Impact of Materials and Processing on Intermediate Temperature-SOFC Performance

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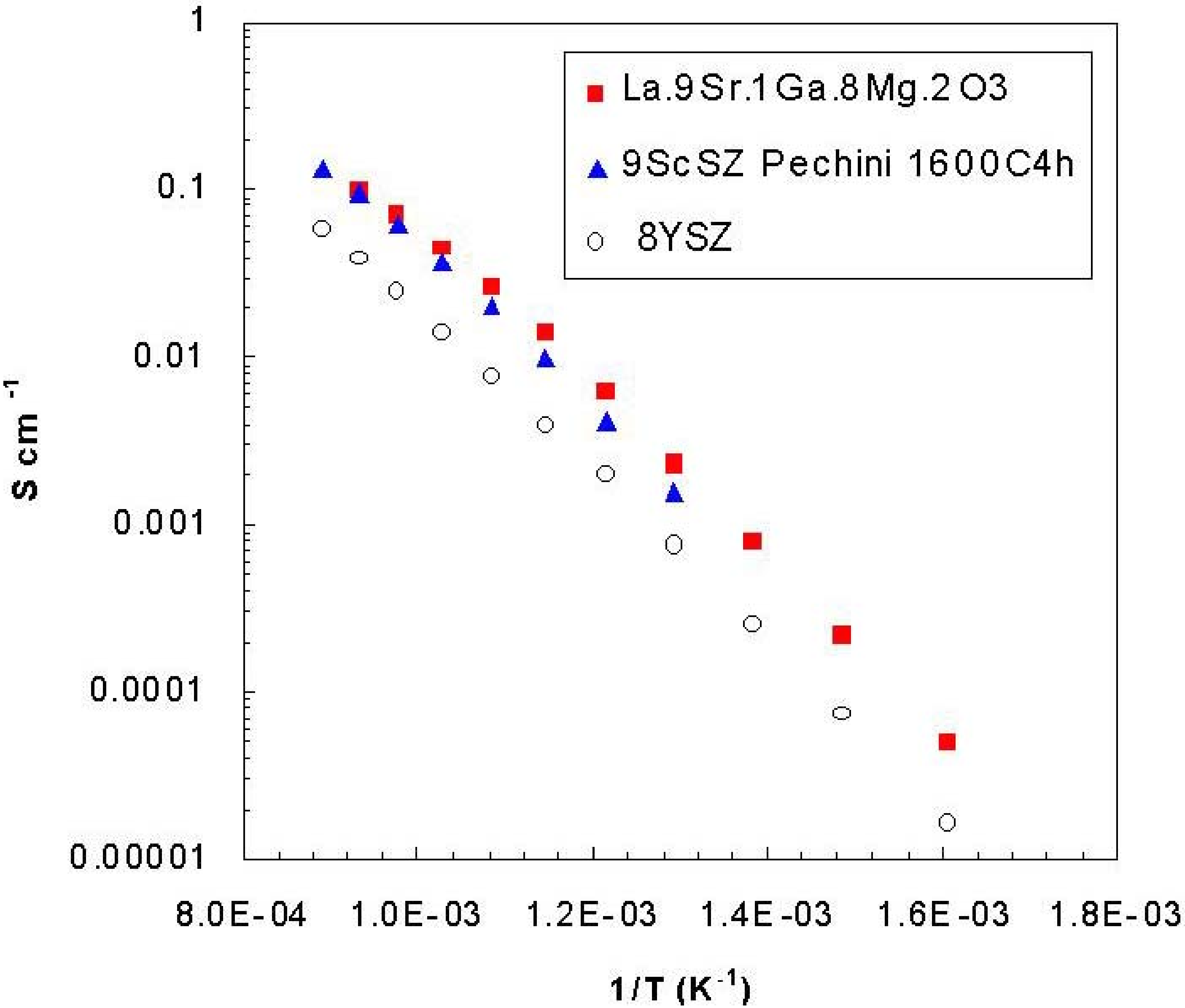
Impacts of Materials and Processing on IT-SOFC Performance

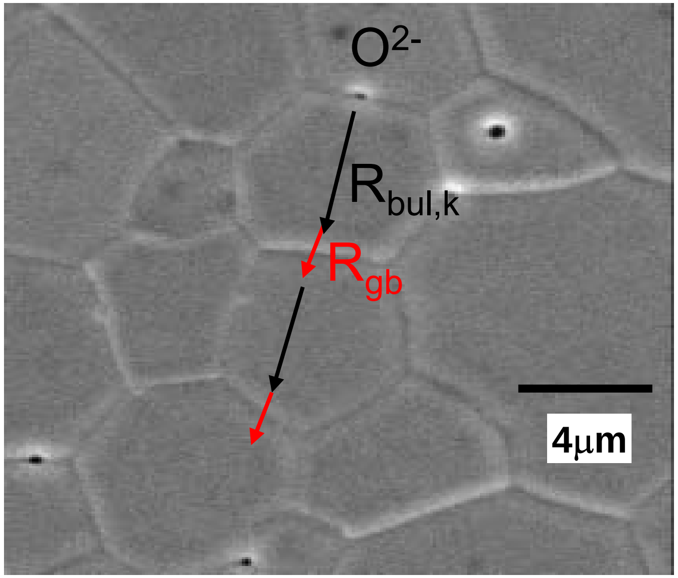
System types	Materials	Subjects
Electrolyte	Zr(Y)O2	[1] Influence of powder preparations on ionic conductivity
	LSGM	[2] Thermal stability (Ga evaporation)
Cathode	LSM-Zr(Sc,Y)O2	[3] High performance anode supported SSZ cell with cobalt post-doping of a cathode
Electrolyte	Zr(Sc,Y)O2	
Anode supported	Ni-Zr(Sc,Y)O2	
Cathode supported	LSM-Zr(Sc,Y)O2	[4] High performance cathode supported thin-film SOFC
Electrolyte	Zr(Sc,Y)O2	
Anode	Ni-Zr(Sc,Y)O2	
Cathode	LSM-ZrO2	[5] High performance cathode development

Electrolyte degration at high current densities

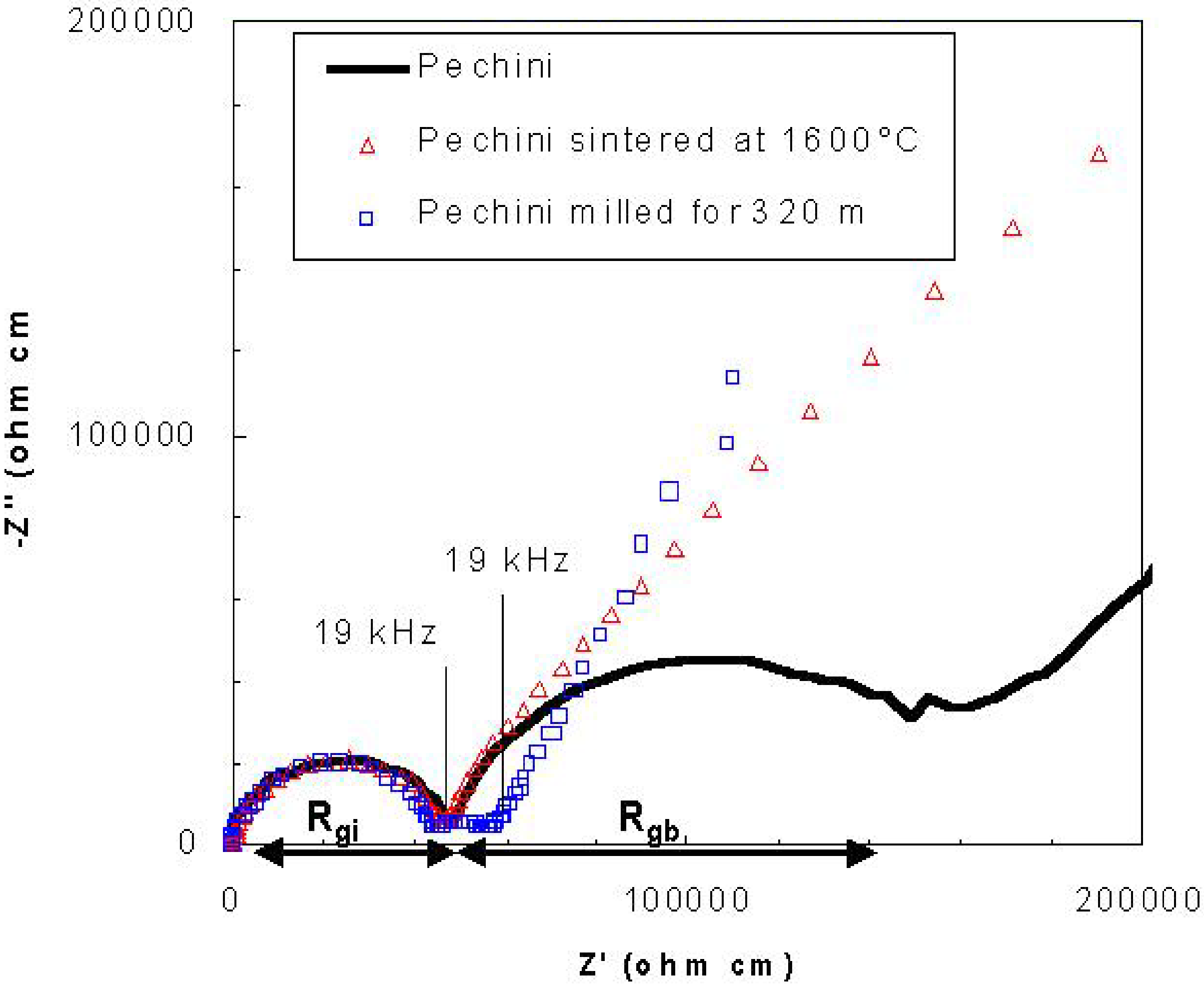
Ionic Conductivities of Electrolyte Prepared at LBNL



Grain boundary resistivity in zirconia systems can significantly affect total conductivity below 800°C.

