High Throughput, In-line Coating Metrology Development for Solid Oxide Fuel Cell (SOFC) Manufacturing

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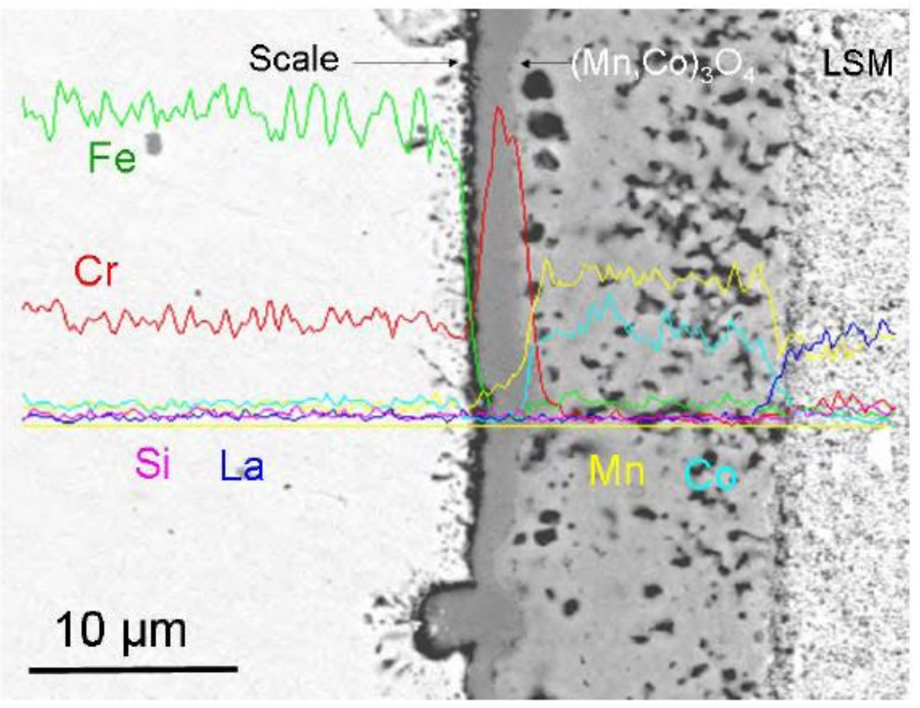
Introduction

Coating and interconnect cross-section



PNNL report ID: PNNL- 17568, May 2008

Protective coating on interconnect:

- Prevent electrode Cr poisoning: Barrier to Cr transport
- Prevent interconnect oxidation: Barrier of oxygen migration

