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ELECTRONIC MATERIALS APPLIED RESEARCH CENTER

Overview of DOE Contract No.: DE-AC-26-99FT40710 at University of Missouri-Rolla

Low Temperature Cathode Supported Electrolytes

Harlan U. Anderson (presenter)
Igor Kosacki
Vladimir Petrovsky
Wayne Huebner

Presented at
SECA Core Technology Program
Review Meeting at

Hyatt-Regency at Pittsburgh International Airport
Pittsburgh, PA

November 16, 2001

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ACHIEVEMENTS – FY 1999-2000

- Films of 16% Y:ZrO_2 Characterized
  - Ionic conductivity of <50 nm grain one micron thick films measured to room temperature *(conductivity of the grains dominates).*
  - Grain size <50 nm for annealing temperatures <800°C.
  - Produced >95% theoretical dense YSZ at 600°C.
- Films of Undoped and Gd Doped CeO_2 Characterized
  - The electrical conductivity of both doped and undoped CeO_2 show grain size dependence.
  - Ionic conductivity of nanocrystalline Gd doped CeO_2 less than that of the microcrystalline.

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  - Electronic Conductivity becomes significant for oxygen activity less than 10^{-14} atm.
- Developed Cathode Substrate for Deposition of 0.5 to 2 Micron Thick YSZ Films for Use as Electrolyte in SOFCs
  - Fabricated porous LSM substrates
  - Synthesized nanoscale CeO_2 suspensions for deposition onto LSM substrate
    - Control of cathode surface porosity to sizes <0.1 micron
    - 3-5 micron thick CeO_2 layers planarize LSM substrate to surface roughness <0.1 micron.
    - Developed a graded LSM substrate

- Developed a process by which 1-5μm thick electrolyte layers can be produced on dense and porous substrate without shrinkage.
- Improved Clean Room *(in order to make electrolyte of areas larger than 0.2 cm^2 our existing clean room must be improved)*
  - Doubled size.
  - More filters and air flow.
  - This was completed March 1, 2001.

Research Planned for FY 2001-2002

- Continue Optimization of the Cathode Substrate. Evaluate:
  - The influence of porous CeO_2 layer on SOFC performance.
  - The influence of the addition of LSCF into CeO_2 layer on SOFC performance.
  - The influence of the conductivity of the CeO_2 layer on SOFC performance.
- Make Single Cell Fuel Cell Measurements
  - Cell performance as a function of electrolyte thickness and temperature.
    - YSZ electrolyte
    - CeO_2 electrolyte
  - Cell performance as a function of electrode composition.
    - Anode
    - Cathode

- Continue Studies Related to Placing Thin Electrolyte Films onto Porous Substrates
  - Polymer precursor onto a graded substrate.
  - Transfer of dense films to a porous substrate.
  - Nanocrystalline/polymer precursor composites.

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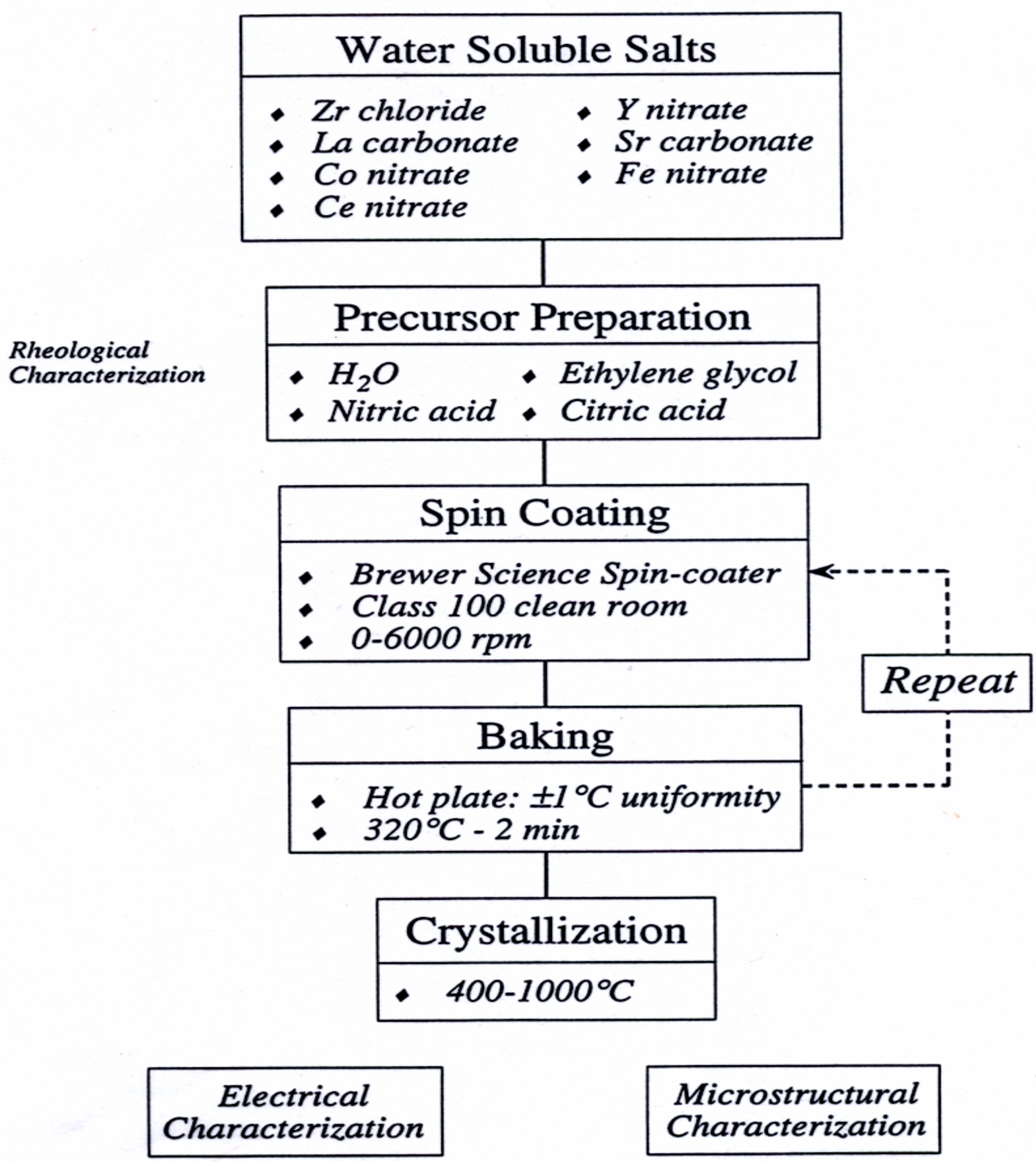
Thin Film Processing