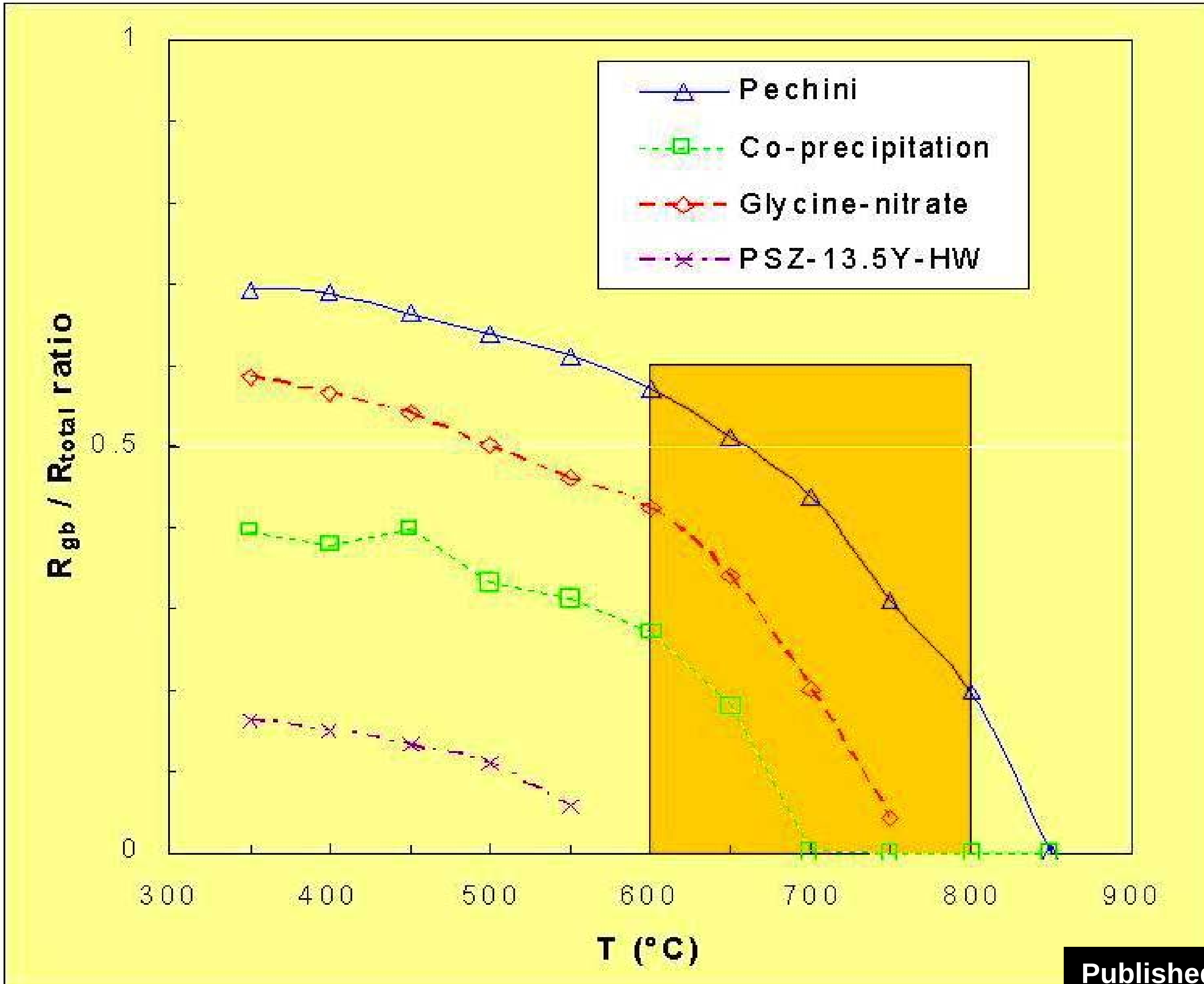


Grain structure of an 8YSZ polycrystal



The total conductivity can be improved by as much as 50 % when sintering temperature is increased or powder particle size is reduced.

Significant Contribution of Rgb Depending on Starting Powders



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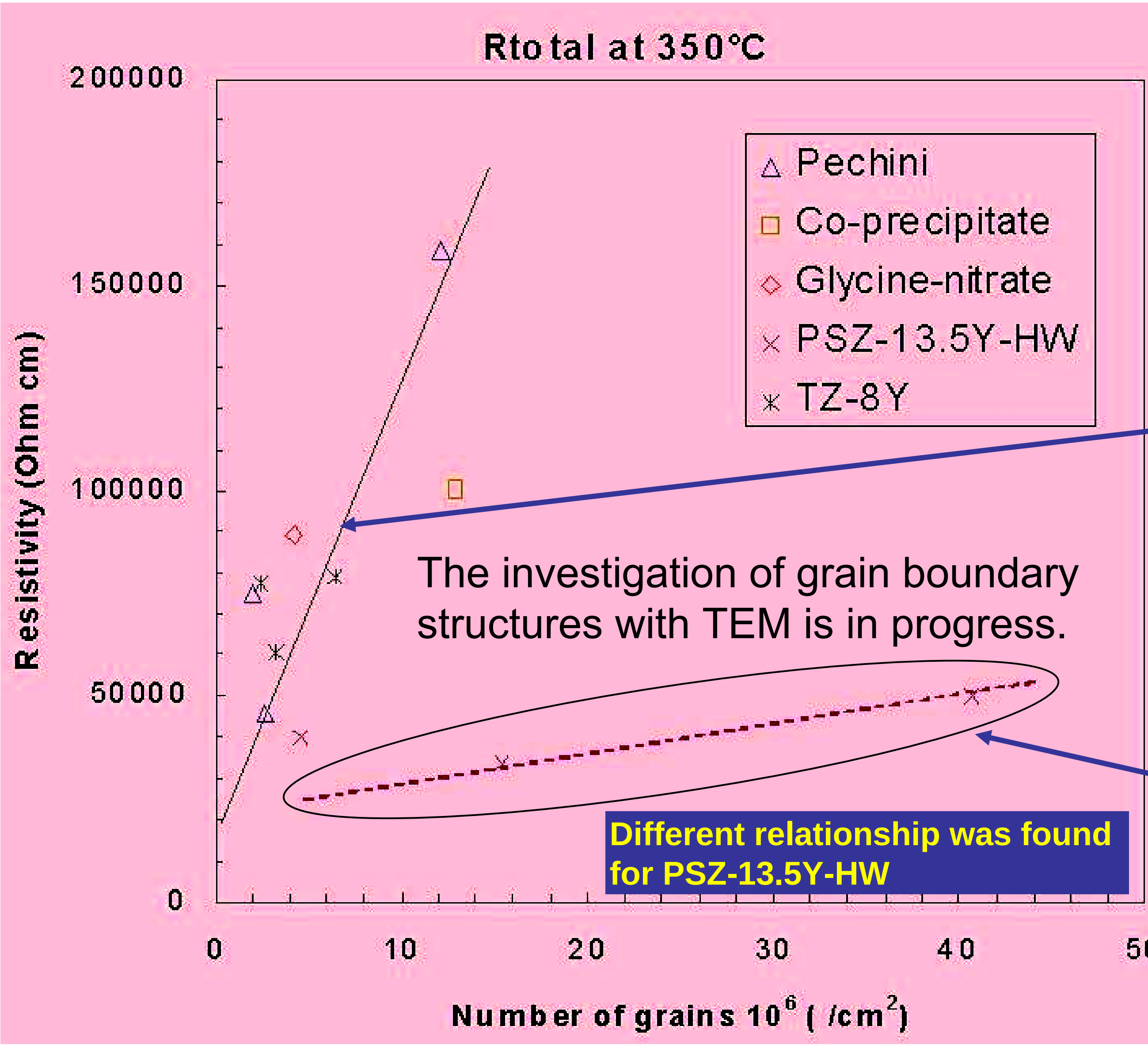
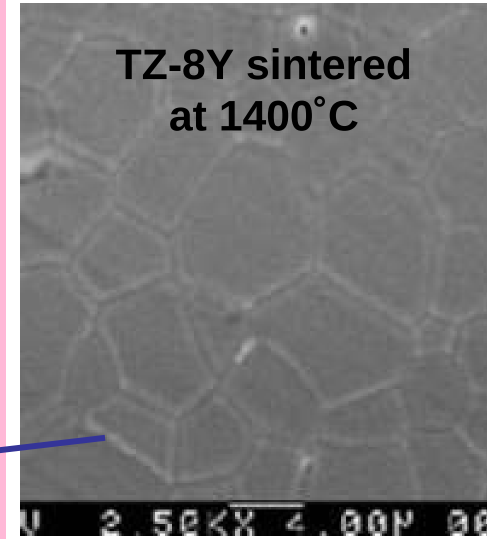
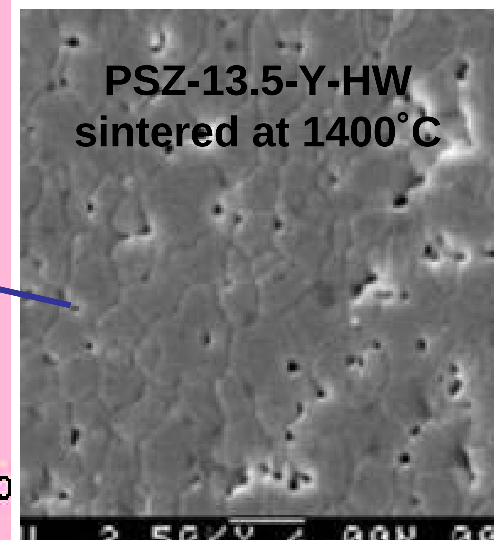
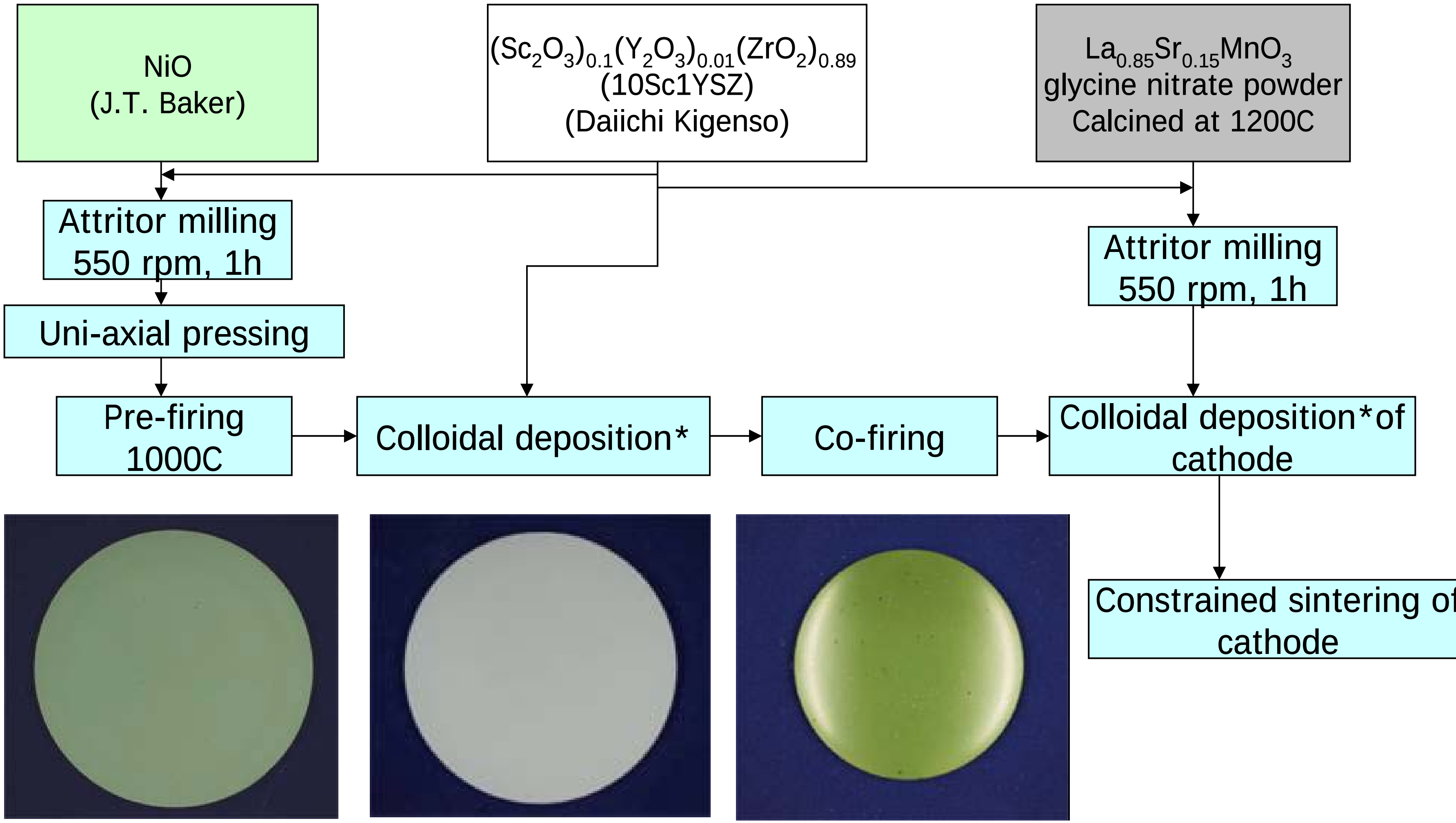
Dependence of Ionic Conductivity on Grain Size in Polycrystalline Zirconia







Cell Fabrication



*S.J. Visco, C.P. Jacobson and L.C. De Jonghe, U.S. Pat. No. 6458170, October 1 (2002)

