DEVELOPMENT OF CERAMIC INTERCONNECT MATERIALS

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MOTIVATION

Challenges of Acceptor-doped Lanthanum Chromite
•Inferior Sintering Behavior
•Reactivity with YSZ Electrolyte
(Formation of Lanthanum Zirconate)

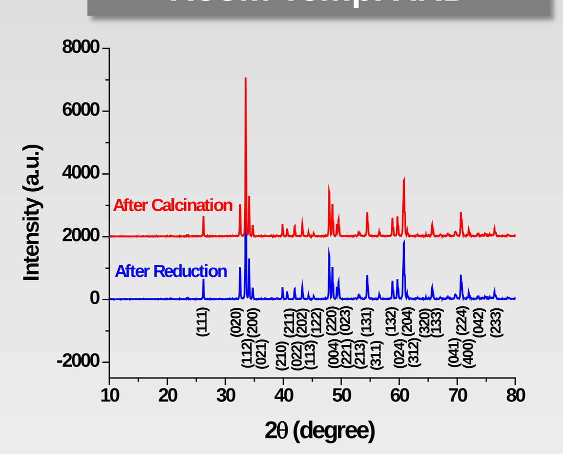
GOALS

Develop Ceramic Interconnect Materials with
•Chemical & Dimensional Stability
•High Electronic & Low Ionic Conductivity
•Improved Sintering Behavior
•Thermal Expansion Match
•Chemical Compatibility with Other Components
Through Doping Yttrium Chromite with calcium on A-site and Transition Metals on B-site

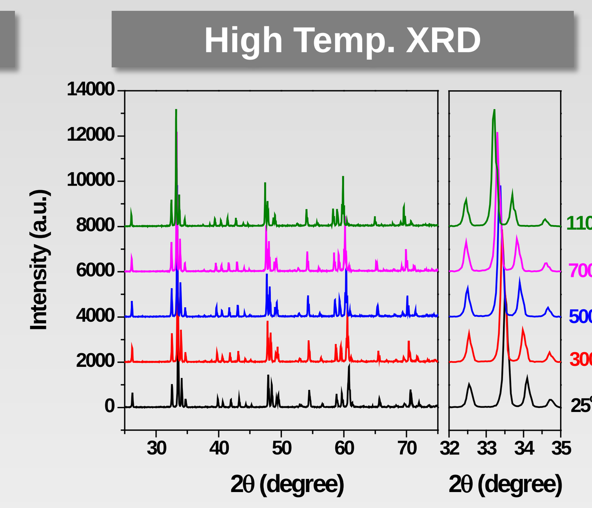
CHEMICAL STABILITY

$Y_{0.8}Ca_{0.2}Cr_{0.85}Co_{0.1}Ni_{0.04}Cu_{0.01}O_3$

Room Temp. XRD



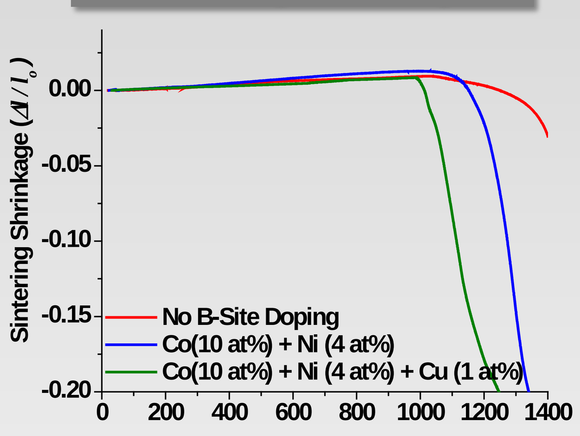
High Temp. XRD



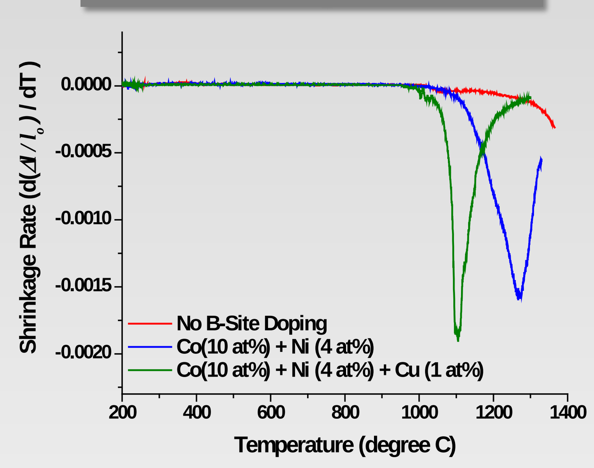
• Single Phase Orthorhombic Perovskite Structure ($25^oC<T<1100^oC$, $10^{-20}atm<p_{O2}<1atm$)

SINTERING BEHAVIOR

Sintering Shrinkage



Shrinkage Rate



• Dilatometry Measurements
• Co- and Ni-doping improves sinterability.
• Small addition of Cu (~1%) remarkably enhances sinterability.

