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High Surface Area Getter Materials for Chromium and Sulfur Capture in SOFC Systems

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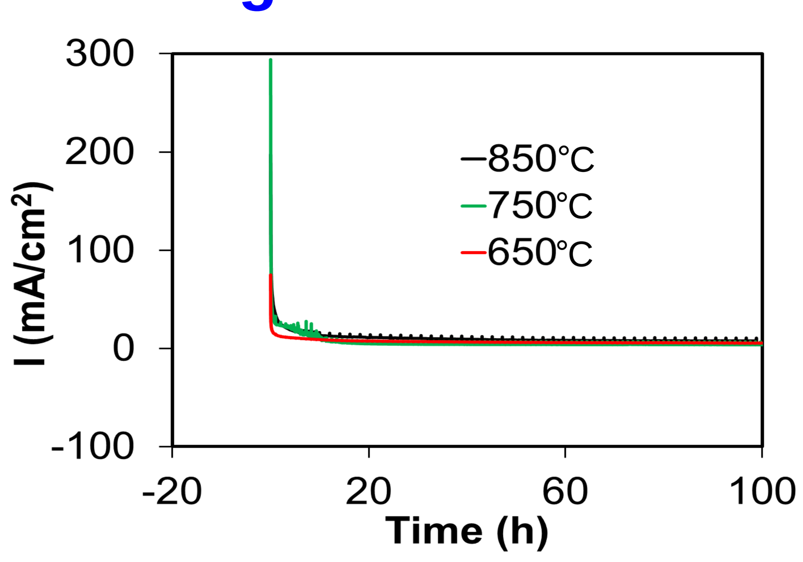
Abstract: Trace levels of chromium and sulfur present in the oxidant gas leads to permanent performance degradation in the cathode of the solid oxide fuel cell. To mitigate the cathode degradation, solid state getters are being designed, fabricated and tested. High surface area (HSA) nanofibers (nanorods) getter materials with micro channels and nano and meso architectures have been synthesized and characterized by XRD, SEM, and TEM techniques. Initial electrochemical tests show that the use of getters prevent the cathode poisoning and electrical performance degradation. Initial test results along with observations on structural characterization has been presented.

Background: Chromium vapor species {$CrO_2(OH)_2$, CrO_3, etc.} originating from BoP components and metallic interconnects poison cathode performance by the formation of $(Mn,Cr)_3O_4$ /$SrCrO_4$ and deposition of Cr_2O_3 at triple phase boundaries (TPB). SOFC cathode degrades rapidly after TPBs are blocked. Our recent studies shows that the chromium poisoning gets worse at high operating temperatures (~850°C) and that chromium poisoning effect is also observed at low operating temperatures (~650°C).

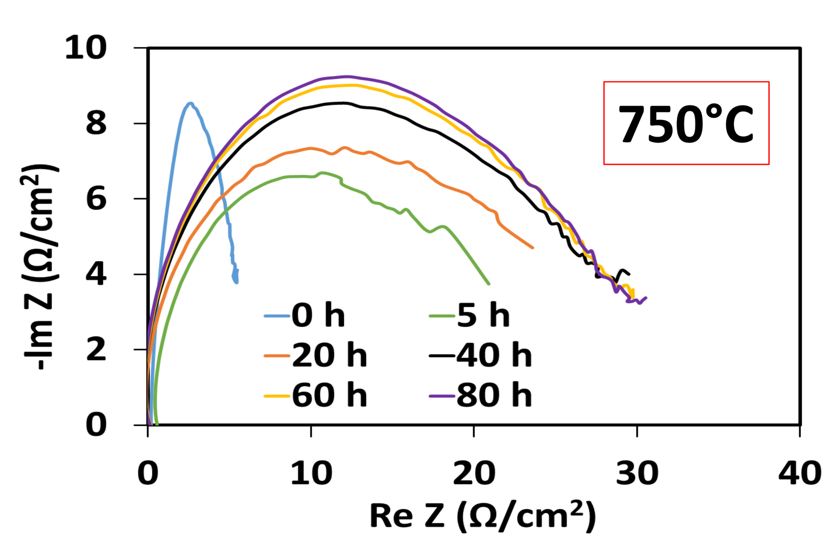
Objective:

- Develop high surface area getters to increase the efficiency of chromium capture and mitigate cathode degradation.
- Electrochemically validate the efficacy of developed chromium getters with high surface area coatings.
- Characterize pretest and postreaction getters and develop chromium capture mechanism.