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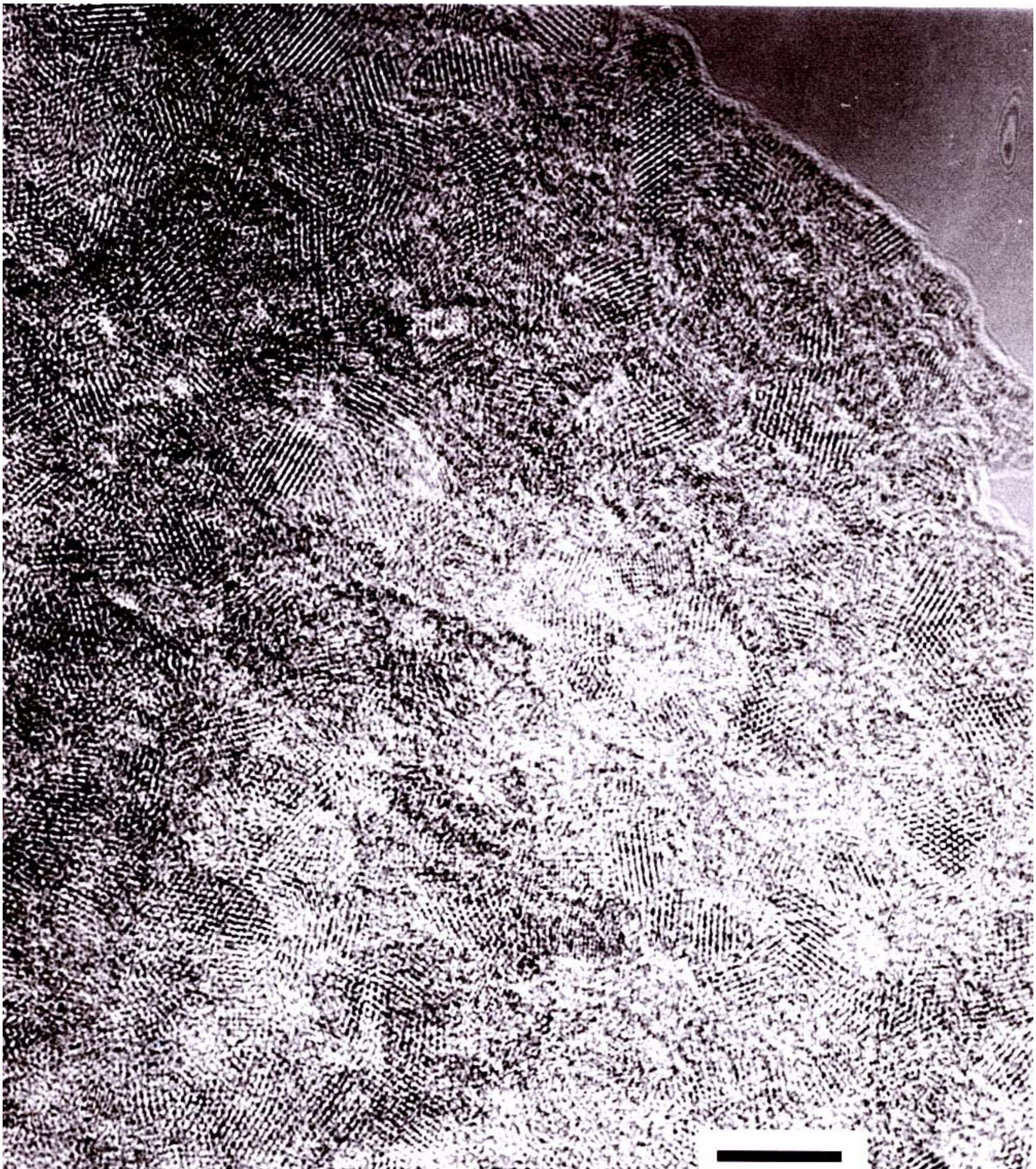