High-Performance Supported Thin Film SOFCs for Reduced Temperatures

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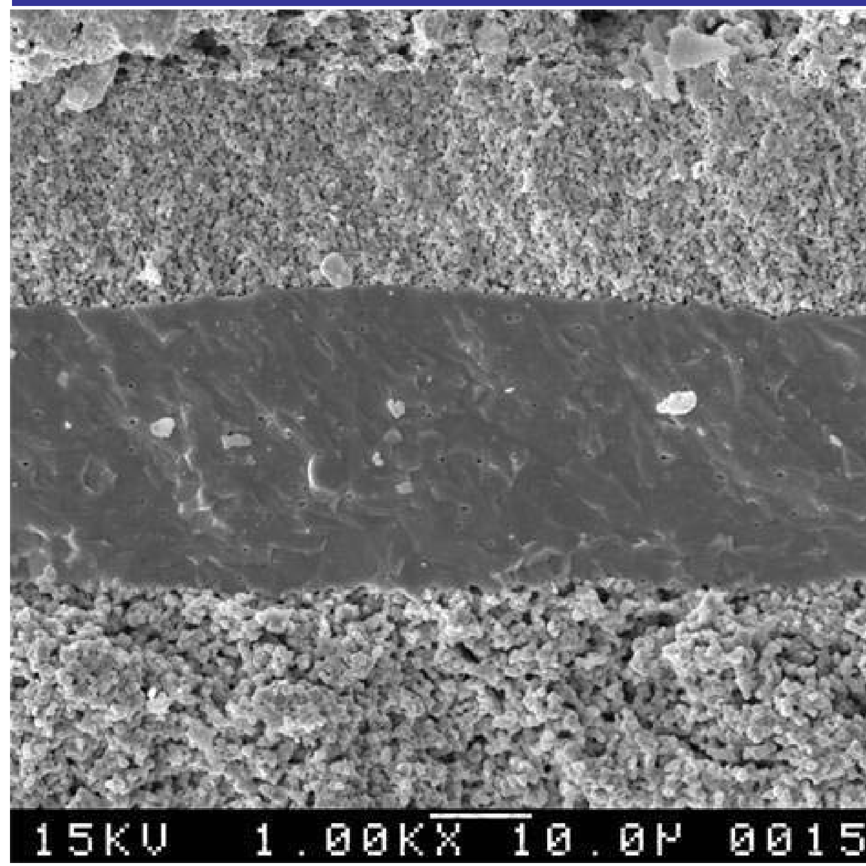
Submitted to SSI

SSZ based Thin-film Cell

$La_{.85}Sr_{.15}MnO_3$-10Sc1YSZ

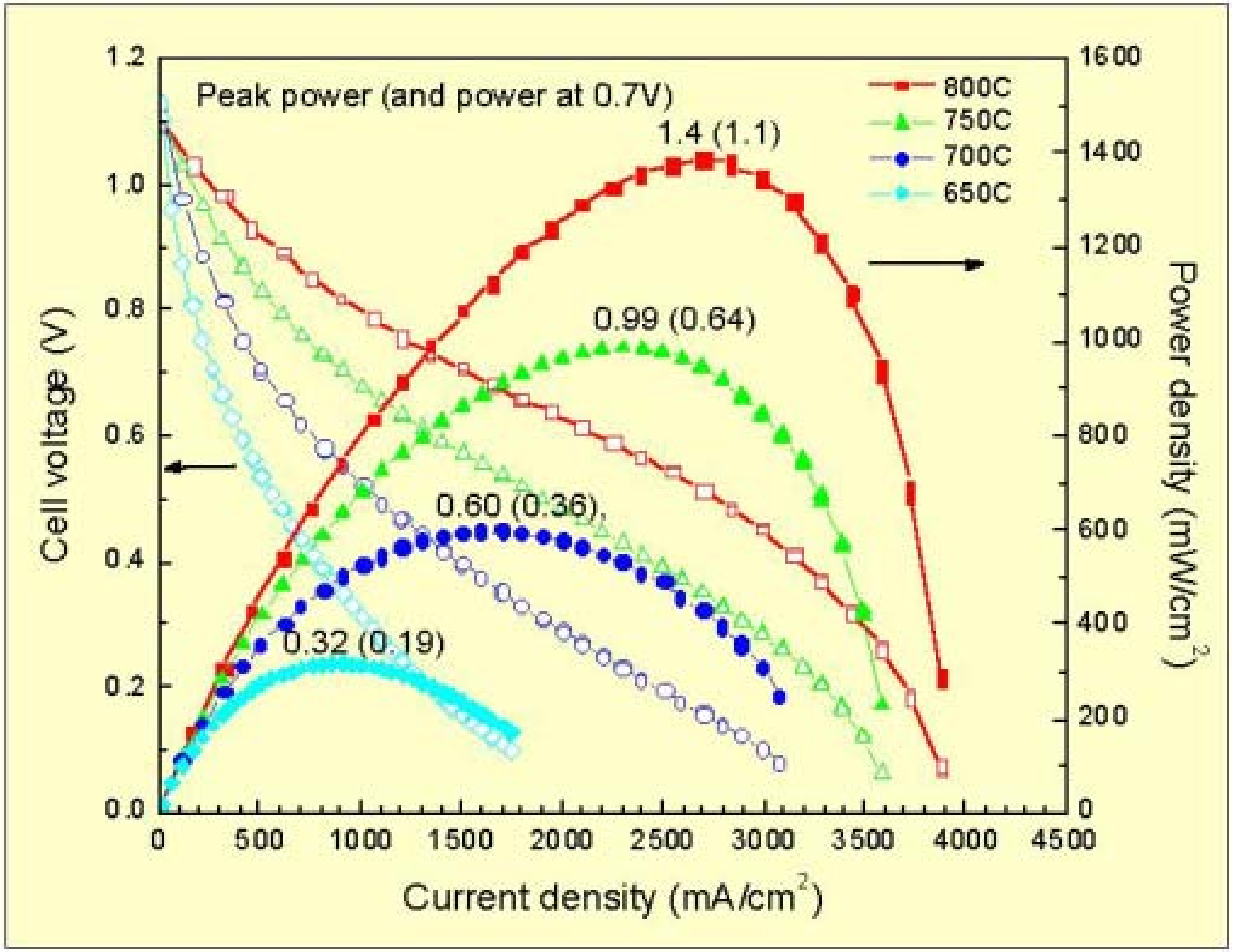
10Sc1YSZ

Ni-10Sc1YSZ



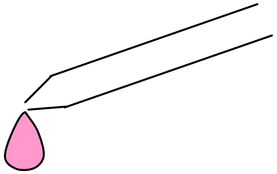
Cross-section of an anode supported fuel cell

Anode supported $(Sc_2O_3)_{0.1}(Y_2O_3)_{0.01}(ZrO_2)_{0.89}$ thin-film solid oxide fuel cell achieved higher performance than the 8YSZ SOFC.



For the 8YSZ SOFC, peak power densities were 0.89 and 0.30 W/cm² at 750 and 700 ˚C, respectively.