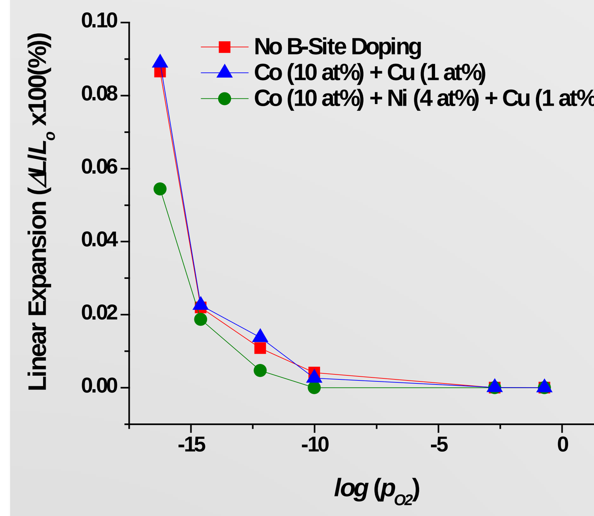
THERMAL EXPANSION

Composition	TEC (X10⁶)
No Dopant	9.7
10% Co	10.8
10% Ni	10.0
10% Co, 4% Ni, 1% Cu	11.1
15% Co, 4% Ni, 1% Cu	12.5
15% Co, 10% Ni, 1% Cu	13.8
$La_{0.8}Ca_{0.2}CrO_3$*	10.05
8 mol% YSZ**	10.9

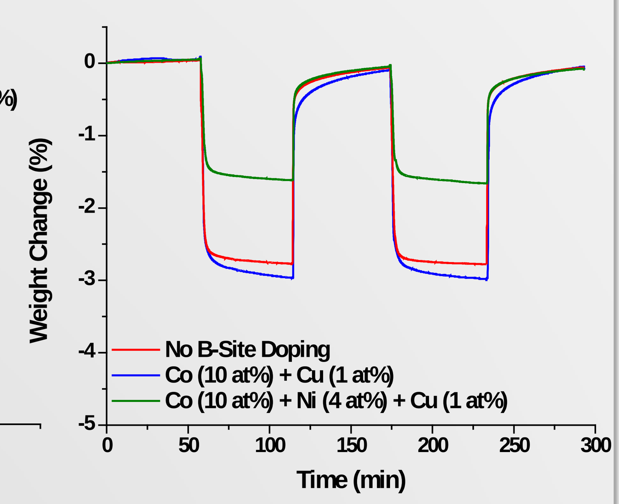
• Co- and Ni-doping increases TEC.
• TEC can be controlled by adjusting B-site doping.

DIMENSIONAL STABILITY

Chemical Expansion



Isothermal TGA



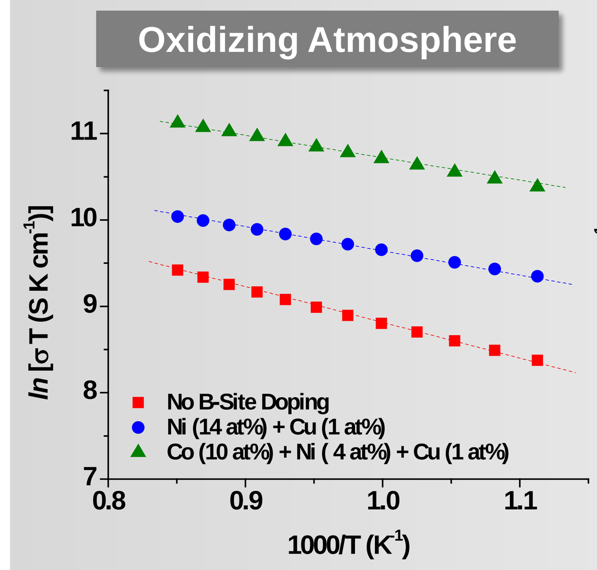
Reduced Chemical Expansion and improved dimensional stability with Ni-Doping

Suppressed Oxygen Evolution and Stabilized Defect Structure in Reducing Environments

