Mitigation of Cathode Poisoning Using Chromium Getters

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Abstract: Gas phase chromium contaminants, originating from the metallic cell to cell interconnect and balance of plant (BoP) components, is one of the major causes for cathode degradation in solid oxide fuel cell (SOFC) power systems. Details of chromium gettering technique, which has effectively mitigated the cathode poisoning by capturing the chromium vapor before it reaches to the electrochemically active lanthanum strontium manganite(LSM) cathodes. Comparable experiments conducted up to 300 hours have showed that the half-cells in the presence of a chromium getter and chromium vapor remain stable similar to the half-cell in absence of Cr vapors and a getter. Sintered Cr_2O_3 granules were used as constant chromium source. The validation tests at different cathode flow rates between 50-500 sccm have been completed. EIS, XRD, FIB-TEM, and SEM-EDS techniques have been employed for the characterization of the pretest and posttest samples. SEM-EDS data show that the chromium is captured by the getter within a short distance of 2-5 mm during 100-300 hours tests and no chromium species is detected on the posttest lanthanum strontium manganite (LSM) cathode. Mechanisms of chromium poisoning and capturing is discussed.

Background:

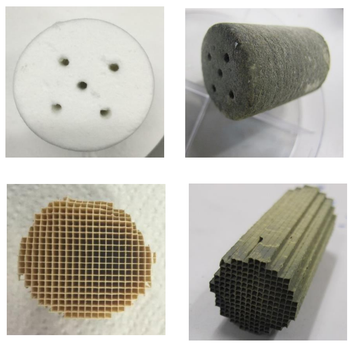
LSM serves as the state-of-the-art SOFC cathode. Chromium vapor species {$CrO_2(OH)_2$, $CrO(OH)_2$, CrO_3} originating from BoP components as well as metallic interconnects poison LSM cathode by the reaction and formation of $(Mn,Cr)_3O_4$ /$SrCrO_4$ and deposition of Cr_2O_3 at triple phase boundaries (TPB). SOFC cathode degrades rapidly after TPBs are blocked. In this study, *in-operando* electrochemical validation of the chromium getters has been performed through monitoring the cathode performance and posttest characterization.

Objective:

- Develop cost effective getter to mitigate LSM cathode degradation caused by chromium poisoning.
- Electrochemically validate the efficacy of developed chromium getters.
- Characterize getter and develop gettering mechanism.

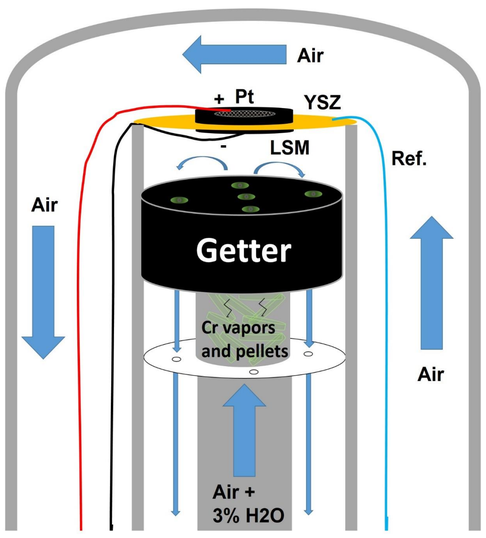
Experimental Approaches

Support **Getter**



Getter material	$Sr_xNi_yO_z$ compound
Materials synthesis	Dip-coating supports in aqueous solution of $Sr(NO_3)_2$: $Ni(NO_3)_2$ (3:2 mole). Calcined at 600ºC for 6 h.
Substrate	Cordierite/ Alumina fiber board
Substrate dimension	2” (length), 0.8”-1” (dia.)

Symmetric cell configuration

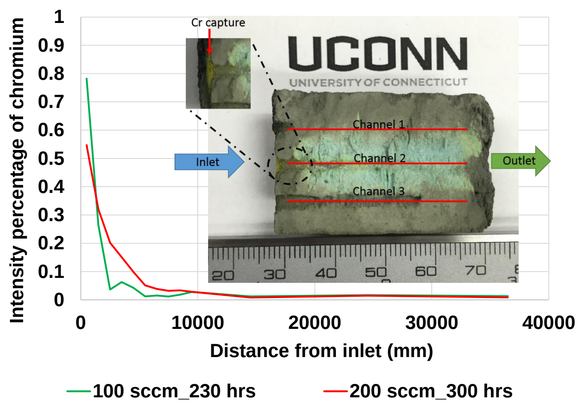


Symmetric cell	LSM/YSZ/Pt
Cr source	Cr_2O_3 pellets
Cr. Getter	$Sr_xNi_yO_z$ over Cordierite/Alumina fiber board support
Temperature	850°C
Time	100 - 300 hours
Cathode atmosphere	Air - 3% H_2O, 50-500 sccm

Characterization of Chromium Getters

SEM - EDS

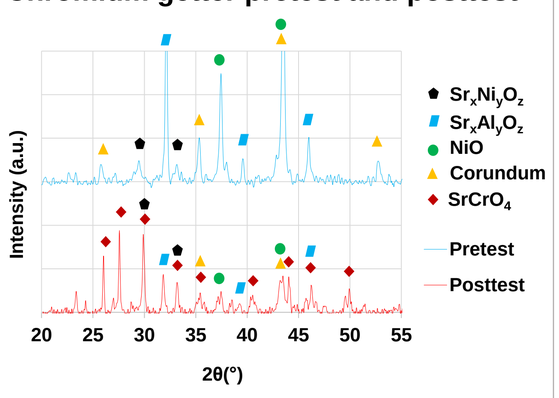
Flow rate effect on chromium profile



- The getter material captures chromium species within 2-5 mm from inlet.