Improvement of Cathode Performance by Cobalt Nitrate Infiltration



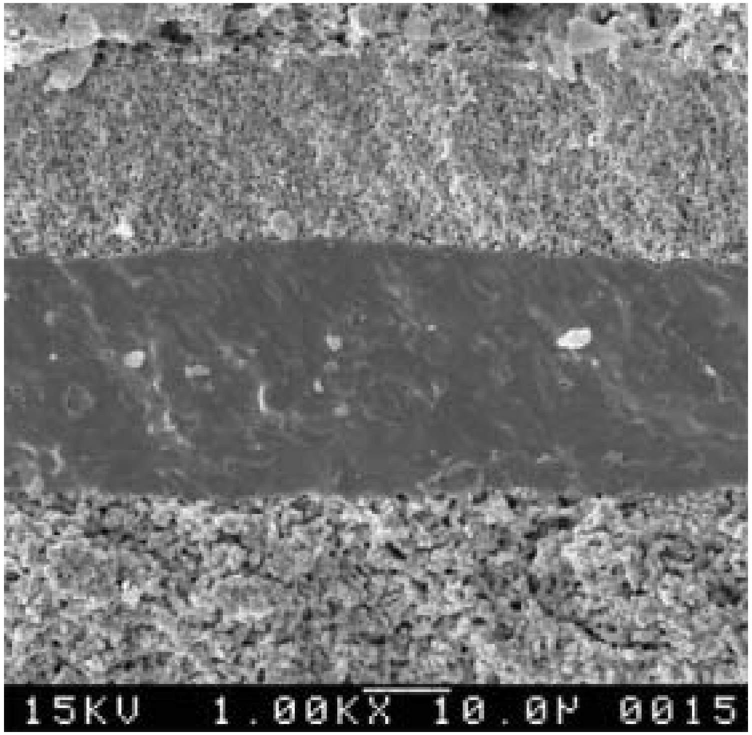
Post-firing cobalt doping of cathode

2 mg/cm^2 Co nitrate

$La_{.85}Sr_{.15}MnO_3$-**10Sc(Y)SZ**

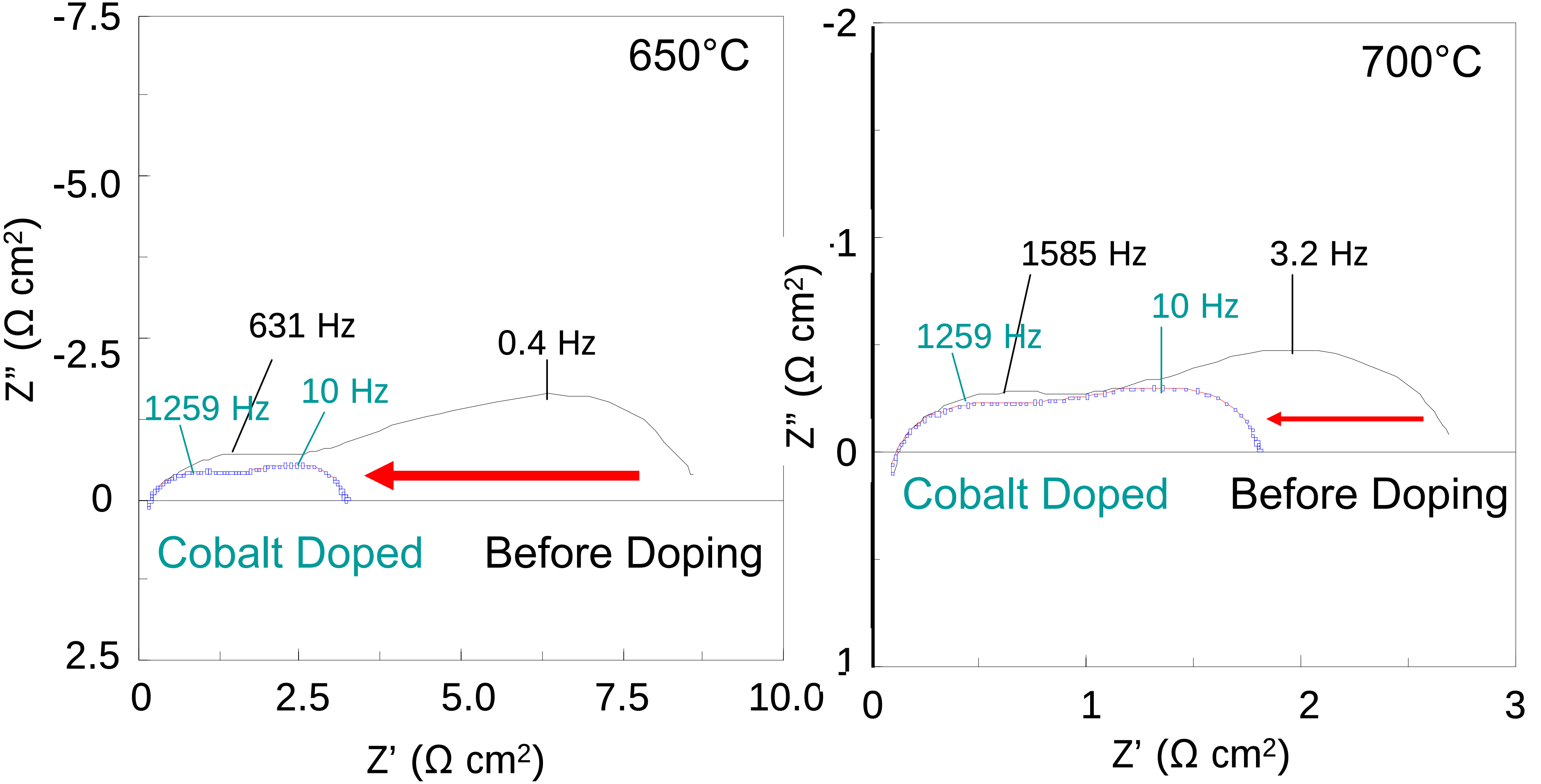
10Sc(Y)SZ

Ni-**10Sc(Y)SZ**

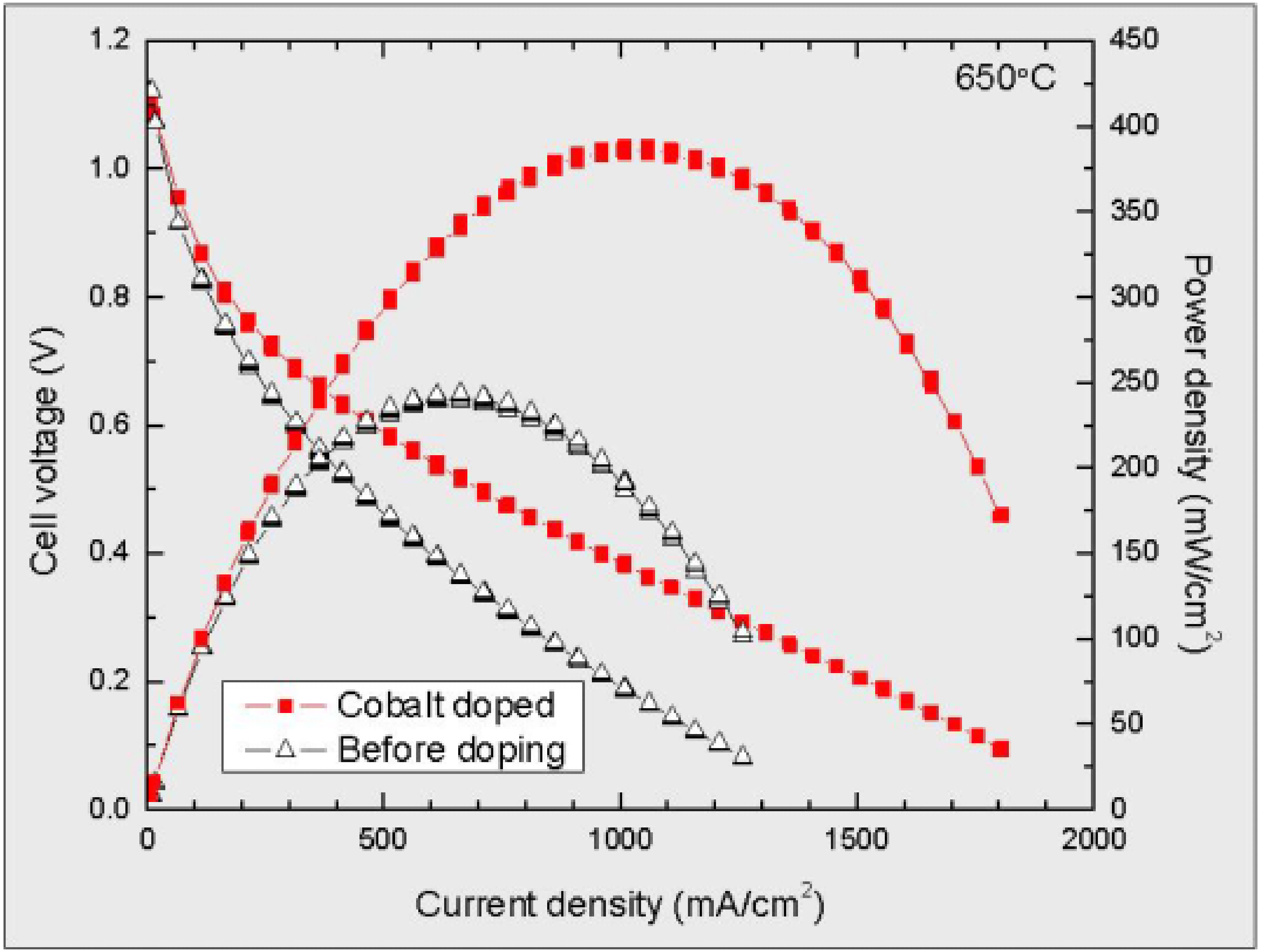


Impedance Spectra for Co Doped LSM Cathodes

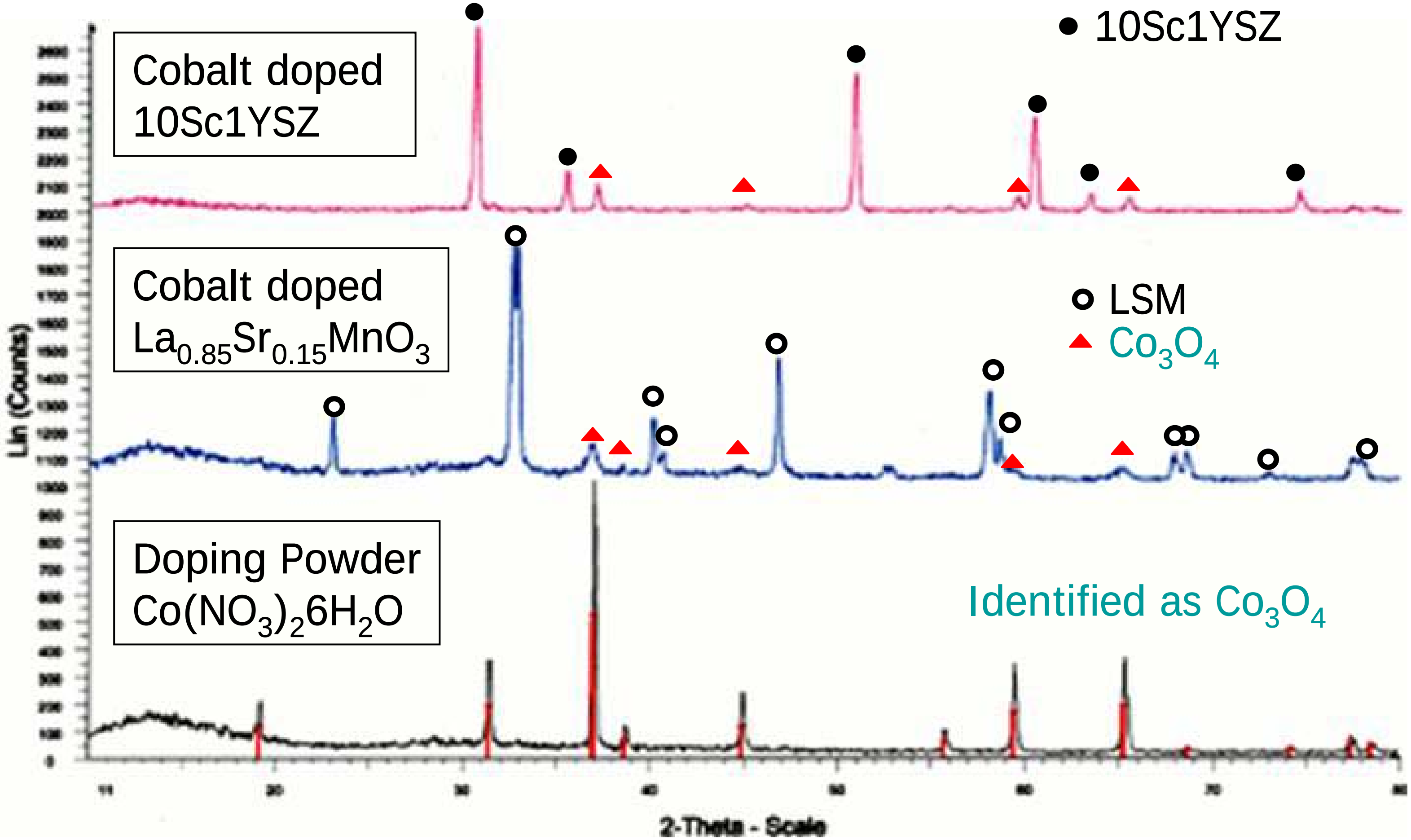
Cathode side half cell



Further improvement in the power density was obtained by as much as ~2 times at 650°C by cobalt doping of cathode using a simple infiltration method.



