§11. The Microstructure of Laser Welded Y Doped V-4Cr-4Ti Alloys after Ion Irradiation

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1. Introduction

The welding procedure is one of the key technologies for use of V-4Cr-4Ti alloys as a large component [1]. But the embrittlement caused by interstitial impurities during welding is highly pronounced. To avoid the pick-up of impurities (e.g. oxygen and nitrogen) from the welding environment, electron beam (EB) and gas tungsten arc (GTA) welding [2,3] were conducted using vacuum chamber or glove box. Recently, laser welding technology for the alloys was developed by NIFS (National Institute for Fusion Science) by controlling the flow rate of high purity argon gas [4,5]. Because of flexible, in-field, automated and remote operation, and small weldment and heat affected zone (HAZ), laser welding is an attractive welding technology. However, quite little is knows as to the irradiation effect on the weldment. Our previous studies [6] on neutron irradiated V-4Cr-4Ti alloy (NIFS-HEAT2) revealed that tiny Ti(CON) precipitates were homogenously formed in the weld metal at 673K and the formation was prominent in comparison with base metal. The effects of post-weld heat treatment (PHWT) on weld metal, effectively improving the CVN impact properties for unirradiated material and for material irradiated at lower temperatures, are not effective or have a very limited effect at higher irradiation temperatures where the growth of Ti(CON) precipitates were prominent. On the other hand, Y addition on V-4Cr-4Ti alloys is expected to reduce the Ti(CON) formation, because oxygen is scavenged by Y. The present paper summarized, therefore, the microstructural evolution of laser welded Y doped V-4Cr-4Ti alloy during ion irradiation.

2. Experimental Procedure

Welded joints used in this study were prepared from V-4Cr-4Ti-0.15Y alloy. Before the YAG laser welding (bead-on-plate welding) in a high purity argon atmosphere, the samples were annealed in a vacuum at 1273K for 2hr. The detailed welding procedure was described elsewhere [3]. A 2.4MeV copper ion irradiation was carried out with the tandem accelerator at Kyushu University. The TEM samples were sliced from welded materials and irradiated at 873K up to the dose of 12 dpa. After the irradiation, the specimen was electro-polished by a back thinning method, and the area near the peak damage region (at about 700 nm) was observed by TEM. The damage rate and the implanted copper concentration in this region were 1.7 x 10^{-4} dpa/s and 10^{-2} at. % (at 1 dpa), respectively.

3. Results

Fig. 1 shows the microstructural evolution of base metal and weld metal of V-4Cr-4Ti –0.15Y alloy irradiated at 873K. In the figure, microstructure of V-4Cr-4Ti (NIFS-HEAT2) is also shown for comparison. In the case of NIFS-HEAT2, fine titanium oxides with {100} habit planes were observed even at the dose of 0.75 dpa. The number density of Ti(CON) decreased with increasing dose and the growth of Ti(CON) precipitates was prominent at higher dose levels above 4 dpa. Estimated oxygen levels from the measured density and size of Ti(CON) precipitates were inserted in fig.3. In this estimation, Ti(CON) precipitates are assumed to be TiO (NaCl type crystal structure). For the case of NIFS-HEAT2, the estimated oxygen levels from the microstructure increased with dose and the value of the sample irradiated at 12 dpa is about 20 times higher than that of unirradiated sample. In V-4Cr-4Ti-0.15Y alloy, on the other hand, Ti(CON) precipitates were observed in all dose levels but smaller Ti(CON) precipitates were observed, in comparison with NIFS-HEAT2. The estimated oxygen levels of the base were almost half of NIFS-HEAT2. But, in the higher dose level above 7.5 dpa, the growth of Ti(CON) became prominent. The same oxygen pick-up from vacuum environment during ion irradiation is also reported in ref [7]. Therefore, in higher dose levels, oxygen pick-up from irradiation environment is essential, and thus further studies are needed on Ti(CON) formation (oxidation kinetic) during irradiation.

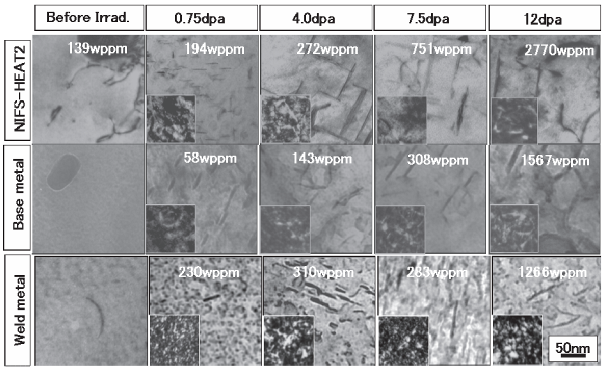

Fig.1 Microstructure at 873K

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