§17. Improved Hydrogen Permeation Reduction of MOD Er_2O_3 Coating on JLF-1

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Reduced activation ferritic/martensitic (RAFM) steels are considered as the candidate structural materials for the blankets of future DEMO reactors while have high permeability of hydrogen isotopes in the operational temperature range. To suppress the tritium permeation through the structure materials, the fabrication of thin ceramic coatings as tritium permeation barriers (TPB) on the ducts surface of RAFMS steels has especially been proposed for the molten salt or Pb-Li blankets because of their low tritium solubility. Er_2O_3 coatings were fabricated as TPB coating on the RAFM steels on because it can suppress deuterium permeation to the same range as Al-based coatings. The purpose of the present study is investigate the influence of the baking atmosphere on the hydrogen permeation barrier performance of metal organic decomposition (MOD) Er_2O_3 coatings fabricated by dip-coating process, which is suitable for large area coating on the components with a complex shapes.

The Er_2O_3 MOD liquid precursor, which was composed of low boiling point ester and carboxylate of erbium, was used as the liquid organic precursor to form the precursor layer on the Fe-9Cr-2W-0.1C based JLF-1(Japanese Reduced Activation Ferritic Martensitic steel) and decomposed into the Er_2O_3 coating by baking at 600°C in air or 700°C in the flowing high purity Ar. After baking, coating surfaces were observed by SEM and composition of oxidized layers were analyzed by XRD. The hydrogen permeation reduction factor was obtained by the comparing the hydrogen permeation flux through the coated and bare JLF-1 specimens with the same loading pressure of 40kPa.

Fig. 1 shows the phase analysis of Er_2O_3 coating on the substrate by XRD. The peak of Fe_2O_3 was found for the baking in air while the peak of Cr_2O_3 was found for baking in pure Ar. This means that different compositions were formed in oxidized layers below the coatings when they was baked in different atmospheres. The possible reason for the difference may be that low oxygen partial pressure (10ppm) in pure Ar could suppress the formation of Fe_2O_3 and high temperature induced the diffusion of Cr from the JLF-1 substrate.

Fig. 2 shows the SEM observations of the coating surfaces. When baked in air, coating has a rough surface with many small coating particles and small cracks. In case of baking in Ar, coating has a relatively smooth surface while some bulgy parts were found and maybe contain carbon or carbides. According to the XRD analysis, the the formation of different compositions in oxidized layers critically affected the coating surface conditions, e.g. smoothness, small cracks.

With the different loading pressure of H_2, the power law relationship between the steady-state H flux and the loading has an exponent of n=~0.5 and n=~1 for bare JLF-1 and coated JLF-1, respectively. This means that the H_2 recombination on the coating surface dominated the process of H_2 permeation through the specimen, which is different from the lattice diffusion for the bare JLF-1.[1] Thus, H_2 permeation reduction factor was improved from ~15 to 100 at 600°C when baking atmosphere was changed from air to Ar(in Fig. 3). When baked in Ar, that the suppression of formation of Fe_2O_3 layer improved the coating surface conditions is considered to be responsible.

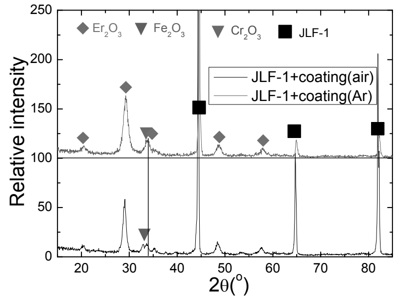

Fig. 1. XRD patterns of Er_2O_3 coating on JLF-1 substrates with different baking atmospheres

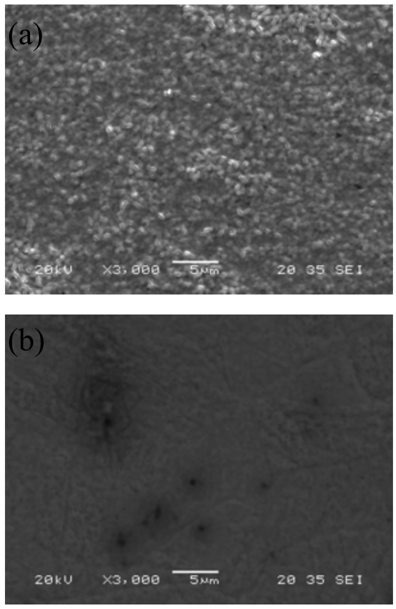

Fig. 2. SEM images of coating surfaces; (a) coating on JLF-1 baked in air; (b) coating on JLF-1 baked in Ar.

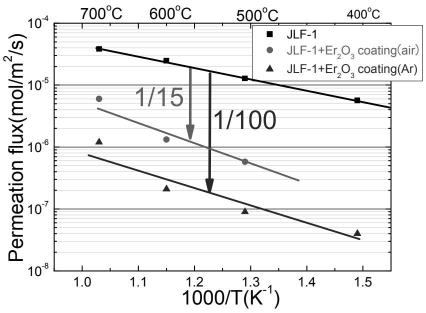

Fig. 3. H_2 permeation reduction factor of coating with different temperatures

1) D. Levchuk, et al.: Physica Scripta. T108 (2004)119–123