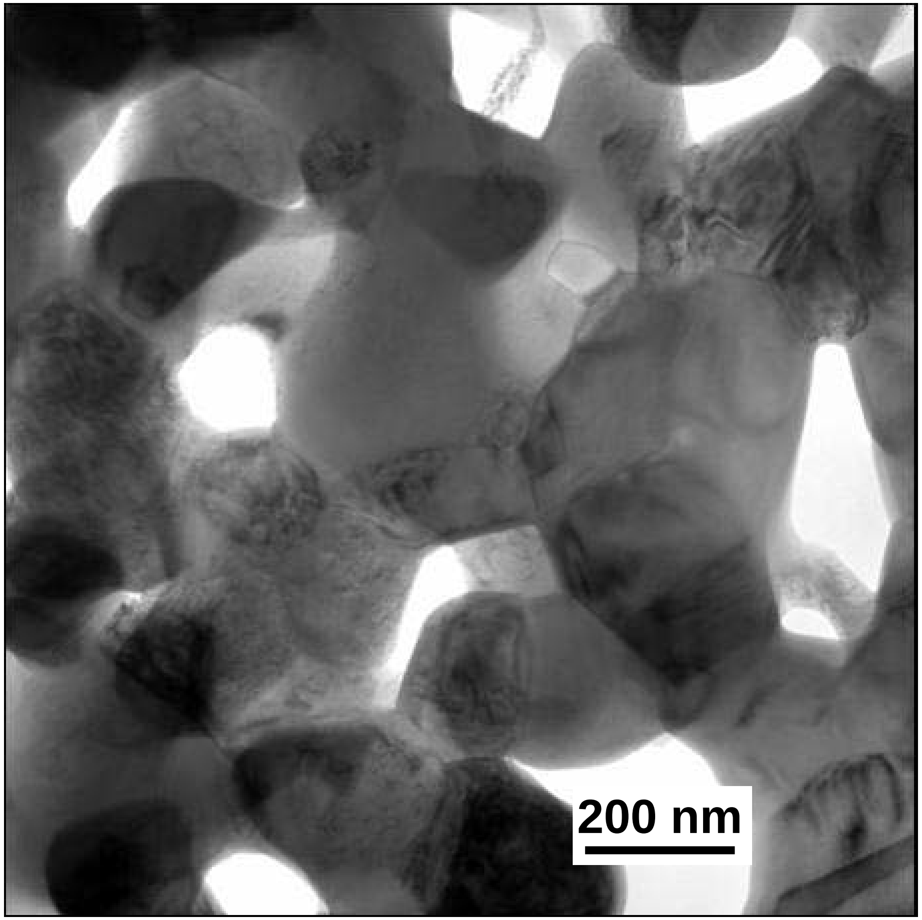
XRD: Co Doped Powders Heated at 650°C



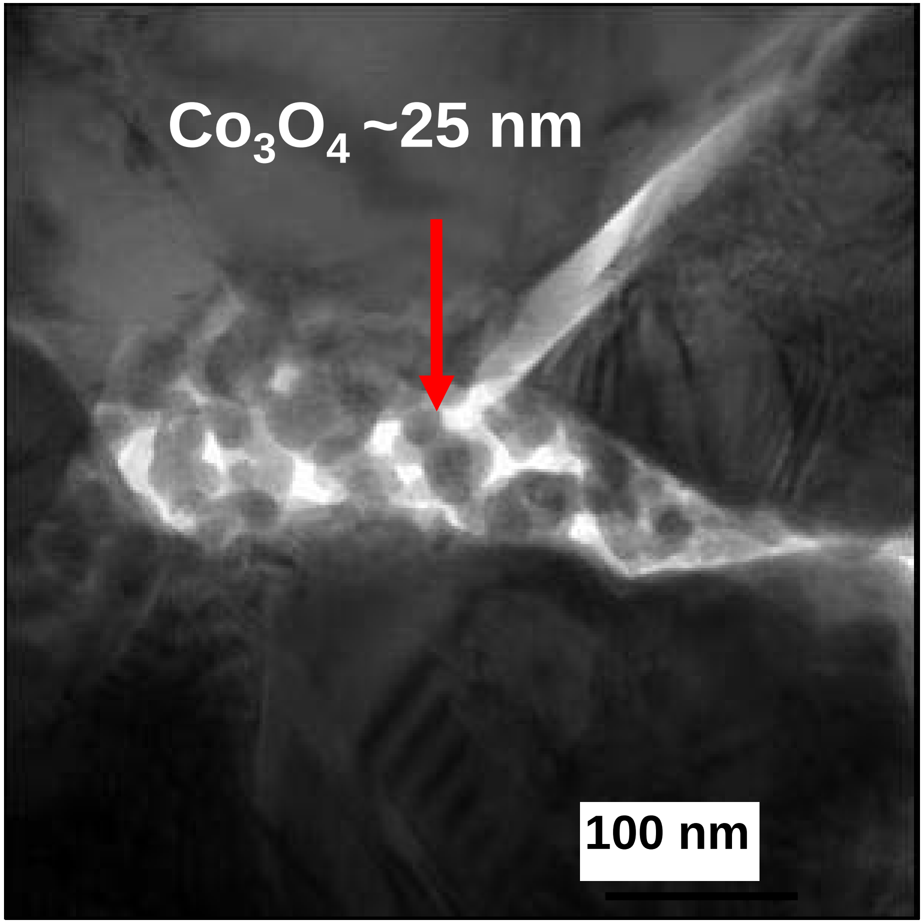
No reaction product with 10Sc1YSZ nor LSM

TEM: Co_3O_4 Particles in the Pores of LSM-10Sc1YSZ Composite

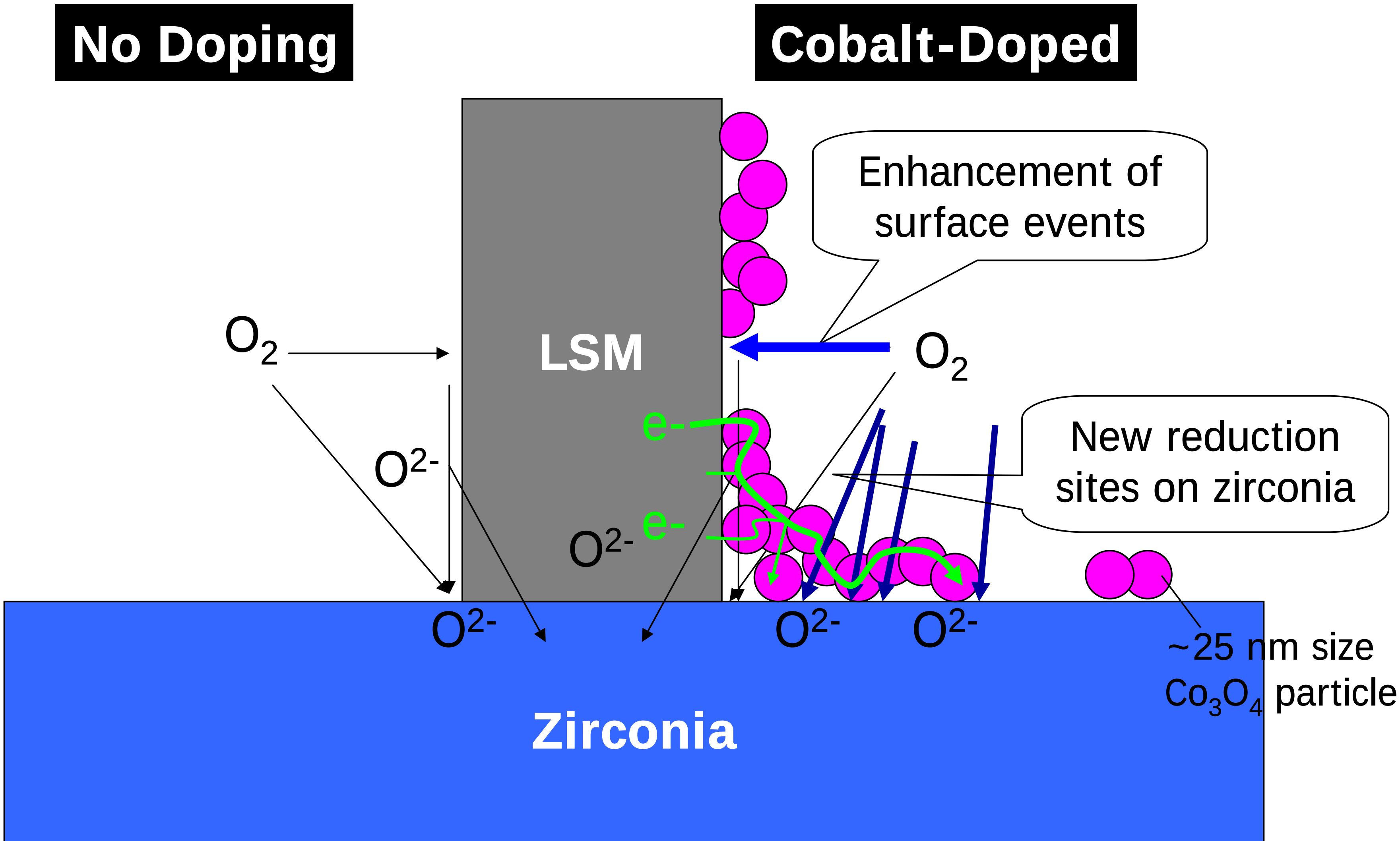
Before Doping



Cobalt Doped



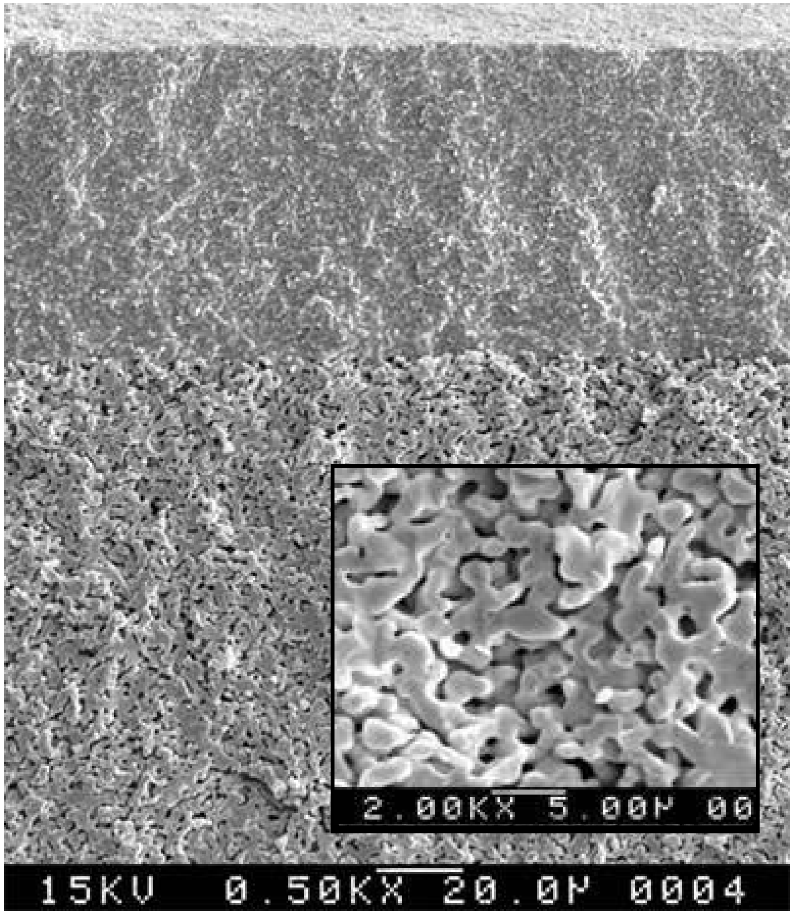
Enhancement of Cathode Performance by Post-Firing Cobalt Doping



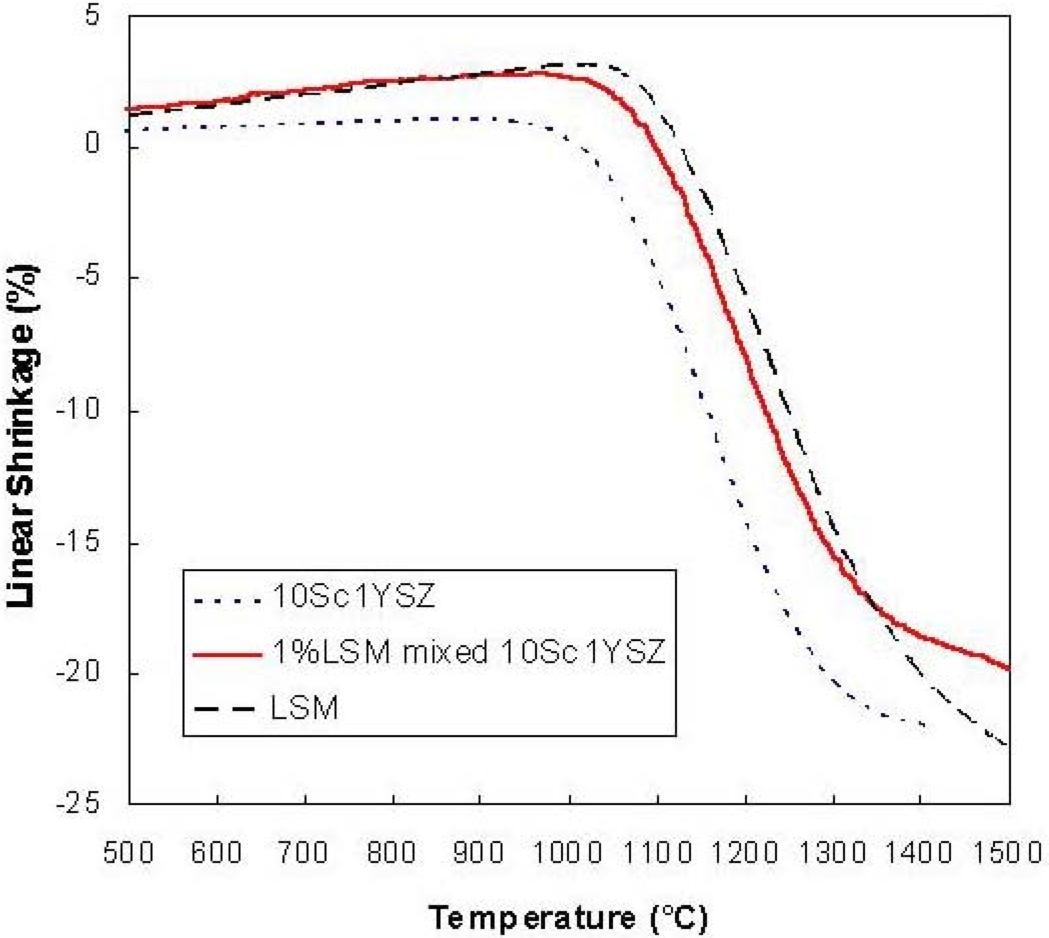
Co-fired Cathode Supported Thin Film IT-SOFCs

The bi-layer disks composed of the homogeneously porous LSM substrate and the 10Sc1YSZ film were obtained by co-firing at 1250˚C. Relatively large linear shrinkage >25% was required under the low temperature sintering with hindering by LSM.

