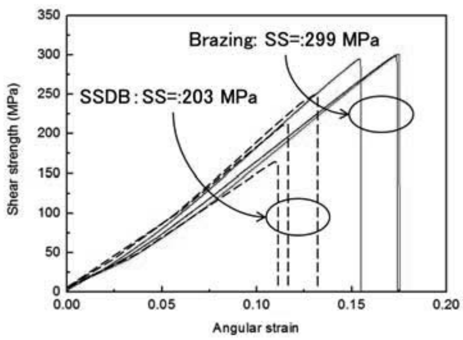

Fig. 2: The shearing load-strain curves of SSDB and brazed joint tested by torsional shearing method.