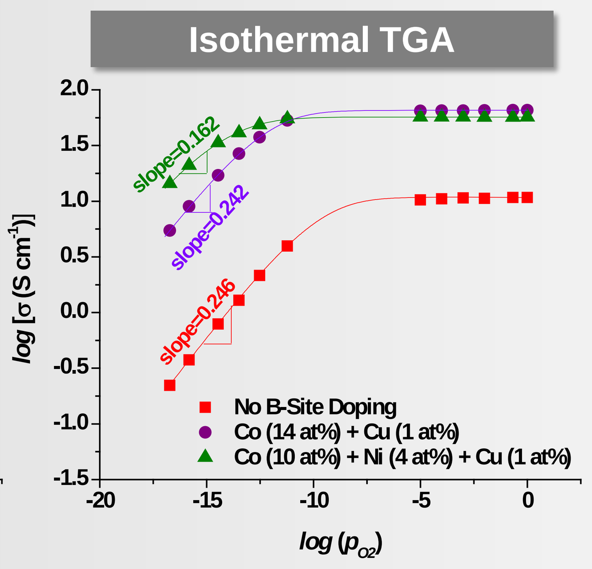
• Co- and Cu-doping has negligible effect on the chemical expansion and the amount of oxygen loss.

ELECTRICAL CONDUCTIVITY

Oxidizing Atmosphere



Isothermal TGA



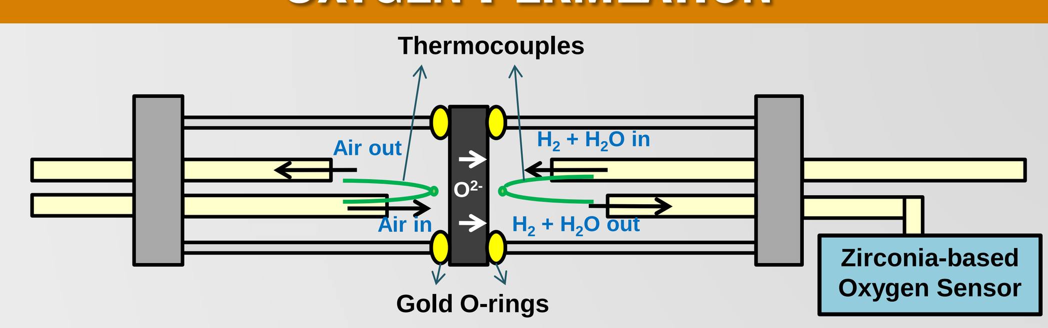
• Co-doping improves conductivity in oxidizing atmosphere.

• Ni-doping improves conductivity in reducing atmosphere.