$(Mn,Co)O_4$ (MCO) is a commonly used barrier coating layer

Coating defects inhibit SOFC performance and stability

→ Need manufacturing-scale defect detection techniques

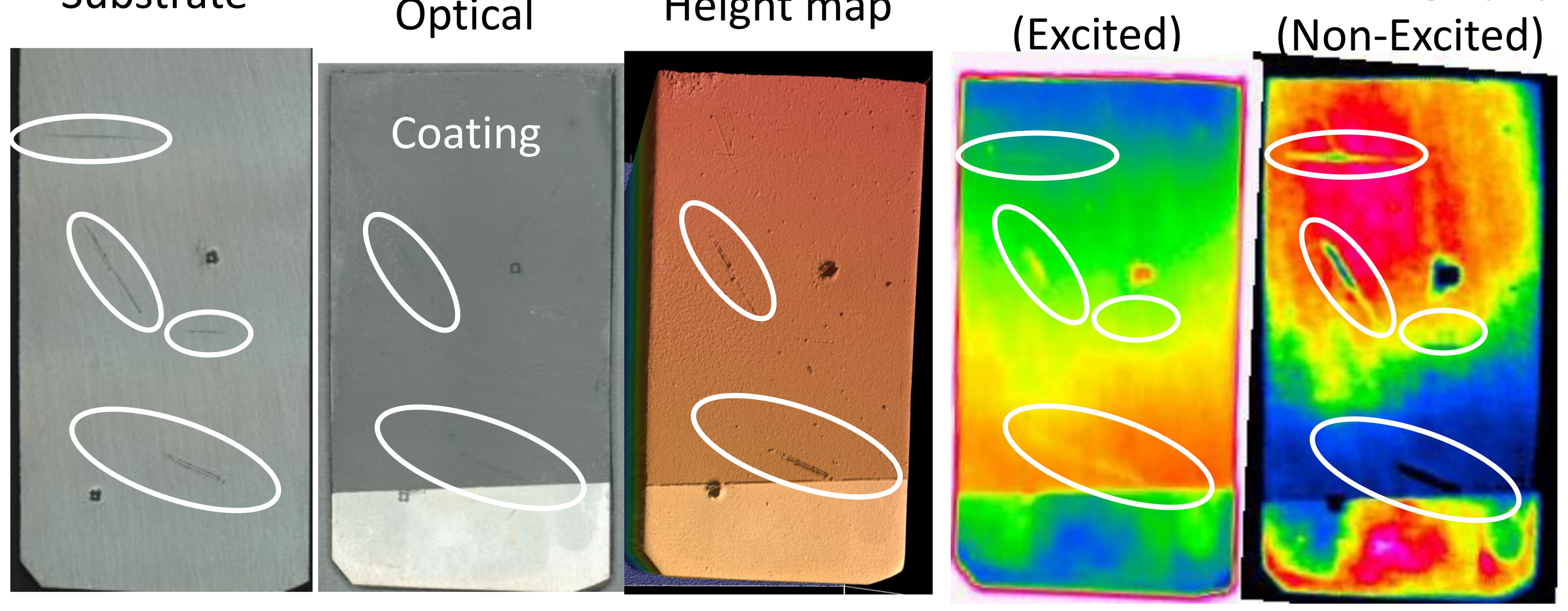
Project Goals and Approach

- *Identify key interconnect coating and substrate defects that lead to coating failure;*
- *Assess capabilities of in-line metrology techniques, e.g., optical profilometry (Redox) and thermography (NREL), to probe defects;*
- *Demonstrate improved long-term performance of SOFC stacks*

Technique	Measured parameter	Automation for interconnect	Speed for large area scan	Non-destructive
Optical Profilometry	Cracks, pores, film uniformity	Yes	Fast	Yes
Optical Reflectance	Cracks, pores, film uniformity	Yes	Fast	Yes
Thermography	Cracks, pores, film uniformity, subsurface defects	Yes	Fast	Yes

