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ABSTRACT

Enamel Coating for Hydrogen and Oxygen Diffusion Barrier

T. Chikada[1], Y. Shimizu[1]

1Shizuoka University, Shizuoka, 836 Ohya, Suruga-ku, 422-8529, Japan.

Functional coatings have developed to reduce hydrogen isotope permeation and corrosion in hydrogen applications such as fusion reactor blankets and hydrogen production systems. Ceramic coatings such as metal oxides showed high hydrogen isotope permeation reduction performance; however, oxidization of steel substrates by oxygen diffusion through the coating at high temperatures causes degradation of the coating. In this study, we fabricated enamel coatings consisting primarily of silicon dioxide that has a low oxygen diffusion coefficient and examined its performance as a functional coating through deuterium permeation measurements, thermal cycle tests, and annneling tests.

The enamel coatings were fabricated on 430-type stainless steel substrates using three kinds of commercially available enamel glazes by dip-coating and heat-treatment at 600–850 ºC for 10–60 min in an argon-hydrogen mixture gas. Surface/cross-sectional obesevartion, crystal structure analysis, and deuterium permeation measurements using a gas-driven permeation system were performed. Also, thermal cycle tests in the temperature range of room temperature–700 °C with a rate of temperature increase/decrease of 100 ºC min–1 and annealing tests at 600 °C for 24 h in air were conducted to investigate thermal durability and oxygen diffusion barrier performance, respectively.

All the coatings showed a decrease in deuterium permeation, achieving the permeation reduction by a factor of more than 1000 in comparison with an uncoated substrate. The coating after the thermal cycles showed a high deuterium permearion flux in the beginning, and gradually decreased with increasing the test temperature, suggesting that the coating remelted at high temperatures and recovered the degradation. The coating showed no oxygen diffusion after the anneling tests. From these results, the enamel coating is promising as a hydrogen and oxygen barrier in hydrogen applications.