Extended Lifetime Metallic Coatings for High Temperature Environmental Protection:
Long-Term Testing to Predict Benefits of Aluminide Coatings

Aluminide coatings have been studied for many years because the formation of a protective external alumina scale results in excellent corrosion resistance in oxidizing, sulfidizing, carburizing and water-containing environments. Steam and exhaust gas environments are of particular interest because alumina is less susceptible to the accelerated attack due to hydroxide formation observed for chromia- and silica-forming alloys and ceramics. One of the factors that inhibits their application is a lack of sufficient data about their potential benefits in terms of lifetime and applicable environments. In order to address that issue, model coatings are being fabricated at ORNL for long-term corrosion testing and diffusion studies (up to 10,000h at 500°-800°C) in order to develop a comprehensive lifetime evaluation approach for aluminide coatings. One ferritic (Fe-9Cr-1Mo) and one austenitic alloy (304L) have been selected as substrate materials and CVD coatings have been used in order to have a well-controlled, high purity coating. It is anticipated that similar aluminide coatings could be made by a higher-volume, commercial process such as pack cementation.

For long-term coating durability, one area of concern has been the coefficient of thermal expansion (CTE) mismatch between the aluminide coating and substrate. This difference could cause cracking or deformation that could reduce coating life. To study this issue, corrosion testing using thermal cycling is of particular interest and results after 2000h at 700°C have shown that repeated thermal cycling with a short cycle time (1h) will cause degradation whereas a longer cycle time (100h) does not, Figure 1. The higher mass gain in 1h cycles reflects penetration of the coating and accelerated attack of the substrate, as is observed for uncoated specimens in this simulated exhaust gas environment (air with 10 vol.% water vapor). This indicates that these coatings are susceptible to repeated thermal cycling at this temperature. For applications with a low frequency of thermal cycling, such as in the case of most fossil energy systems, coating performance appears excellent with low mass gains and the 100h cycle corrosion test will continue to extended times (e.g. 10,000h).

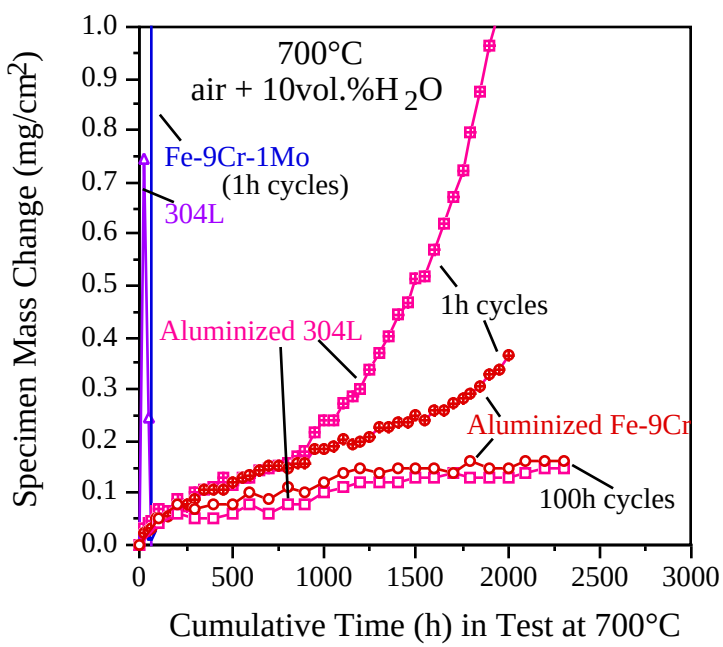

Figure 1. Specimen mass changes during 1h and 100h cycles at 700°C in air+10%H_2O.