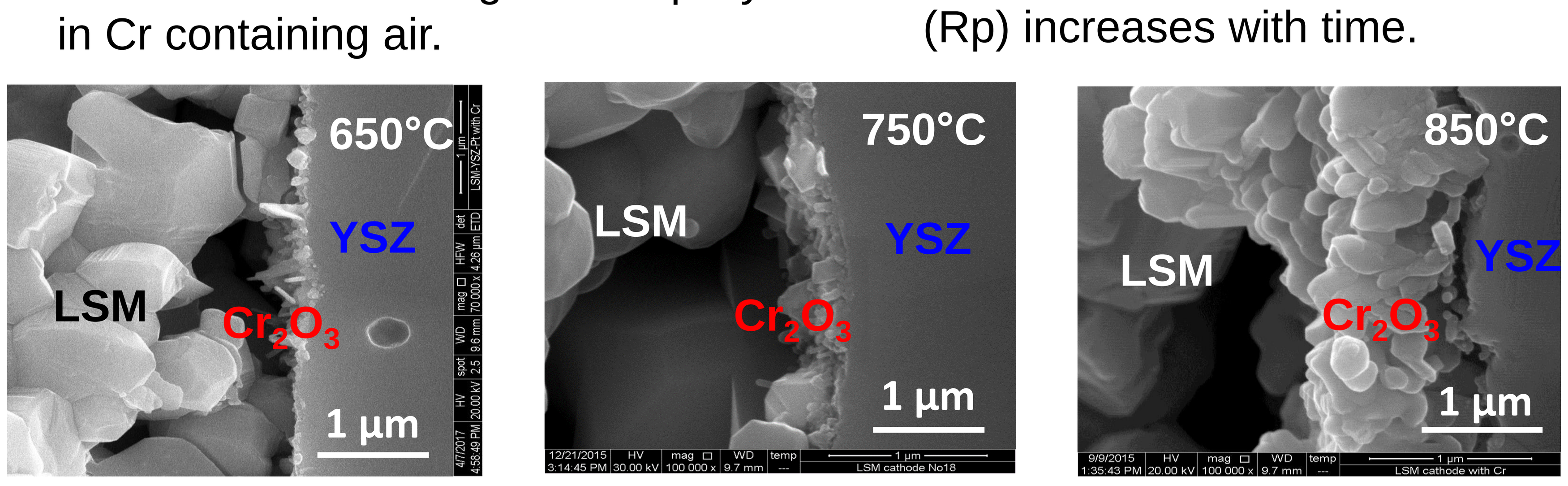
SOFC Degradation Under Exposure to Cr Vapors



- LSM‖YSZ‖Pt cells degraded rapidly in Cr containing air.



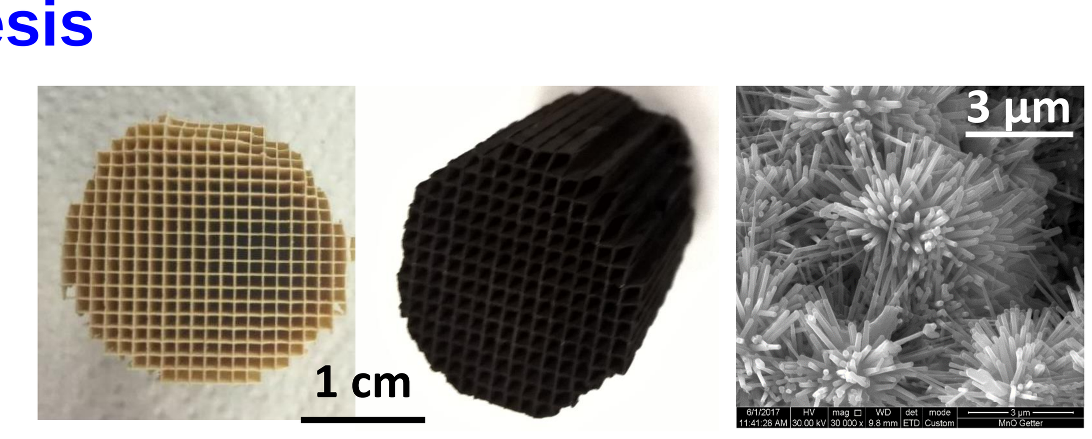
- Cell polarization resistance (Rp) increases with time.