Cross-section of an LSM supported fuel cell



Small amount of LSM significantly hinders the sintering of zirconia



Ionic Conductivity of Stabilized Zirconia in Composite Electrodes

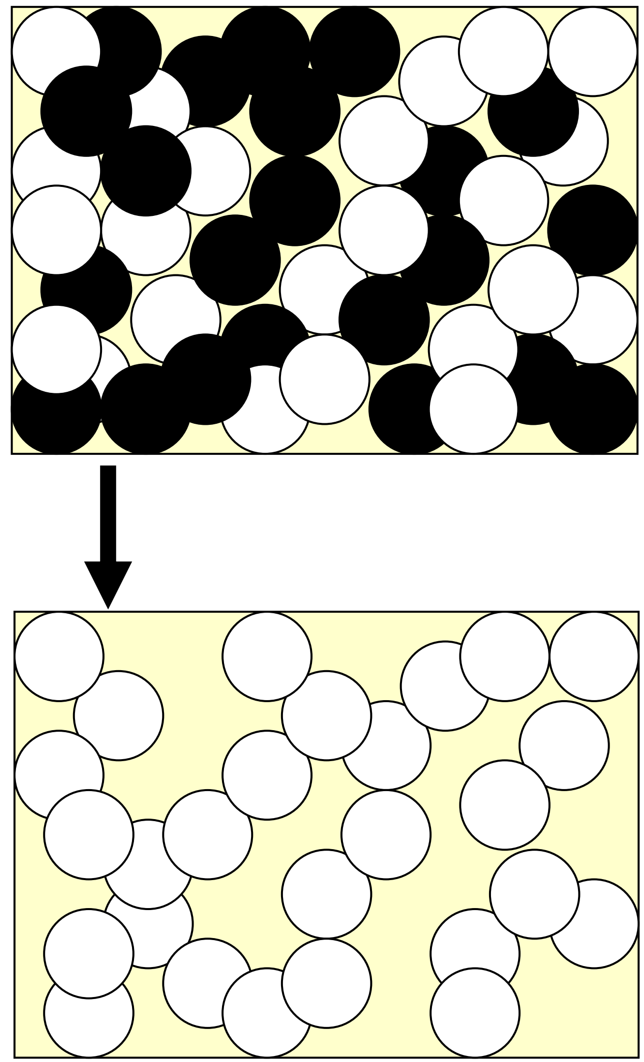
LSM-YSZ composites

(Electronic & ionic conductor)

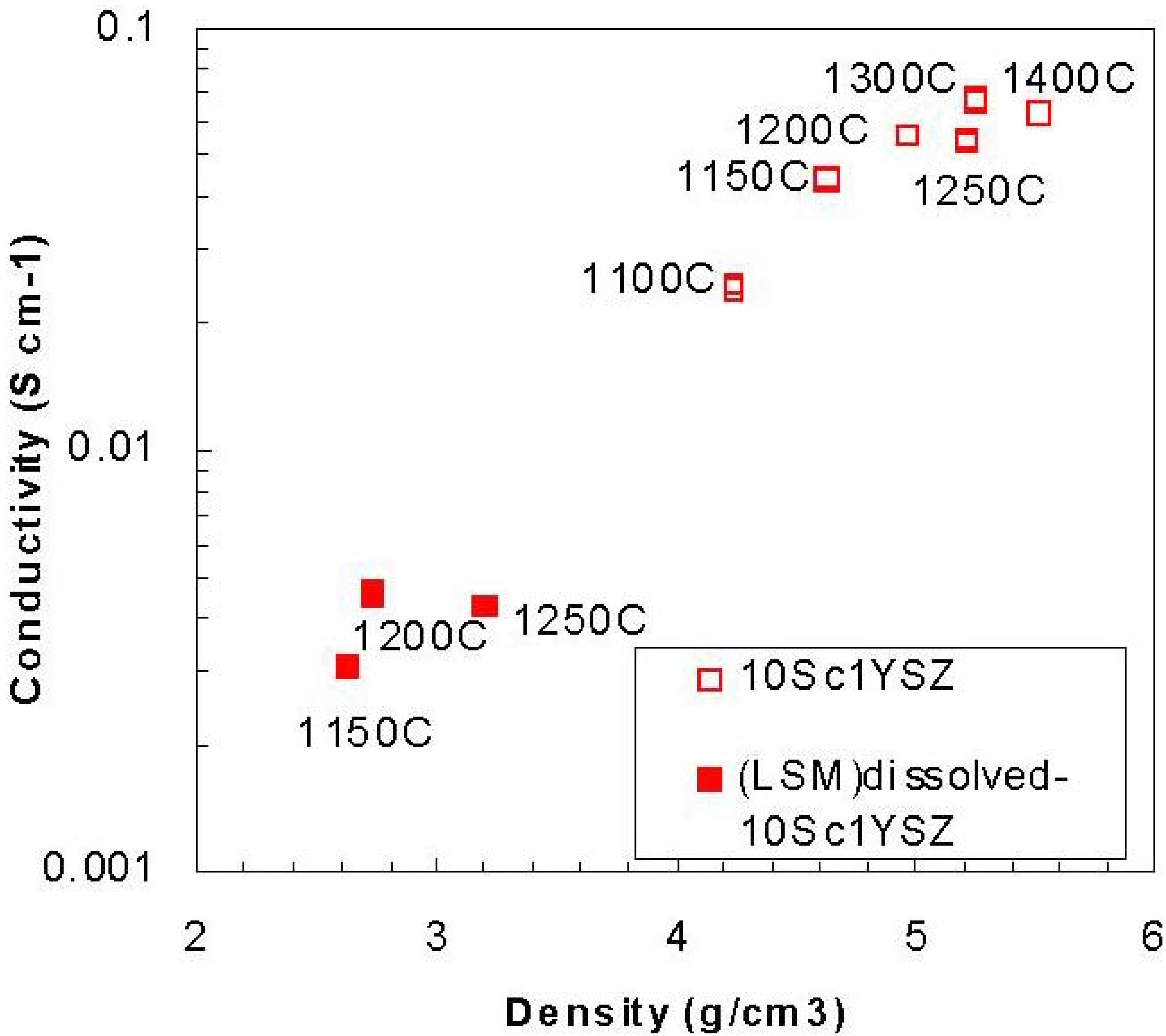
Dissolve LSM with HCl

YSZ framework

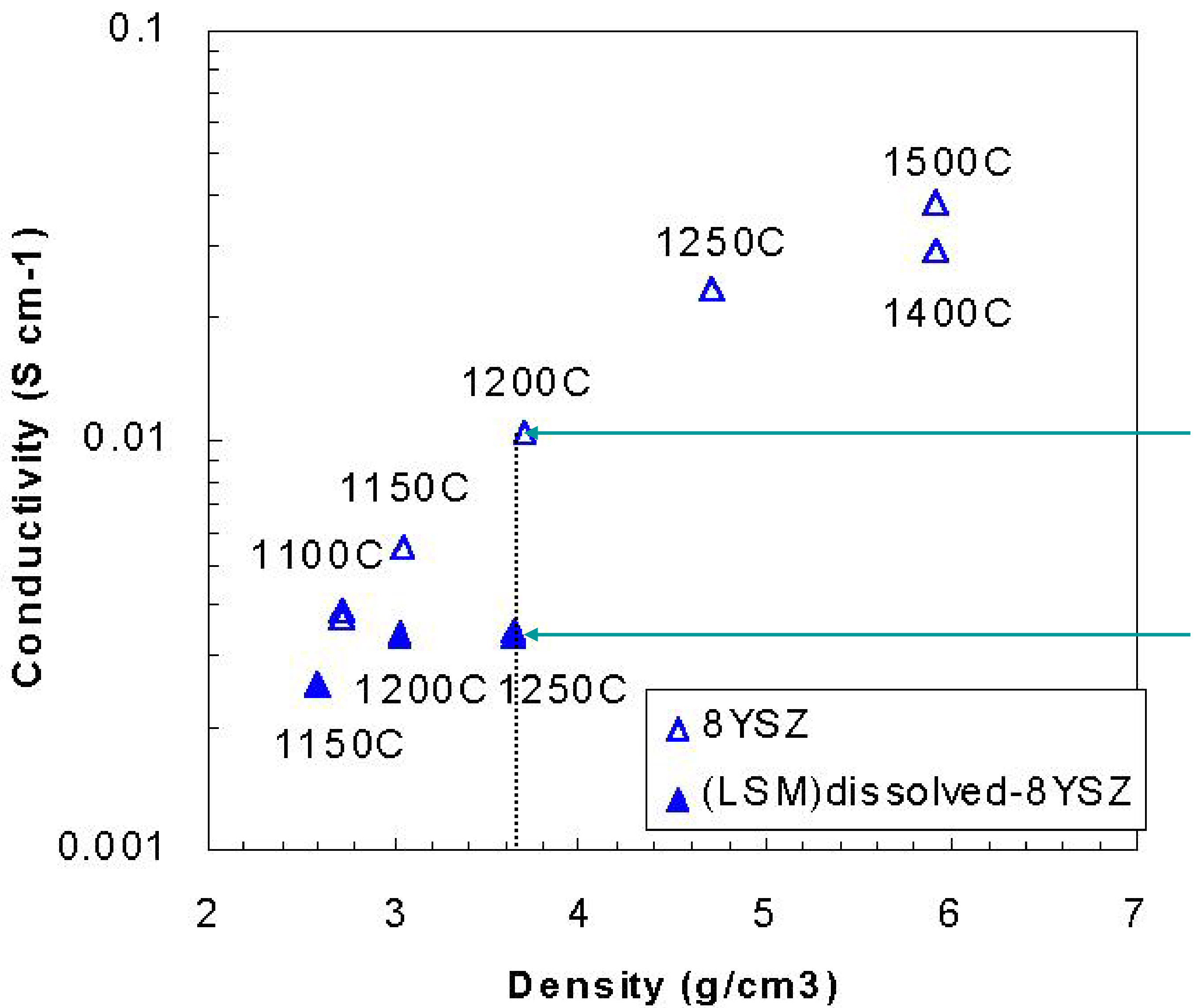
(ionic conductor)



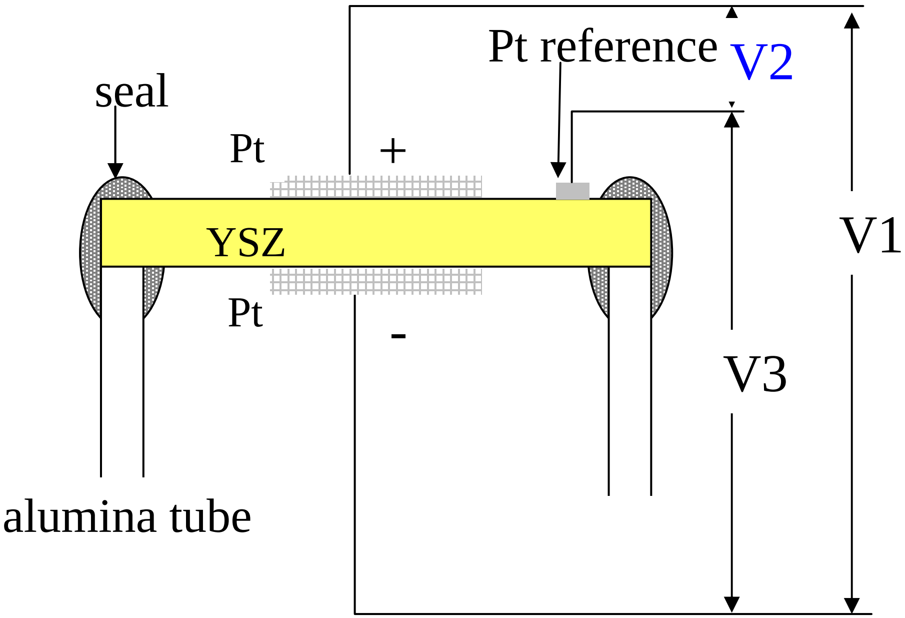
Ionic conductivity in LSM-Y(or Sc)ZrO_2 composites is one order of magnitude smaller than that of full density pure Y(or Sc)ZrO_2



