Alumina Films Prepared on Iron-Aluminide Coatings by In-situ Oxidation Process

W.W. Zhao*, H.G. Yang, Q. Zhan, X.M. Yuan, Y. Hu, TMT Team

Department of Reactor Engineering Research & Design, China Institute of Atomic Energy,
P. O. Box 275-57, Beijing 102413, P. R. China

The reduction of tritium permeation through the structural materials of the blanket and tritium system will minimize radiological hazards. A great effort has been made to resolve the problem by the application of suitable tritium permeation barriers (TPB) coatings. Alumina film has been prepared on top layers of the aluminised steels by in-situ oxidation process. This has been developed as a promise candidate TPB process by our research team of tritium materials and technology (TMT Team) in the past ten years. The characterization of alumina film are summarized and discussed in this manuscript.

The in-situ oxidation process for the 316L and RAFMs specimens aluminised by the pack cementation process was studied under the condition of different oxygen partial pressure and with rare earth element (Ce) doping. The morphology, roughness, thickness, phase and chemical valence of the surface alumina films were characterized by SEM, AES, AFM, XPS and TEM. The results indicated that the alumina films formed on top of the iron-aluminide coatings were mainly composed of Al_2O_3 phase (including a little CeO_2) with the thickness in the range of 200nm-500nm and an average roughness about 325nm. Increasing oxygen partial pressure would promote the content of stoichiometric Al_2O_3, which can be inferred by XPS analysis. Combining with AES and XPS analysis, the selective oxidation mechanism was evaluated for the iron-aluminide. Meanwhile, it was observed that the rare earth effect (REE) of doped Ce had two-side influence on the thickness of alumina film. The alumina film was consisted of α-Al_2O_3 (stable phase) and γ-Al_2O_3 (transient phase) by TEM analysis. Further investigation should be done to improve the ratio of α-Al_2O_3 phase and understand the self-healing mechanisms of the $FeAl/Al_2O_3$ composite coatings in order to achieve better tritium permeation resistance performance.

Corresponding Author:

Mrs. Zhao, Weiwei
veiveizhao@163.com
Department of Reactor Engineering Research & Design,
China Institute of Atomic Energy
P. O. Box 275-57, Beijing 102413, P R China
Tel: +86-10-6935-7373
Fax: +86-10-6935-7821