- **SEM images** show that the thickness of Cr_2O_3 layer in the LSM‖YSZ‖Pt cells increases with operating temperature.

HSA Materials Synthesis

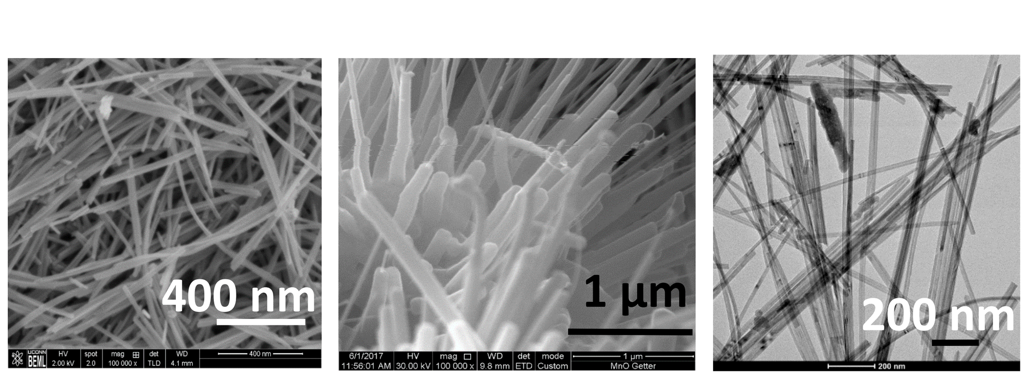
MnO_2 synthesis by Microwave method
↓
Second layer by Impregnation
↓
Calcination at 650-900°C



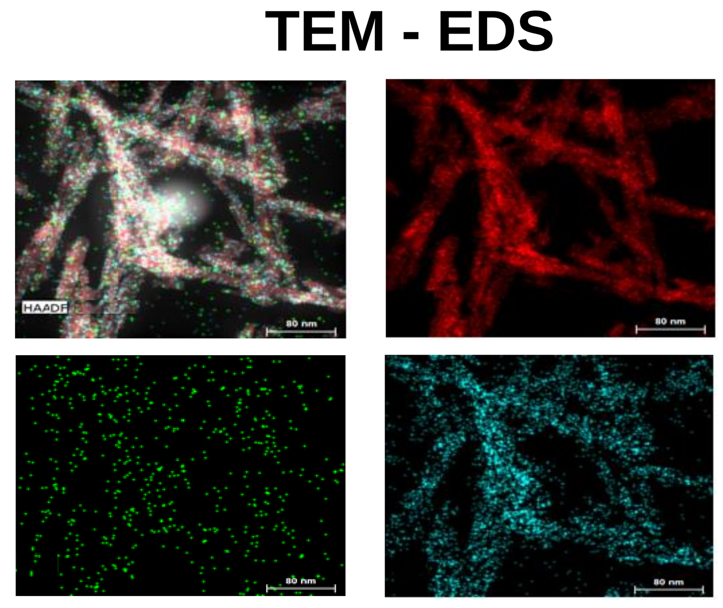
Support **Getter** **Nanofibers**

- Nanofiber coating materials have a high surface area of ~20-65 m²/g with a porous microstructure.

