

## Oxidation Behavior of Cr-based Binary Alloys at High Temperatures

\*John Andrew Kane Perez Jovellana<sup>1</sup>, Zongda Yang<sup>1</sup>, Ziqi Wei<sup>1</sup>, Lijuan Cui<sup>2</sup>, Bo Li<sup>1</sup>, and Hiroaki Abe<sup>1</sup>

<sup>1</sup>Department of Nuclear Engineering and Management, The University of Tokyo, Japan

<sup>2</sup>College of Physics, Sichuan University, China

Development of accident-tolerant fuel (ATF) materials currently focus on application of Cr-based coatings to protect the conventional Zr alloys. One approach to improve Cr properties is via alloying. In this study, Cr-Fe and Cr-Al alloys are prepared using arc melting. Oxidation tests using thermogravimetric analysis were performed to investigate the kinetics. Surface and cross-section morphology were analyzed using SEM. Satisfactory oxidation resistance was observed.

**Keywords:** ATF, chromium, oxidation

### 1. Introduction

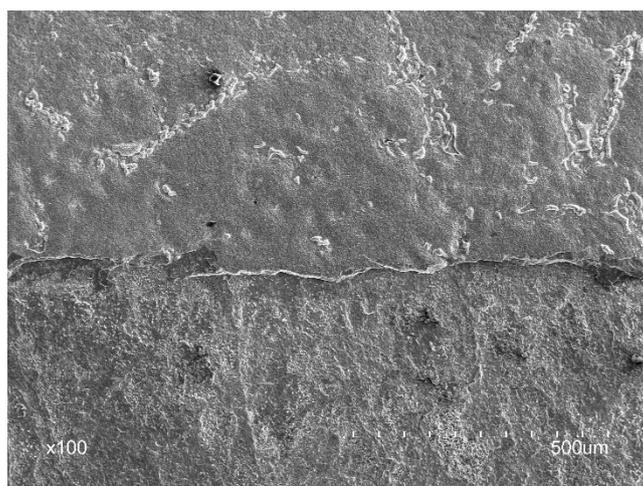
During the Fukushima Daiichi nuclear disaster, the generation of hydrogen was caused by the exothermic oxidation reaction of Zr cladding with steam. Accident-tolerant fuel (ATF) research currently concentrate on applying a Cr-based coating to protect Zr alloy. Enhancements such as Cr alloying may be needed to further improve Cr performance.

### 2. Methodology

Cr-Fe and Cr-Al alloys were prepared via vacuum arc melting followed by thermal annealing. High-temperature oxidation behaviors were studied using thermogravimetric analysis. Surface and cross-sectional images were observed for the oxidized samples. Residual stresses are measured using XRD and identified to be compressive.

### 3. Results and Discussion

From the thermogravimetric analysis, both Cr-7Fe and Cr-2Al shows lower weight gain at high temperature air oxidation compared to Cr, especially at 1000-1200°C. Cr-2Al shows irregular or stepwise behavior due to sudden increases in weight gain, possibly due to oxide scale cracking that accelerates oxidation of exposed substrate. At higher temperature of 1200°C, spallation occurred, and features of remaining scale and exposed substrate can be identified.



**Fig 1.** Cr-7Fe oxidized at 1200°C, showing remaining oxide scale (upper) and spalled area (lower)

### 4. Conclusion

Cr-Fe and Cr-Al show potential improvement compared to pure Cr based on high-temperature oxidation results by providing additional protection of the Cr<sub>2</sub>O<sub>3</sub> scale for the substrate. Deeper investigation of the oxide scale grain microstructure will be performed.