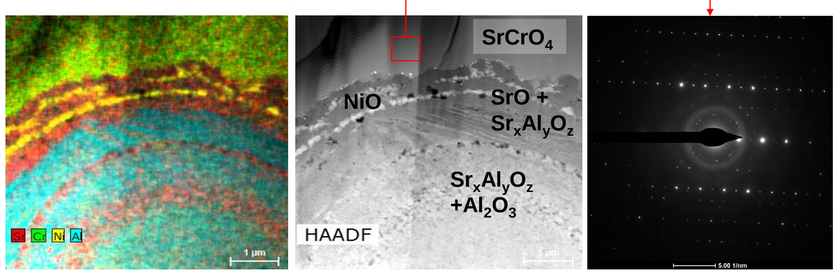
XRD

Chromium getter pretest and posttest



- Stable compounds are formed due to reaction of getter material, substrate, and Cr vapors

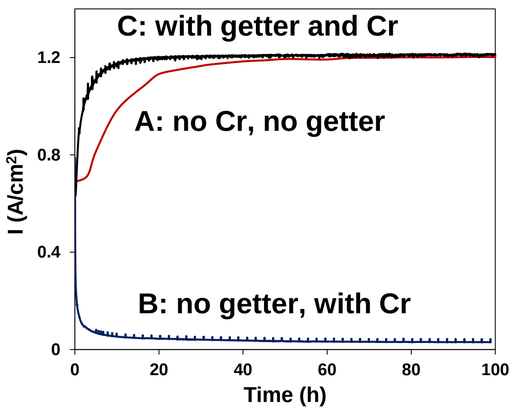
TEM – FIB Analysis



- $SrCrO_4$: formed due to reactions of Cr vapors with $Sr_xNi_yO_z$. NiO is exsolved after.

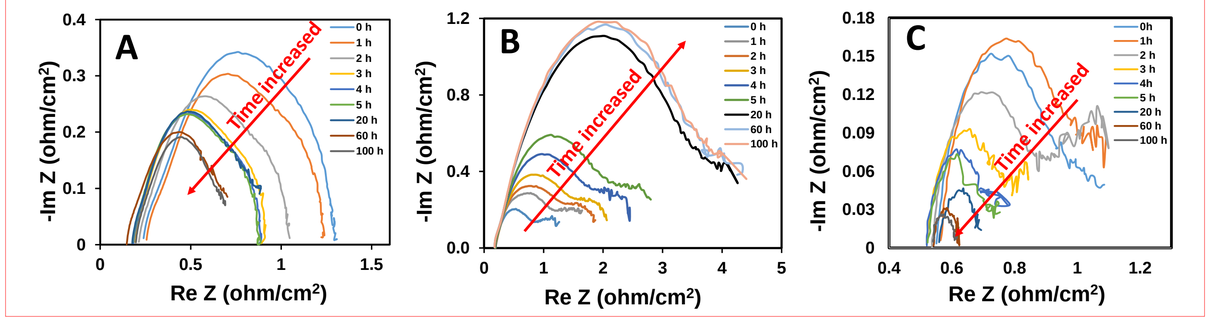
Results: Half- cell tests

I-t curve

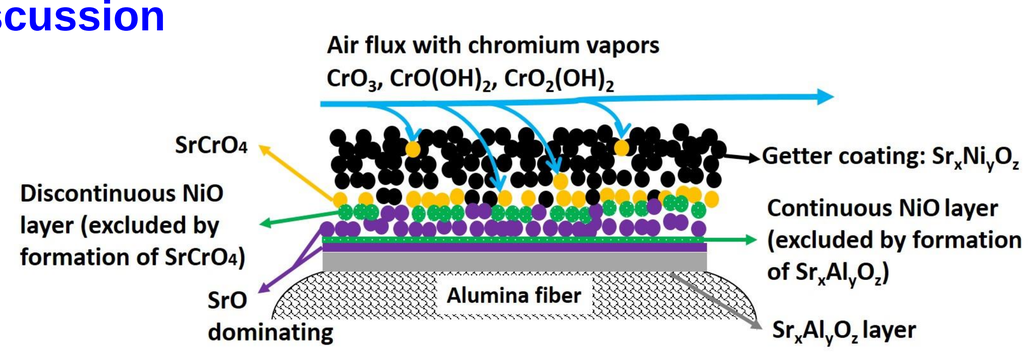


- **I-t curve**: A&C – typical I-t curves show stable performance; B: rapid performance drop within the first few hours of the test
- **EIS:** A&C – Semi-circles shrank with time indicating the cathodic activation; B: Semi-circles stretched with time, indicating an increase of polarization resistance with exposure time in Cr vapor.

EIS



Discussion



$$CrO_3\ (g) + Sr_xNi_yO_z = SrCrO_4 + NiO + O_2\ (g)$$

$$CrO_2(OH)_2\ (g) + Sr_xNi_yO_z + O_2\ (g) = SrCrO_4 + NiO + H_2O\ (g)$$

Summary

- Electrochemical testing of getters in LSM/YSZ/Pt symmetric cells has validated that the developed Cr getters are effective in capturing chromium vapor species.
- Stable compounds form due to interaction between getter and Cr vapors.

Acknowledgements

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