Getter Materials Characterization



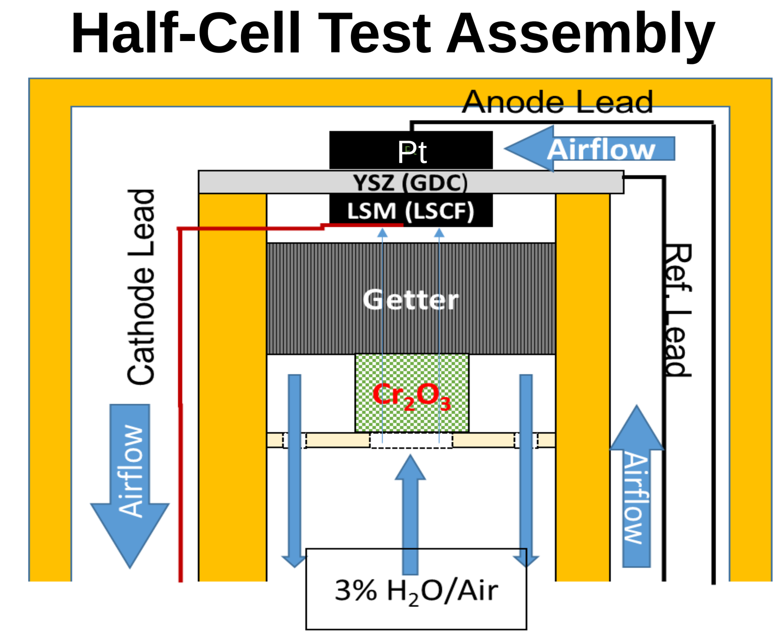
TEM - EDS



- High surface nanofibers with uniform coating of active components.

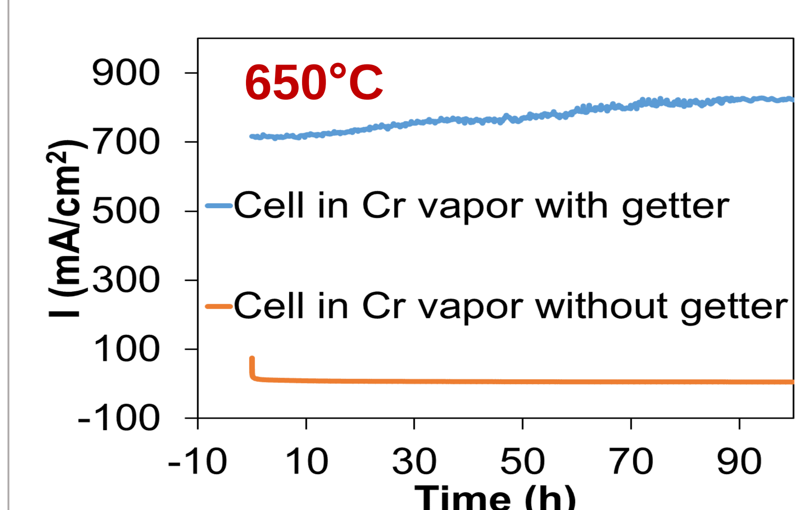
Validation of HSA Getters using Half-Cell Tests

Half-Cell Test Assembly

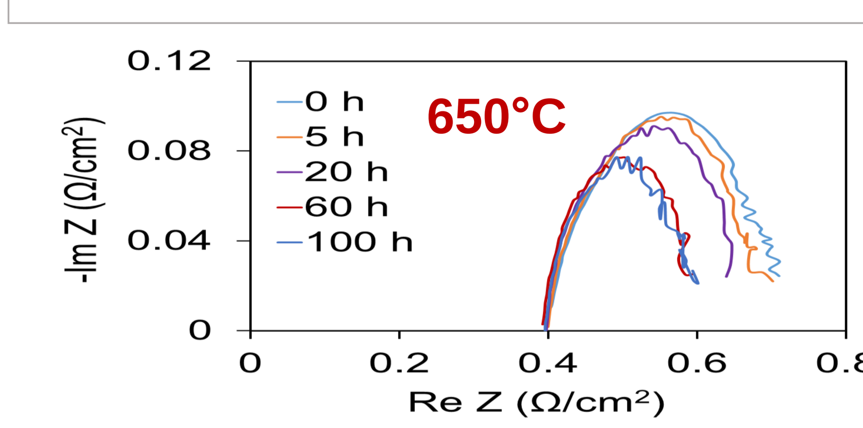


- Accelerated SOFC degradation testing with pure Cr_2O_3 pellets and a flow rate of 150 sccm in a 1" tube.

