Irradiation behavior of alumina scales formed on FeCrAl ODS alloys and the effect of pre-oxidation temperatures

*Hao Yu[1], Sosuke Kondo[1], Yasuyuki Ogino[1], Minha Park[1] and Ryuta Kasada[1]
[1]Tohoku Univ.

Abstract

Alumina-forming FeCrAl ferritic oxide dispersion strengthened (ODS) alloys are considered to be promising materials for nuclear systems. Present work aims to investigate the irradiation behavior of the alumina scales formed on FeCrAl ODS alloys at various pre-oxidation temperatures. Influence of microstructure control through adjusting the pre-oxidation temperatures on the irradiation resistance will be discussed.

Keywords: FeCrAl ODS, Alumina, Irradiation, Pre-oxidation

1. Introduction

The most appealing aspect of the FeCrAl ODS alloys is the ability to spontaneously form a dense α-alumina scale upon exposure to high temperatures, which can protect the alloys from extremely high temperature steam in accidental nuclear environments. Improving the radiation resistance of the alumina scale is essential for nuclear applications. Since the microstructure of the alumina scales is closely related to the temperature [1], in order to understand the role of microstructural control on the improvement of the irradiation resistance of the alumina scales, the irradiation behavior of alumina scales formed at different temperatures has been investigated.

2. Experimental

The alumina scales formed on different pre-oxidation temperatures were characterized by SEM, EPMA and XRD. The pre-oxidized FeCrAl ferritic ODS alloys were irradiated using a 6.4 MeV Fe^{3+} ion beam to 2 dpa at 500 °C in DuET, Kyoto University. Effect of the irradiation on the microstructure of the alumina scales was elucidated with the aid of STEM and 3D-AP characterization techniques. Evolution of the mechanical performance of the alumina scales before and after the irradiation was investigated by means of ultra-small testing technologies (USTT).

3. Result

Fine Y-Zr oxide particles were found in the formed alumina scale, which were originally existed in the alloy substrate and subsequently incorporated into the alumina layer with the inward growth of the alumina. As the pre-oxidation temperature increases, the Y-Zr oxide particles within the alumina layer show a tendency to diffuse from the metal substrate to the gas interface of the scale. The irradiation-induced segregation of Y/Zr along the alumina grain boundaries (G.B.) was confirmed, resulting in a reduction of alumina grain boundary cohesion.

4. Conclusion

Microstructural control by adjusting the pre-oxidation temperature contributes to the microstructural stability of alumina scales during irradiation, especially the distribution of the Y-Zr oxide particles, which provides the possibility to improve the irradiation resistance of the alumina scales.

References

[1] H. Yu, S. Kondo, R. Kasada, N. Oono, S. Hayashi, S. Ukai, Nucl. Mater. Energy 25 (2020) 100798