Conductive and water vapor-resistant coatings for SOFC interconnects

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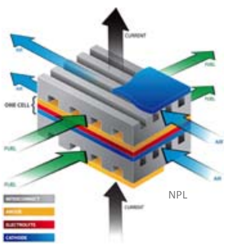
Motivation

Modern Solid Oxide Fuel Cells (SOFC) work at temperatures between 600 and 800ºC. Such temperatures allow to use ferritic-martensitic steels as a material for interconnects, having several advantages compared to ceramic materials. But two major issues are associated with the use of these steels:

- Evaporation of volatile chromium species from the chromium oxide scale due to the presence of water vapor, which leads to poisoning of the cathodes.
- Electrical resistance, which increases over time due to continuous oxidation at elevated temperatures.



Planar Solid Oxide Fuel Cell

Coatings are usually needed to avoid such cathode poisoning and resistance increase

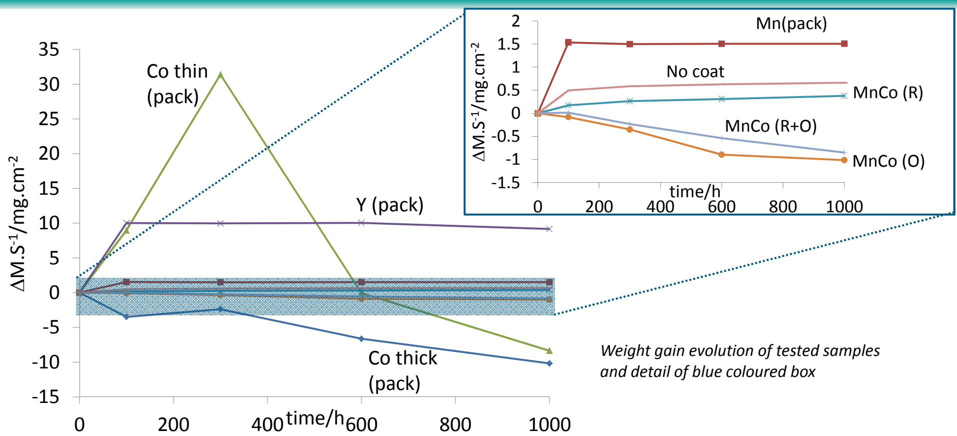
- Overlay coatings: Typically deposited by APS or paste screen printing of conductive ceramics.
- Diffusion coatings: CVD, slurry deposition, or electroplating of metals that form conductive ceramics after heat treatment.
- Main difficulties associated with such coatings are the costs of ceramics production or the difficulty to obtain dense and thin coatings.

Experimental procedure

- $MnCo_2O_4$ is the most common **spinel coating** due to its high electrical conductivity, phase stability, and thermo-mechanical properties [1]
- Reactive elements containing **perovskites** show long stability, high capacity to incorporate Cr, and high electrical conductivity [2]
- **Spinels and perovskite coatings will be deposited by pack cementation (derived from CVD) and slurry deposition of metals or ceramics onto Fe-Cr steels (from 9% to 22%)**

Identification	Coating material	Deposition method	Heat treatment	Targeted coating
Co thick	Co	Pack cementation	1050°C/Ar-H_2(5%)	$(CoCr)_3O_4$
Mn	Mn			$(MnCr)_3O_4$
Co thin	Co		800°C/Ar-H_2(5%)	$(CoCr)_3O_4$
Y	Y			$YCrO_3$
MnCo (R)	$MnCo_2O_4$	Slurry		$(MnCrCo)_3O_4$
MnCo (O)			1000°C/Air	
MnCo (R+O)			800°C/Ar-H_2(5%) +Air	

Results



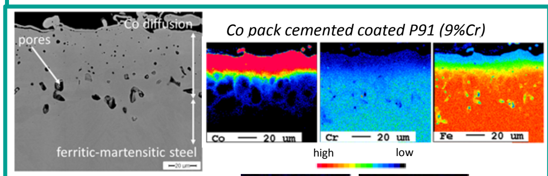
Weight gain evolution of tested samples and detail of blue coloured box

Pack cemented coatings

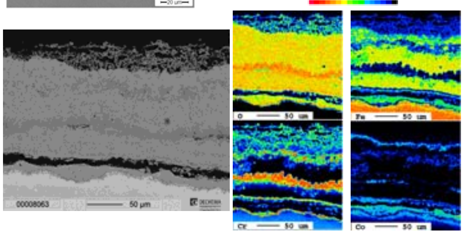
- Co diffusion coatings show the highest weight gains followed by spallation of the scale
- Y diffusion coating shows very high weight gain but no scale spallation
- Mn pack cemented coating shows the lowest weight gain and no scale spallation

Slurry coatings

- $MnCo_2O_4$ overlay coating following a redox process as well as coatings sintered at high temperature in air show adhesion loss
- $MnCo_2O_4$ overlay coating heat treated under reducing atmosphere shows the lowest weight gain with no adhesion loss



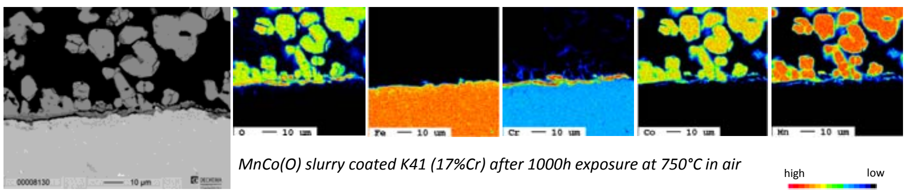
Co pack cemented coated P91 (9%Cr)



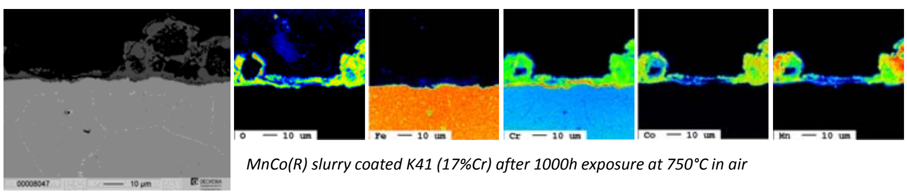
Co pack cemented coated K41 (17%Cr) after 1000h exposure at 750°C in air

Co-based pack cemented coatings

- In order to increase Co activity during the coating process high amounts of activator are needed which promote “active oxidation” of the coating during its exposure at SOFC oxidative conditions



MnCo(O) slurry coated K41 (17%Cr) after 1000h exposure at 750°C in air



MnCo(R) slurry coated K41 (17%Cr) after 1000h exposure at 750°C in air

Co-based slurry coatings

- Spinels sintered under oxidizing conditions contain lower Cr quantities than those sintered totally or partially under reductive conditions

Prospects

- MnCo coatings are the most promising candidates.
- Co diffusion coatings by pack cementation has provoked accelerated substrate oxidation of interconnect materials.
- In order to reduce costs coatings will be manufactured by deposition of metallic particles via slurry application.

[1] T. Kiefer,”Entwicklung neuer Schutz- und Kontaktierungsschichten für Hochtemperatur-Brennstoffzellen“ PhD. Fakultät für Maschinenbau der Ruhr-Universität Bochum, 2007
[2] S. Fontana, R. Amendola, S. Chevalier, P. Piccardo, G. Caboche, M. Viviani, R. Molins, M. Sennour, *J. Power Sourc.*, 171, 2007, 652–662

Acknowledgment

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