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機能性セラミックス被覆のリチウム鉛腐食における ガンマ線照射影響

Gamma-ray irradiation effect on liquid lithium-lead corrosion for functional ceramic coatings

城田 賢渡[1]、三浦 颯太[1]、法月 亮介[1]、藤原 輝[1]、Do Duy Khiem[1]、
松浦 航[1]、田中 照也[2]、近田 拓未[1]
Kento Shirota[1], Sota Miura[1], Ryosuke Norizuki[1], Hikaru Fujiwara[1],
Khiem Do Duy[1], Wataru Matsuura[1], Teruya Tanaka[2], Takumi Chikada[1]

[1]静岡大、[2]核融合研
[1]Shizuoka Univ., [2]NIFS

1. Introduction

Functional ceramic coatings have been developed to suppress tritium permeation through structural materials in fusion reactor blankets. Our previous study revealed the coatings have high permeation reduction performance and compatibility with tritium breeders [1]. On the other hand, the coatings are exposed to high dose neutrons and gamma-rays in the actual reactors; however, there is limited knowledge on corrosion behaviors in gamma-ray irradiation environments. Therefore, in this study, we report the effects of gamma-ray irradiation on corrosion behavior of the coating through liquid lithium-lead (Li-Pb) exposure tests with and without gamma-ray irradiation.

2. Experiment

Zirconium oxide (ZrO_2) coatings were fabricated on reduced activation ferritic/martensitic steel F82H (Fe-8Cr-2W) substrates by metal organic decomposition method. The coatings were exposed to liquid lithium-lead (Li-Pb) at 600 ºC for 500 hours: 100 hours under a ^{60}Co gamma-ray irradiation environment and 400 hours without irradiation. The irradiation dose was approximately 27 kGy. Thereafter, surface and cross-sectional observations of the samples before and after the exposure tests were performed by scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDX).

3. Results and discussion

Surface SEM images of the sample after the liquid Li-Pb exposure test with and without gamma-ray irradiation are shown in Fig. 1. The surface morphology of the unirradiated sample was slightly rougher than before the exposure test. On the other hand, undulating corrosion products formed on the whole irradiated coating surface, indicating corrosion reactions were accelerated by irradiation. Besides, EDX analysis showed a higher concentration of Fe on the surface of the irradiated sample, while a lower concentration of O. That suggests the thicker corrosion product layer formed on the irradiated coating. We consider that gamma-ray or secondary electrons generated by Compton scattering and the photoelectric effect of Pb excited Li, which activated the reaction on the coating surface and produced a large amount of corrosion products including Li.

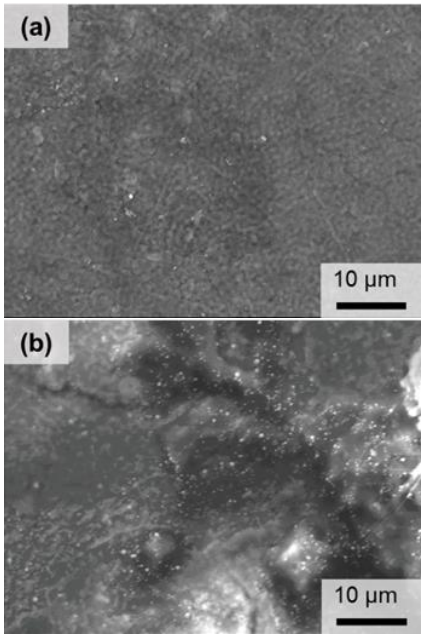

Fig. 1 Surface SEM images of ZrO_2 coating after Li-Pb exposure test at 600 ^{O}C for 500 hours (a) without and (b) with gamma-ray irradiation for 100 hours.

Reference
[1] M. Matsunaga *et al.*, J. Nucl. Mater., 511 (2018) 537–543.