

Protective and High-temperature Coatings

Room Town & Country A - Session MA2-2-WeM

Thermal and Environmental Barrier Coatings II

Moderators: **Fernando Pedraza**, La Rochelle University, Laboratory LaSIE, France, **Francisco Javier Pérez Trujillo**, Universidad Complutense de Madrid, Spain

8:40am **MA2-2-WeM-3 Comparison of the Protective Performance of YSZ Coatings on Austenitic Steel Under Static and Dynamic Molten Carbonate Conditions**, *M. Teresa de Miguel, Gustavo García Martín [gusgarci@ucm.es], M. Isabel Lasanta, Jaime Chaves, Francisco Javier Perez Trujillo*, Universidad Complutense de Madrid, Spain; *Pauline Audigé, Sergio Rodríguez, Alina Agüero*, Instituto Nacional de Técnica Aeroespacial (INTA), Spain

The development of protective coatings is crucial for mitigating the severe corrosion caused by molten salts operating at high temperatures in Concentrating Solar Power plants. While nitrate-based salts are currently used as thermal storage media in CSP plants, carbonate salts offer superior thermal stability. The properties of the Li-Na-K carbonate eutectic were enhanced by the addition of 0.5% of $\alpha\text{-Al}_2\text{O}_3$ nanoparticles. The new mixture presents a reduced melting point and an increase in the decomposition temperature, allowing the operation of the CSP plants at 700 °C. This increase would enhance steam generation efficiency and would reduce the Levelized Cost of Electricity (LCoE). However, the intense corrosive effects of molten carbonates demand the development of durable protective coatings to extend the lifespan of critical components.

This study evaluates the performance of yttria-stabilized zirconia (YSZ) sol-gel coatings applied to the 310H austenitic steel when it is exposed to static and dynamic conditions in a lab-scale setup. Corrosion tests were conducted at 700°C for up to 2500 hours in the eutectic ternary $\text{Li}_2\text{CO}_3\text{-Na}_2\text{CO}_3\text{-K}_2\text{CO}_3$ mixture with $\alpha\text{-Al}_2\text{O}_3$ additive. The protective behavior of the coatings was assessed through gravimetric analysis, microstructural characterization and XRD. The performance of the coated material was also compared with the uncoated substrate. The coated samples exhibited an improved corrosion resistance, whereas the uncoated steels showed substantial degradation, including detachment and high mass variation. The presence of the YSZ coating reduced the corrosion extent by over one-third, with the thickness of the corrosion products measuring approximately 200 μm - 300 μm on the uncoated substrate, and between 50 μm - 70 μm on the coated samples.

The YSZ coating exhibited very similar behavior under both dynamic and static conditions. No significant difference was observed in the thickness of the corrosion product layer. Additionally, the same multilayer structure was identified, with the outer layer mainly composed of LiFeO_2 , while the inner region was enriched in iron and chromium oxides. However, the uncoated austenitic steel showed higher degradation when exposed to dynamic conditions, displaying cracks along the corrosion layer and detachments.

These findings highlight the potential of YSZ coatings to enhance the durability of structural materials in next-generation CSP plants employing molten carbonates.

9:00am **MA2-2-WeM-4 Enhanced Oxidation Resistance of Ni substrate by Sputtered Nanotwinned $\text{Al}_9\text{SiCo}_{20}\text{Cr}_{20}\text{Ni}_{45}\text{NbMo}_4$ Medium-Entropy Alloy Thin Films at High Temperatures**, *Jun-Hui Qiu [junhui-qiu@gapp.nthu.edu.tw], Yi-Chun Yen, Fan-Yi Ouyang*, Department of Engineering and System Science, National Tsing Hua University, Taiwan

High-entropy alloys exhibit various properties, such as superior thermal stability, oxidation resistance, and corrosion resistance. These characteristics have sparked interest in using HEAs as anti-oxidation protective coatings. The nanotwinned structure within these alloys contributes to their high hardness and thermal stability, while the sluggish diffusion in high entropy alloys helps lower oxidation rates.

In this study, $\text{Al}_9\text{SiCo}_{20}\text{Cr}_{20}\text{Ni}_{45}\text{NbMo}_4$ medium-entropy alloy thin films with a nanotwinned structure were successfully fabricated using magnetron sputtering system on a nickel-metal substrate. Then, the samples were subjected to high-temperature oxidation tests at 600°C, 700°C, and 800°C for 72 hours in dry air using a thermogravimetric analyzer to investigate the high-temperature oxidation behavior of these films and their protective effects against oxidation on nickel substrates. The results demonstrated that the medium-entropy alloy films exhibited strong oxidation resistance, leading to significantly lower oxidation rates and mass gain than pure nickel. The oxidized films had smoother surfaces than bare nickel substrates, with no pores or cracks. Due to grain growth at high

temperatures, the (111) texture and nanotwinned structure in the films partially disappeared at 600°C and 700°C, although some twin structures remained. At 800°C, the twin structures were nearly absent, forming larger grains and a more pronounced (200) diffraction peak. After 24 hours of oxidation at 800°C, chromium oxide particles began to precipitate on the surface, with size and density increasing over time. At 600°C, the oxide layer on the films consisted of an inner aluminum oxide layer and an outer chromium oxide layer, mainly driven by the inward oxygen diffusion. After oxidation at 700°C and 800°C, the oxide layer evolved into a three-layer structure with an inner aluminum oxide layer, a middle chromium oxide layer, and an outer aluminum oxide layer. With prolonged oxidation time, the outer aluminum oxide layer developed an island-like structure with a discontinuous thickness. After extended oxidation at 800°C, form chromium oxide within and on the surface of the aluminum oxide. Additionally, internal oxidation of aluminum occurred inside the film.

Author Index

Bold page numbers indicate presenter

— A —

Agüero, Alina: MA2-2-WeM-3, 1
Audigé, Pauline: MA2-2-WeM-3, 1

— C —

Chaves, Jaime: MA2-2-WeM-3, 1

— D —

de Miguel, M. Teresa: MA2-2-WeM-3, 1

— G —

García Martín, Gustavo: MA2-2-WeM-3, **1**

— L —

Lasanta, M. Isabel: MA2-2-WeM-3, 1

— O —

Ouyang, Fan-Yi: MA2-2-WeM-4, 1

— P —

Perez Trujillo, Francisco Javier: MA2-2-WeM-3, 1

— Q —

Qiu, Jun-Hui: MA2-2-WeM-4, **1**

— R —

Rodríguez, Sergio: MA2-2-WeM-3, 1

— Y —

Yen, Yi-Chun: MA2-2-WeM-4, 1