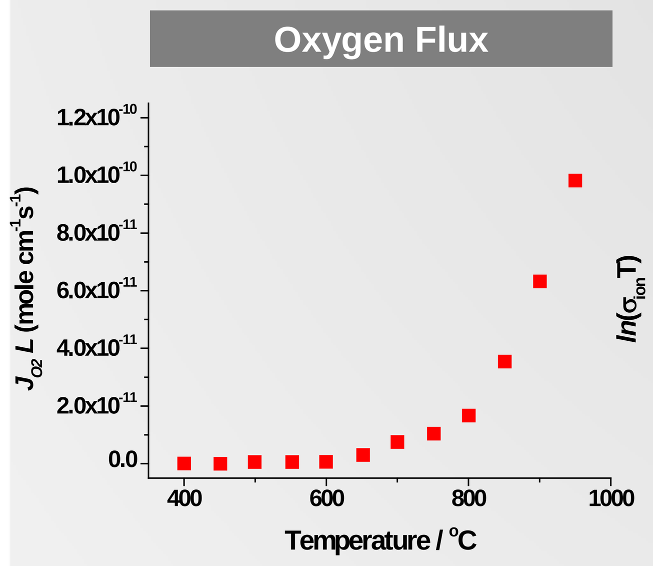
Increased Charge Carrier Density

Suppressed Oxygen Vacancy Formation

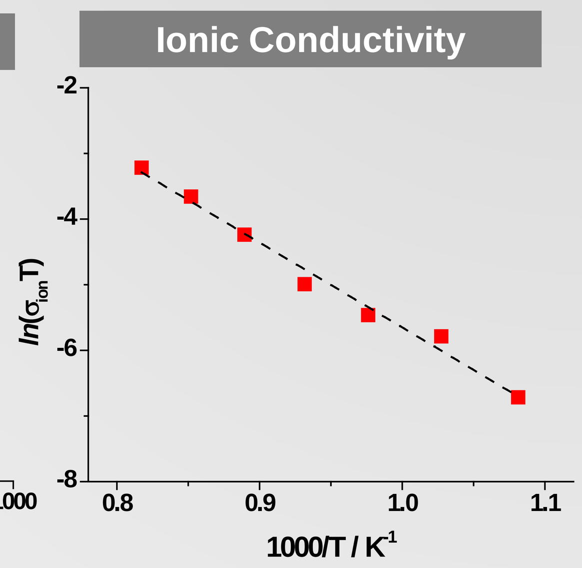
OXYGEN PERMEATION



Oxygen Flux

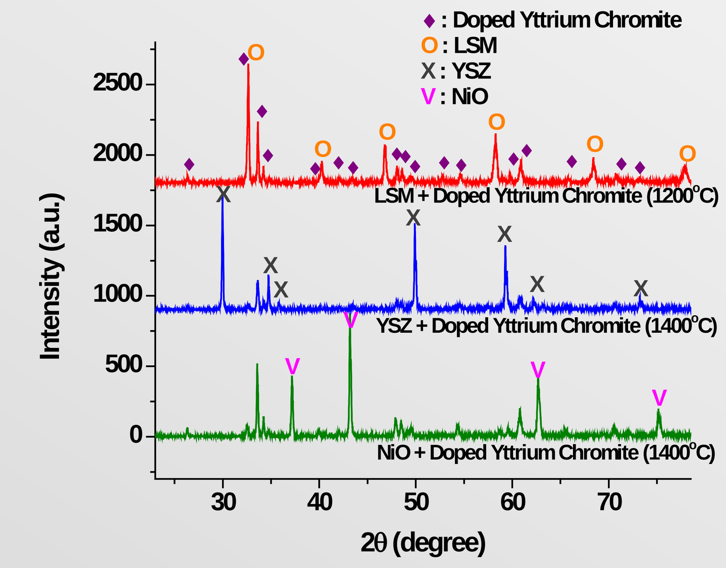


Ionic Conductivity



• Estimated Leakage Current Density < 5 mA/cm² (800^oC, $10^{-20}<p_{O2}<0.21$, 20 μm thick Interconnect)

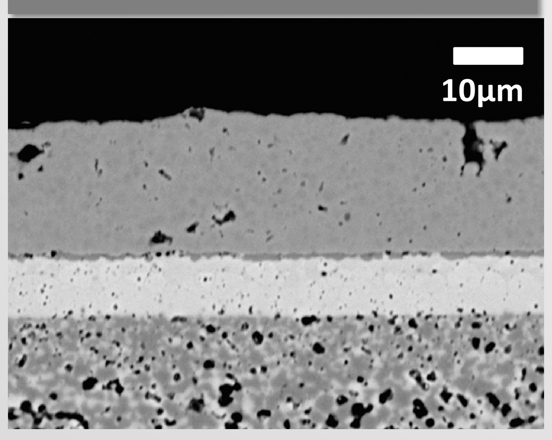
CHEMICAL COMPATIBILITY



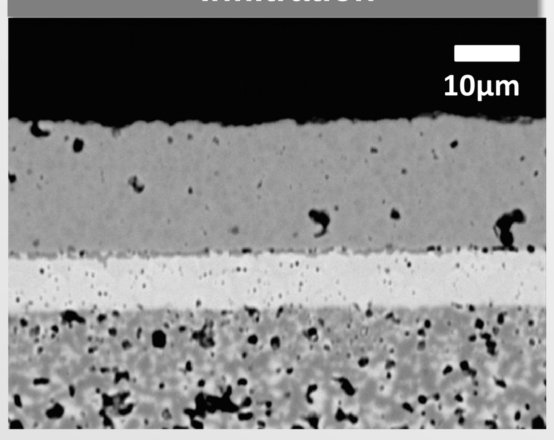
• Chemically Compatible with YSZ, NiO, and LSM at Processing Temperatures.

FILM DENSIFICATION

Co-sintering + Infiltration



Constrained-sintering + Infiltration



Addition of Infiltration Step

Nearly Full Densification of Screen-Printed Films

SUMMARY

Calcium- and Transition Metal-doped Yttrium Chromite
•Glycine-Nitrate Process
•Single Phase Orthorhombic Perovskite Structure Between 25 and 1100°C Over Wide pO_2 Range
•Cu-doping significantly improves sinterability.
•TEC can be controlled through B-site doping.
•Conductivity is improved by Co- and Ni-doping.
•Ni-doping improves stability toward reduction.
•Oxygen ionic leakage current is sufficiently low.
•Chemically compatible with YSZ, NiO, and LSM.
•Full densification can be achieved by addition of infiltration process.

ACKNOWLEDGEMENT

Support from the U.S. Department of Energy, National Energy Technology Laboratory (NETL) through Solid-State Energy Conversion Alliance (SECA) program is gratefully acknowledged. PNNL is operated by Battelle Memorial Institute for the U.S. Department of Energy under Contract DE-AC06-76RL0 1830. The authors appreciate XRD analysis by CN Cramer and T Varga, SEM analyses by JE Colman, and SEM sample preparation by SJ Carlson and CE Chamberlin.

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