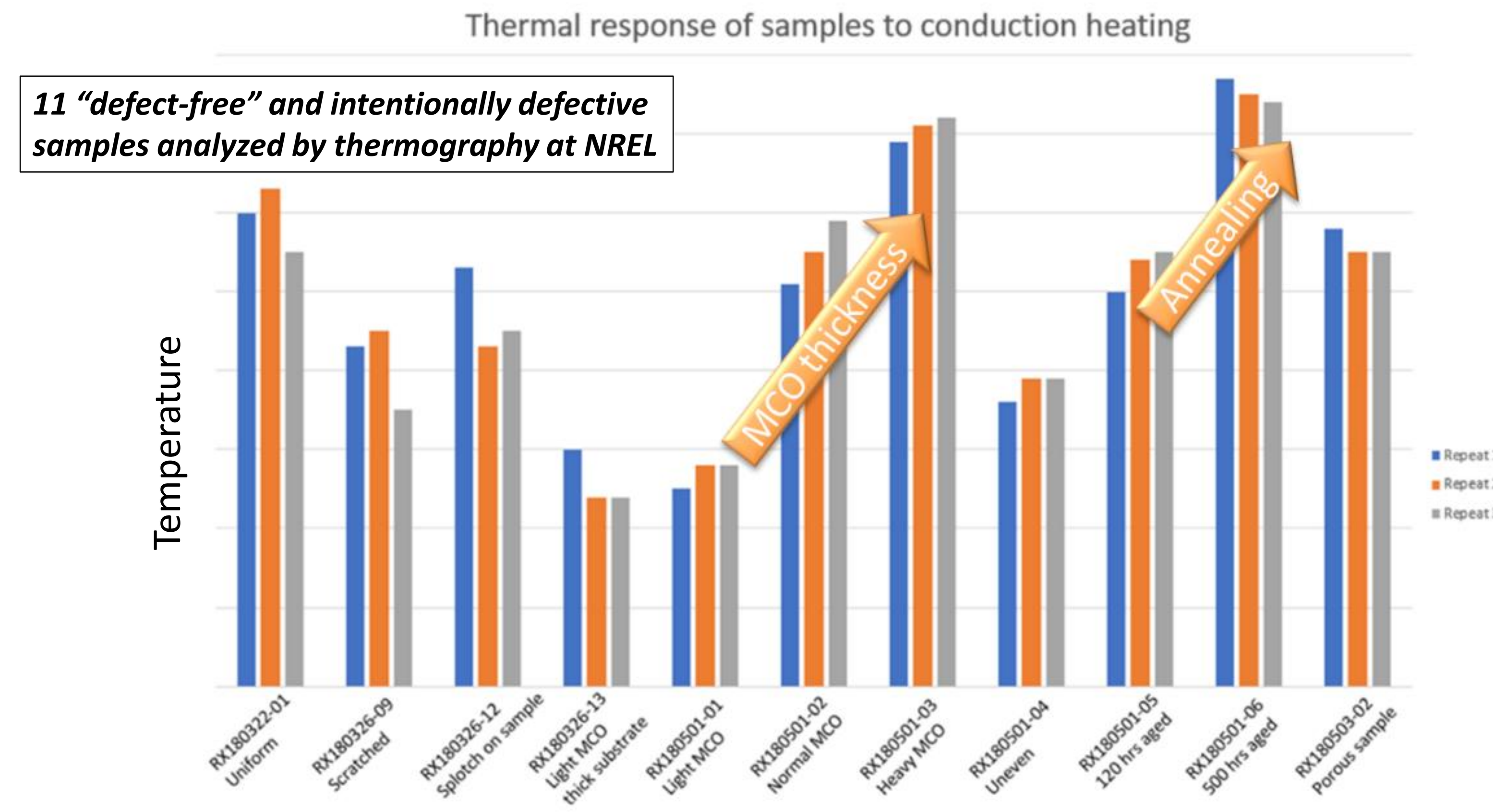
Results

Metrology of sample with intentional scratches in substrate



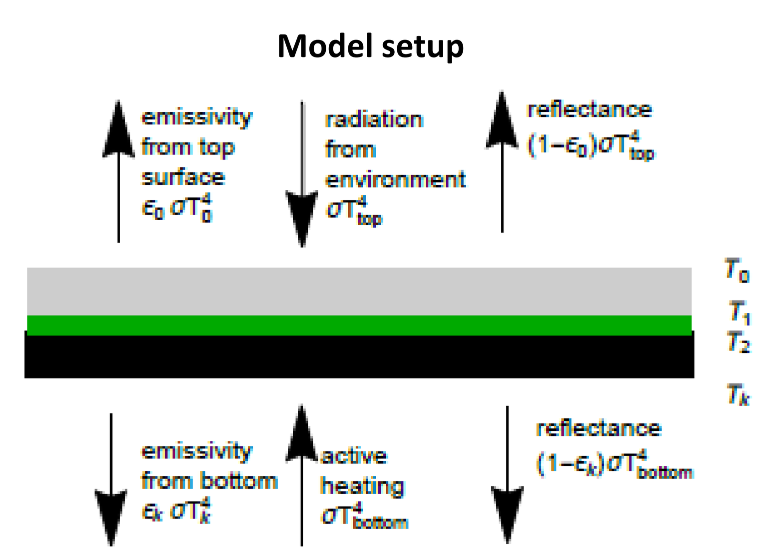
- *Thermography detects all 4 scratches*
- Spatial variation in IR images even when there is no thermal excitation
- Thermal map "reversal" when a specimen is excited vs. non-excited

Trends observed in thermal responses



- Trends in thermal responses with extent of defects (e.g., thin vs. thick samples) observed
- Variations recorded in thermal response across individual samples observed, indicating some change in morphology and/or composition