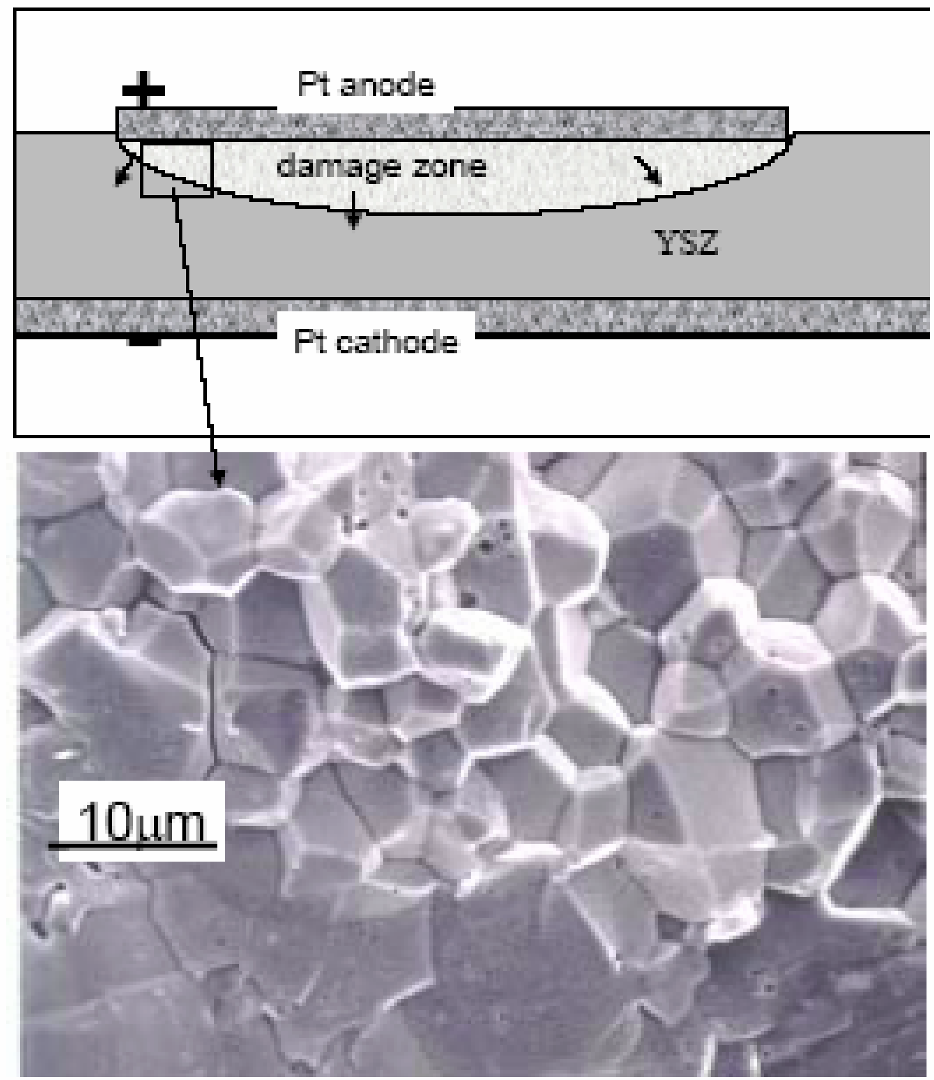
Ionic conductivity of YSZ in YSZ-LSM is lower than that of the zirconia polycrystals sintered at reduced temperatures having similar density (considerable influence of LSM on the conductivity in the zirconia polycrystals)



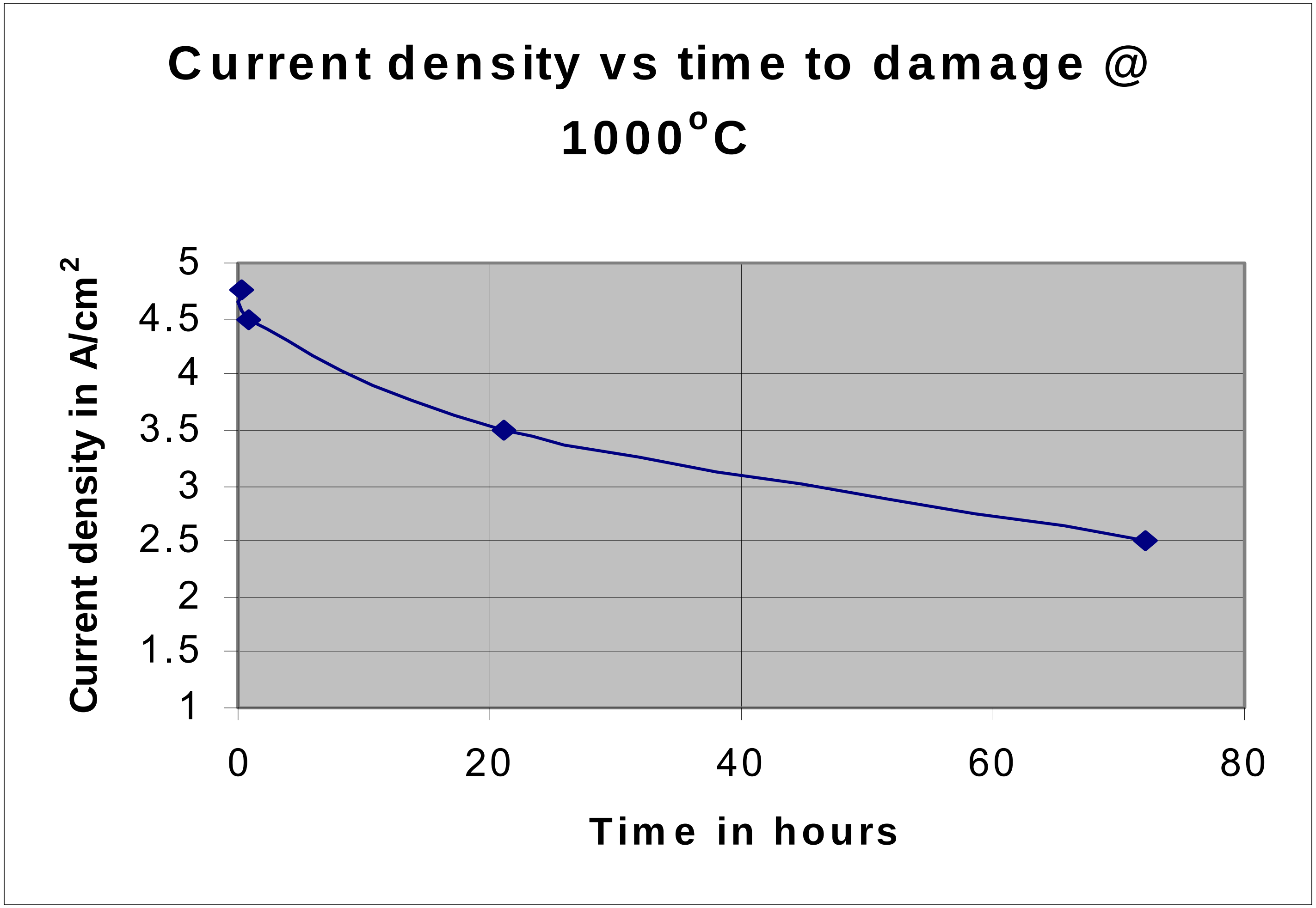
Testing of Pt/8YSZ/Pt air/air cells at high current density



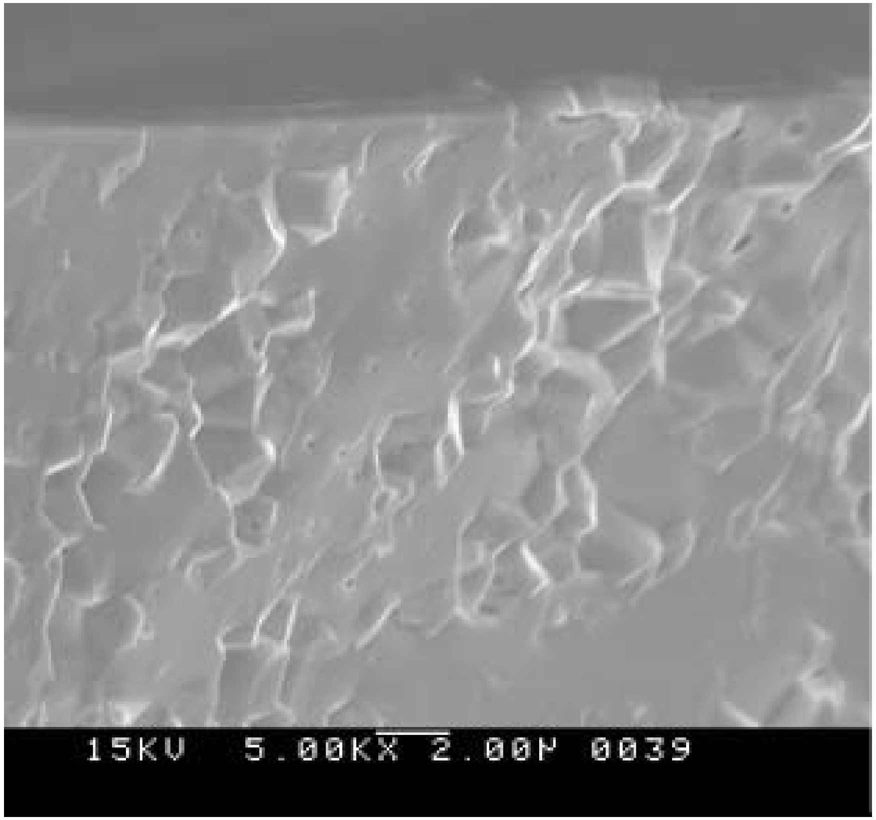
Testing at 1000 $^{o}C/4.5\ A/cm^2$



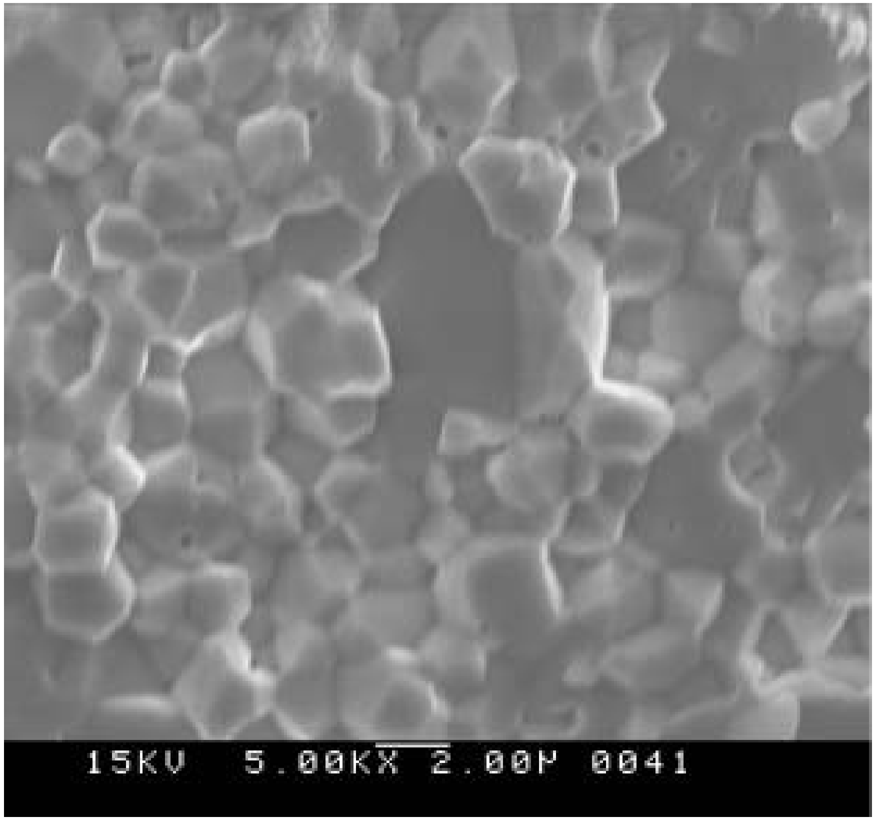
Dependence of time to rapid voltage rise on current density



