§13. The Microstructure of W Sprayed Low Activation Structural Materials

Watanabe, H,. Yoshida, N. (RIAM Kyushu Univ.), Nagasaka, T., Muroga, T.

1. Introduction

Bonding technology of W on V-4Cr-4Ti alloys (NIFS-HEAT-2) is one of the key technologies for use of V-4Cr-4Ti alloys in a large component. However the susceptibility of these alloys to the embrittlement caused by interstitial impurities during the procedure is highly pronounced. Recently, the development and fundamental properties of W sprayed V-4Cr-4Ti alloys are studies by NIFS and universities. Fig. 1 shows the microstructure of interface between NIFS-HEAT-2 and VPS-W. As shown in the figure, relatively large scale of voids were formed close to the interface. And blocky Ti precipitates, which are commonly observed in the NIFS-HEAT-2, are not detected. To understand the effects of neutron irradiation on the materials, specimen preparation for irradiation had just started.

In this annual report, therefore, the recent progress on the microstructural evolution and radiation hardening of laser welded V-4Cr-4Ti alloy in HFIR-17J irradiated in Li environment is summarized.

2. Experimental Procedure

Welded joints used in this study were prepared from a high purity V-4Cr-4Ti alloy, which was designated as NIFS-HEAT-2[1]. Before the YAG laser welding (bead-on-plate welding) in a high purity argon atmosphere, the samples were annealed in vacuum at 1273K for 2hr. The detailed welding procedure was described elsewhere [2]. Oxygen concentrations of the sample before and after welding were 139 and 158 wt ppm, respectively. Neutron irradiation was carried out in HFIR-17J at temperature of 723 and 873K in a europium-shielded RB position for 5 cycles for total 9930 MWD. The total neutron dose of irradiation was 3.7 dpa for vanadium alloys. After irradiation, the lithium-filled capsules were disassembled and the specimens were rinsed, completely. The transmission electron microscopy and Vickers hardness tests were conducted after the irradiation and post-irradiation annealing at 773-1073K for 1hr.

3. Results

The microstructure of laser welded NIFS-HEAT-2 was strongly dependent on irradiation temperature. Fig. 1 shows the TEM images of weld metal (a), heat affected zone (HAZ) (b) and base metal (c), after irradiation at 723K and 873K, respectively. In the figures, corresponding images of the materials taken by kinematical conditions (s>>0, s is the Bragg deviation parameter) are also shown. The results of Vickers hardness test of the materials are inserted in the left corner of the photos. At 723K very high dislocation density was observed and prominent precipitation was not detected. On the other hand, at 873K, Ti(CON) formation becomes prominent. Radiation enhanced formation of Ti(CON) precipitates with {100} habit planes and dislocations. Ti(CON) precipitates were homogenously formed in the weld metal. The average precipitate size in the base metal and weld metal was 48.8 and 16.1 (nm), respectively. The measured number density of precipitates in the base metal and weld metal were 4.0 x 10^{21} and 1.9 x 10^{22}(m^{-3}), respectively. On the other hand, in our previous study in JMTR, enhanced precipitation formation in weld metal was detected at 673K. Moreover, at 873K, the microstructure of the weld metal was divided into two regions, namely, precipitate segregation (PS) and precipitate-free (PF) areas. But, relatively larger Ti(CON) precipitates were observed at 873K. But, at 873K, PS and PF areas were not observed in the weld metal. Vickers hardness of base metal at 723K and 873K is 189.9 and 180.6, respectively. But, higher value is measured in weld metal and HAZ.

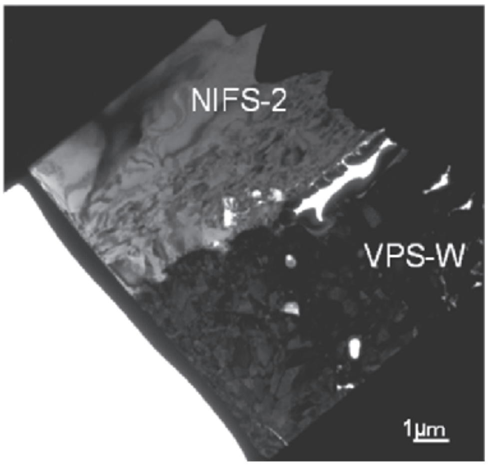

Fig.1. Microstructure of interface between NIFS-HEAT-2 and VPS-W.

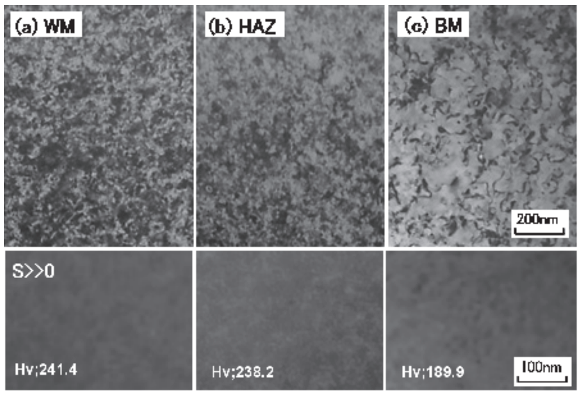

Fig. 2. Microstructure of weld metal (a), heat affected zone (HAZ) (b) and base metal (c), after irradiation at 723K.

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2) T. Nagasaka, T. Muroga, M. L. Grossbeck, T.Yamamoto, J. Nucl. Mater. 307-311 (2002)1595.
3) Nam-Jin Heo, T. Nagasaka, T. Muroga, A. Nishimura, K. Sinozaki and H. Watanabe, Fusion Science and Technology, 44(2003)470.