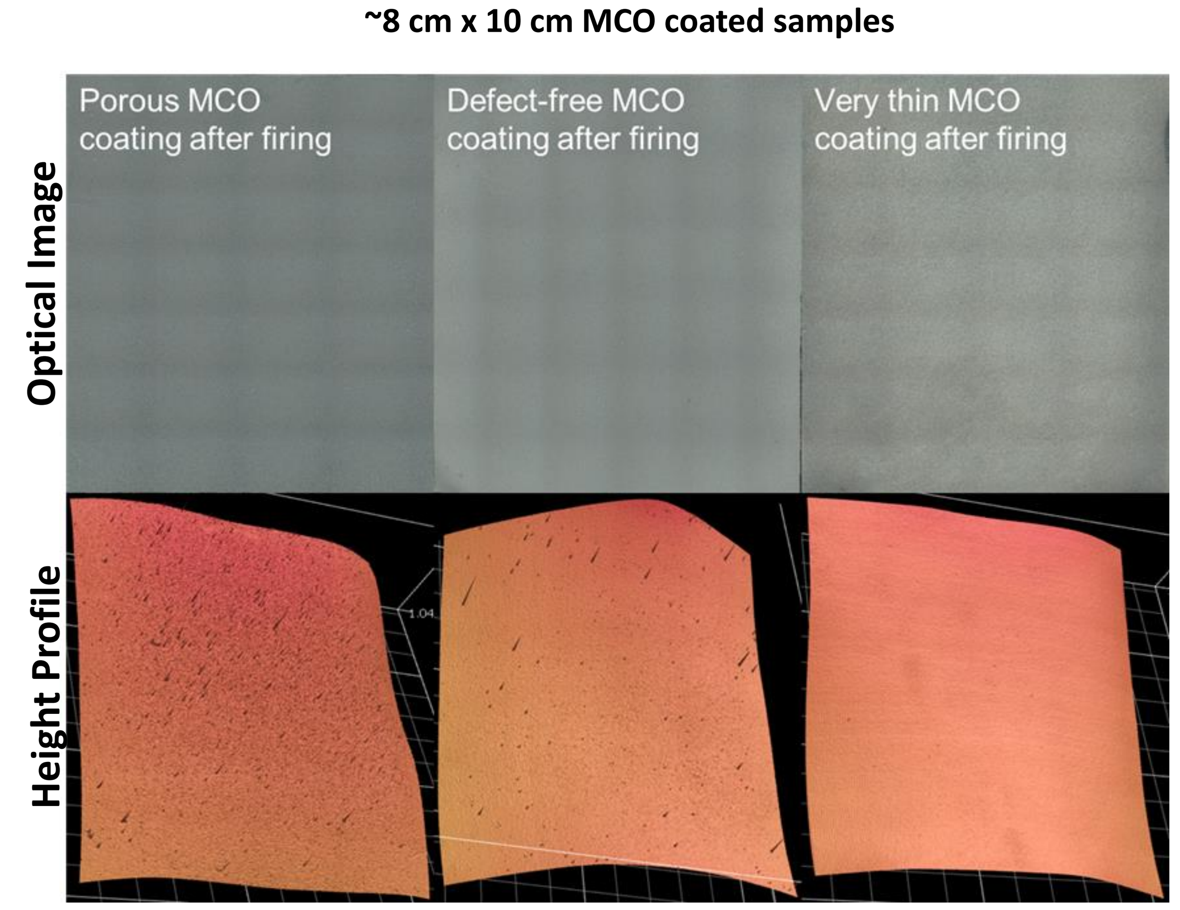
Modeling of thermography data



- Thermal response dominated by surface properties of film (e.g., emissivity and reflectance)
- Thermal map reversal due to thermal reflectance from higher environment temperature above sample
- Currently evaluating model assumptions and investigating new measurement techniques (e.g., transient stimulation)