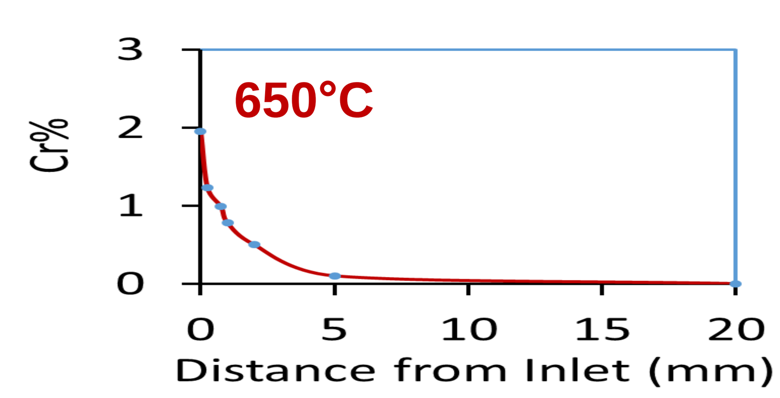
Electrochemical Performance



- Stable performance was achieved with a getter compared to fast degradation without a getter.

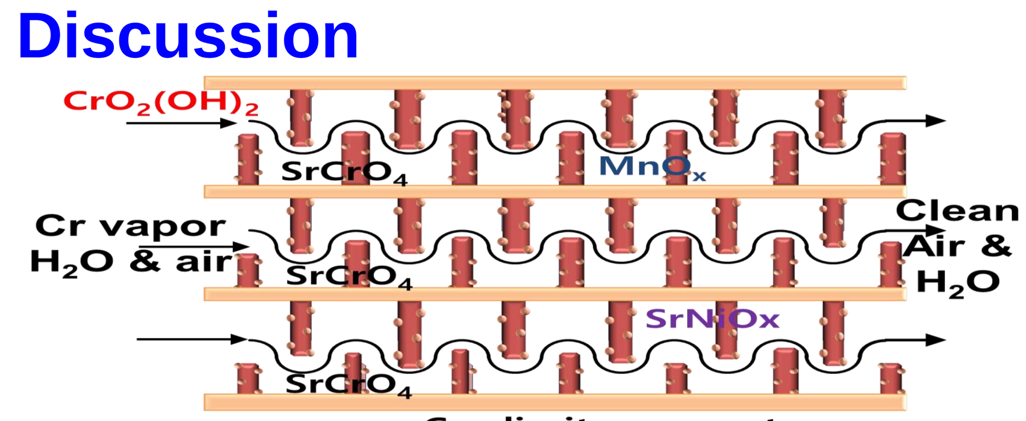


- EIS spectra show that Rp keeps stable after cathode activation.



- Getter captures Cr within 5 mm.

Discussion



Getter efficiency determined by:

- Active compositions
- High surface Area
- Optimal microstructure
- Turbulent flow patterns

$$CrO_3\ (g) + Sr_xNi_yO_z\ (s) = SrCrO_4\ (s) + NiO\ (s)$$

$$CrO_2(OH)_2\ (g) + SrO.MnO = MnO_2\ (s) + SrCr_2O_4\ (s) + H_2O\ (g)$$

Summary

- HSA getter materials have been synthesized for Cr capture.
- Electrochemical testing of getters in LSM‖YSZ‖Pt half-cells have validated that the developed HSA Cr getters are effective in capturing chromium vapor species.

References

- B Hu and P Singh et al., *Inter. J. Hydrogen Energy* 2017, 30, 1-9.
- SY Chen and SL Suib et al., *ACS Appl. Mater. Interfaces* 2016, 8, 7834–42.

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