Damage dependence on operating temperature

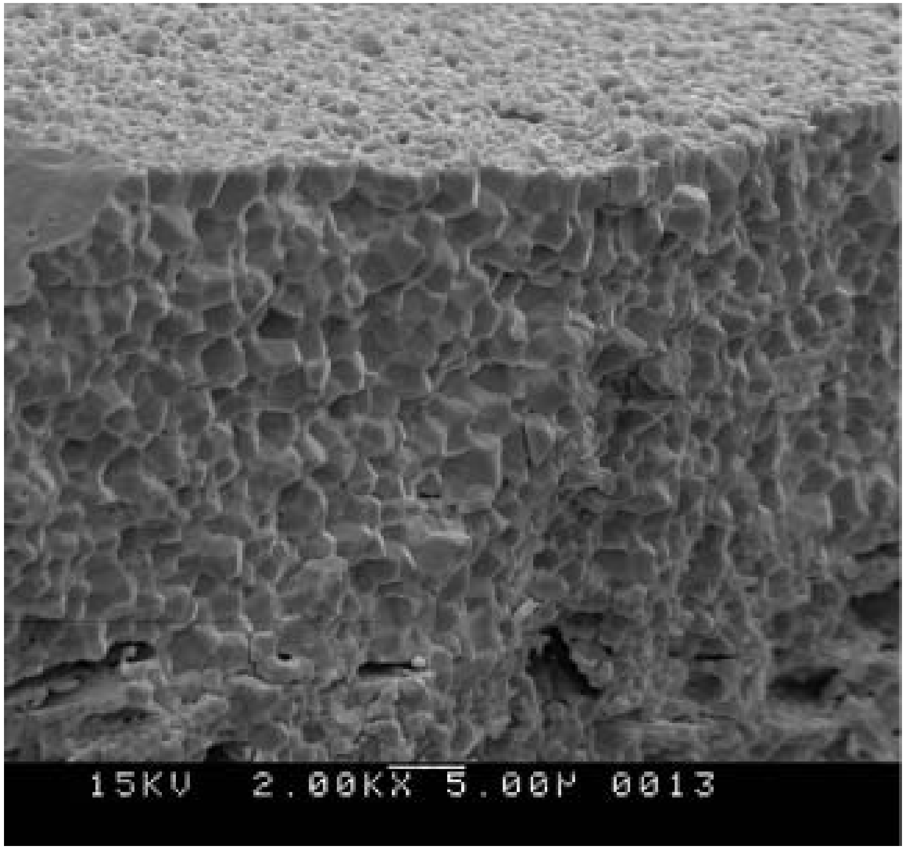


4.5A/cm^2 current @ 800°C

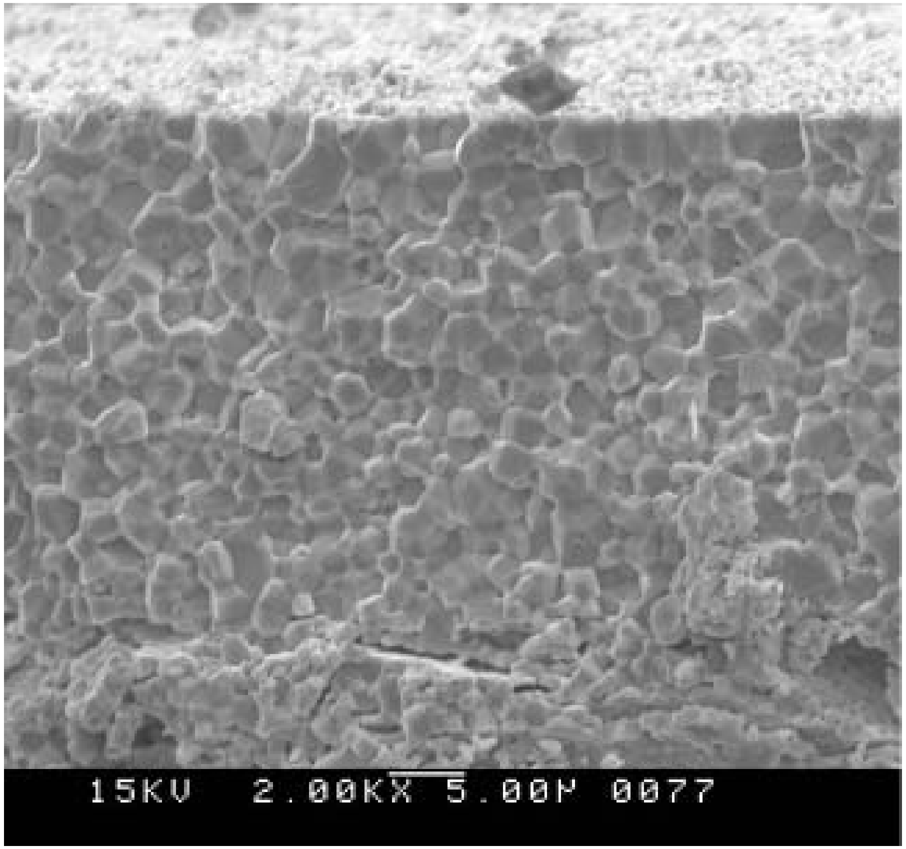


4.5A/cm^2 current @ 1000°C

Electrolyte damage due at different current densities

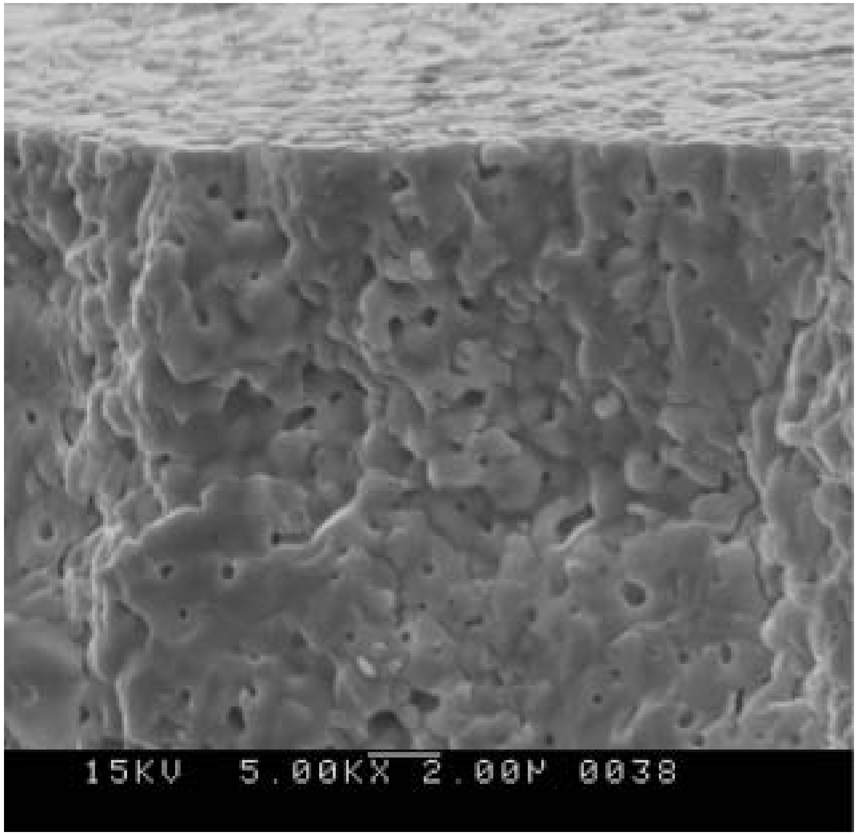


2.5A/cm^2

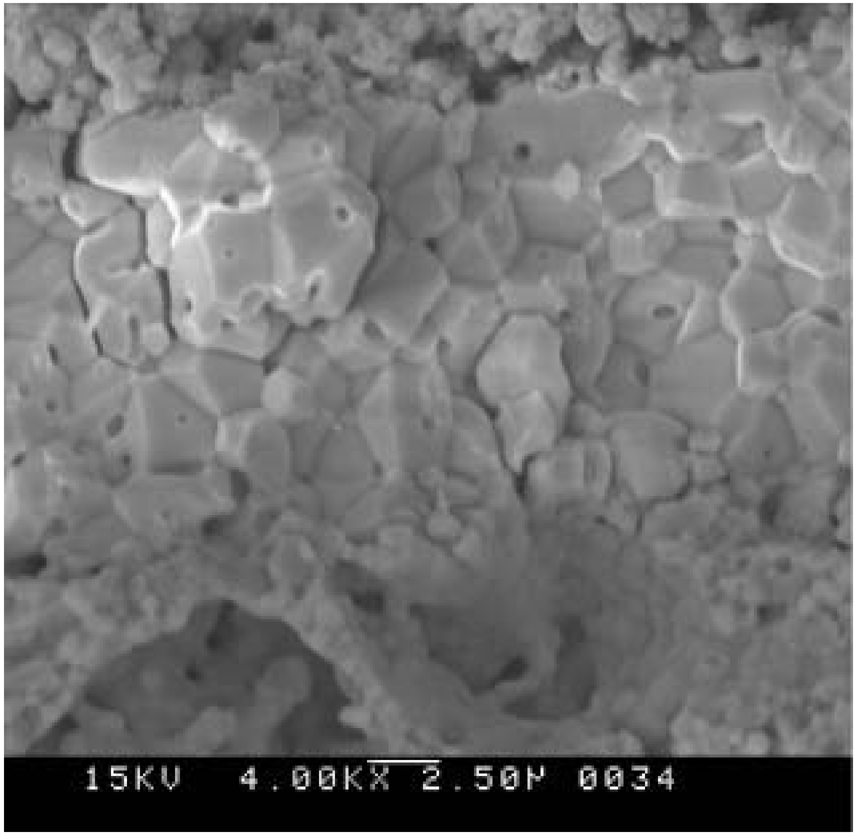


3.5A/cm^2

Damage observed in ceria electrolytes under DC current



CGO electrolyte (6 A/cm2)



SDC electrolyte (3.5 A/cm2)

Summary

- Grain boundary resistance of YSZ is significant at low temperatures and careful choice of powders and processing may be critical for good low temperature performance
- SSZ based thin-film cells outperform YSZ cells at all temperatures with increasing advantage at low temperatures
- Simple infiltration of LSM cathodes significantly improves performance, particularly below 750 ^{o}C (appears to be due to Co_3O_4 nanoparticles)
- At 1000 ^{o}C, YSZ electrolyte exhibit significant damage at anode (oxygen exit side) at high current densities, further study is needed to determine if this is a problem for fuel cells.

Acknowledgment

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Program Manager: Lane Wilson