Optical imaging detects porosity and thin intentional defects

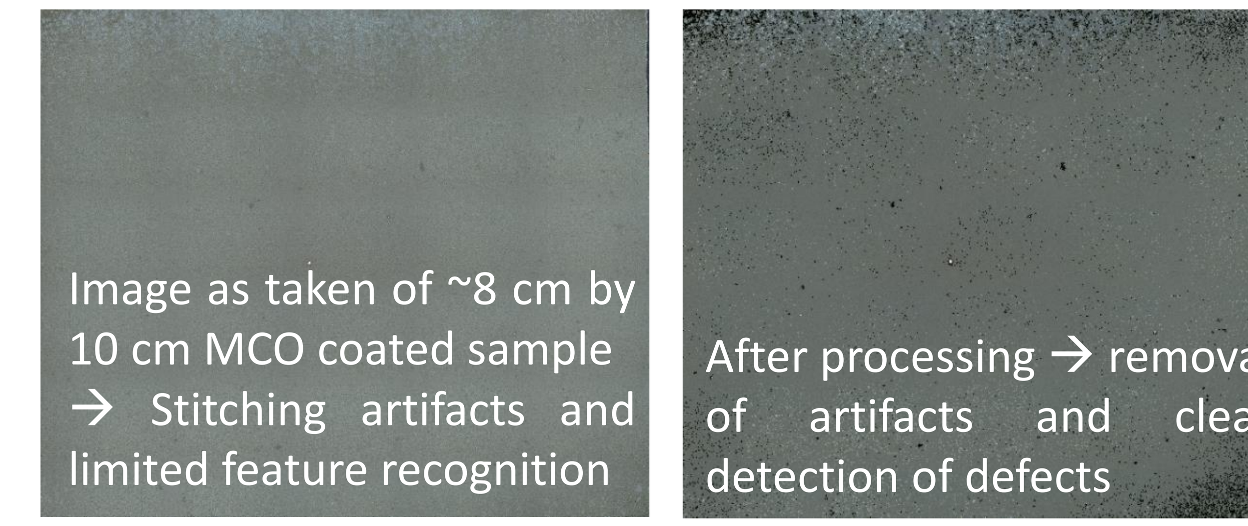
~8 cm x 10 cm MCO coated samples



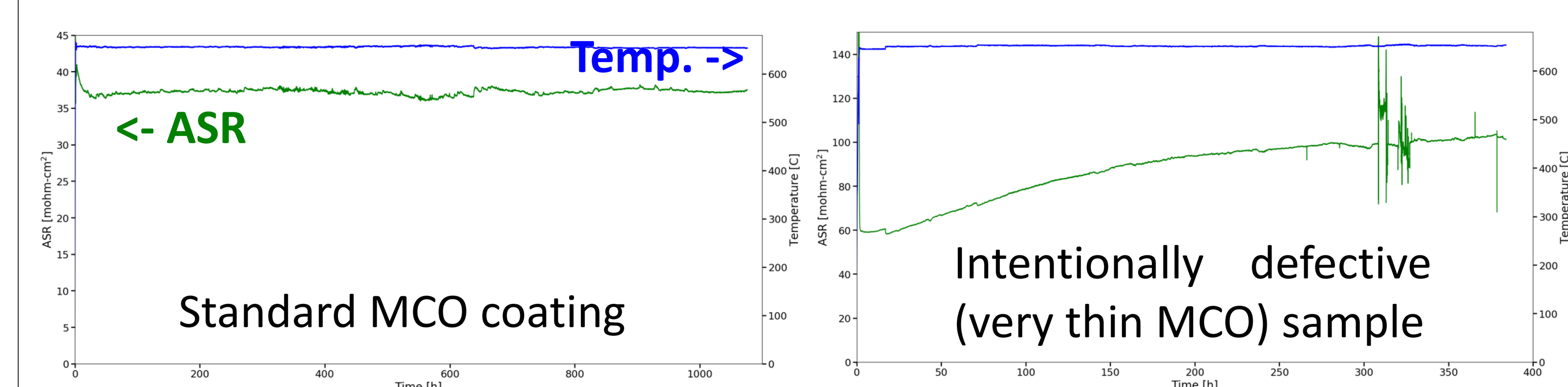
- Less homogeneity detected in thin coatings as compared to "defect-free" coating
- High to low roughness trend (porous > "defect-free" > thin coatings) detected
- High throughput optical techniques able to detect defective samples

Image analysis development

Software tool development for automated defect detection



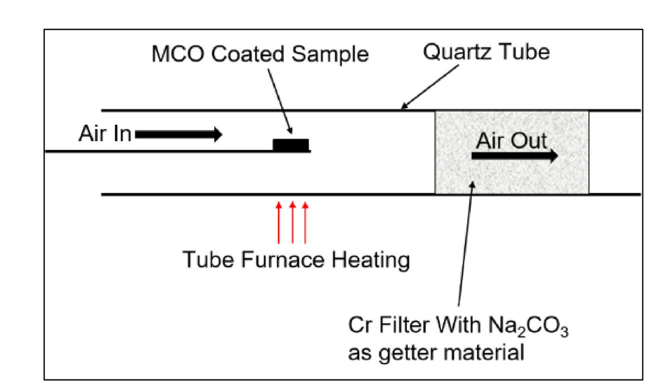
Area-specific-resistance (ASR) measurement of coating



- Standard MCO coating has ASR <50 mΩ-cm^2 for >1,000 hours at 650 °C
- Thin coating has high ASR and porous coating (not shown) has low ASR
- High porosity may lead to more Cr volatilization in porous coating

Cr volatility measurements

Detection of Cr volatility through defective and non-defective MCO coatings



Future Work

- Evaluate Cr volatility from defect-free and defective MCO coated samples
- Perform SOFC performance test with MCO coated interconnects
- Demonstrate scale-up of defect detection techniques to in-line manufacturing conditions

Summary and Conclusions

- Trends in thermal responses with extent of defects (e.g., thin vs. thick samples) observed
- Variations recorded in thermal response across individual samples observed, indicating some change in morphology and/or composition
- Porosity variation observed via roughness change
- Intentionally thin coating shows unacceptable ASR
- Intentionally highly porous coating exhibits low ASR, however, Cr volatility may be high

Acknowledgement

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