YSZ thin film annealed at 400°C for 2 hrs. dg= 6nm

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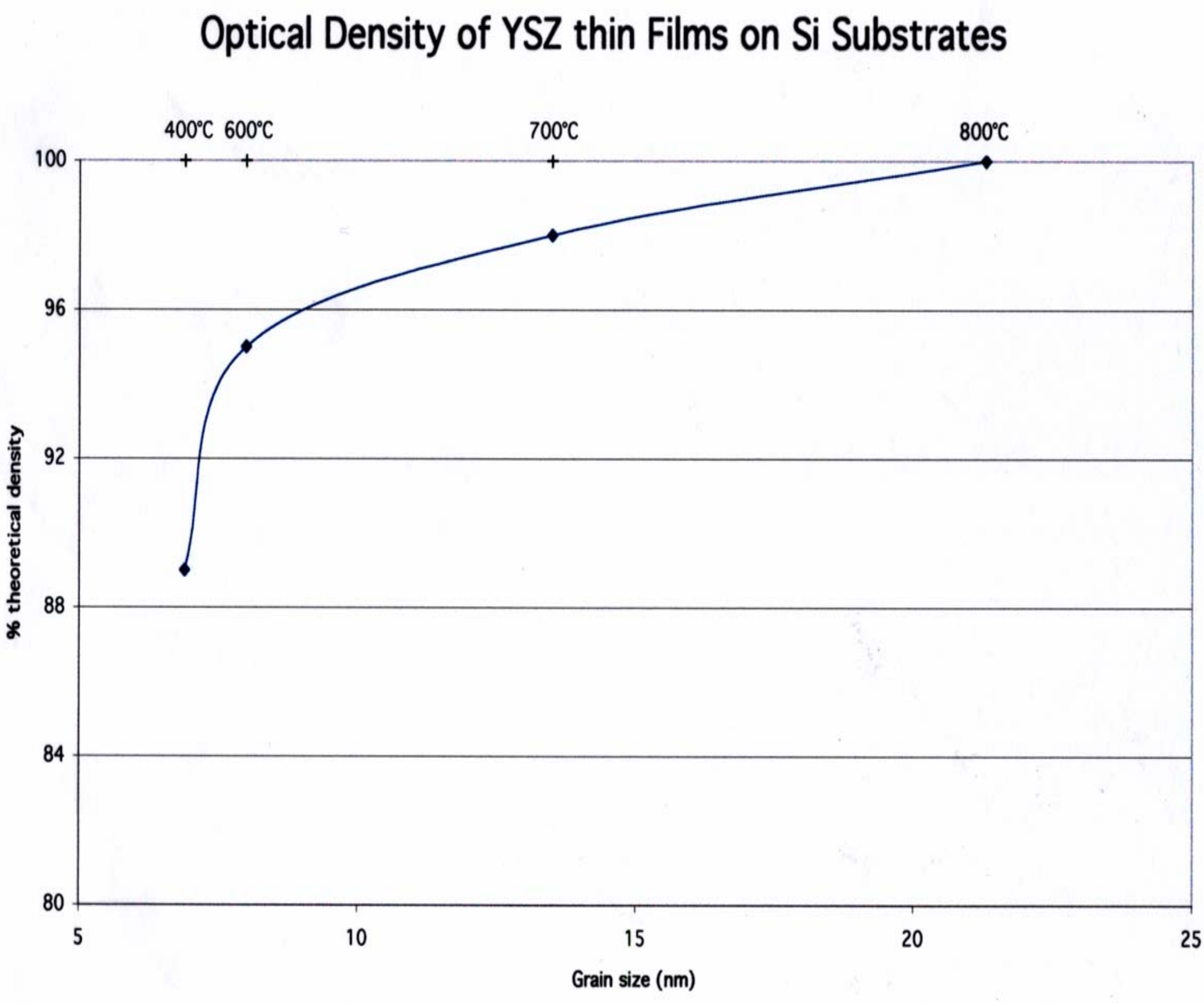

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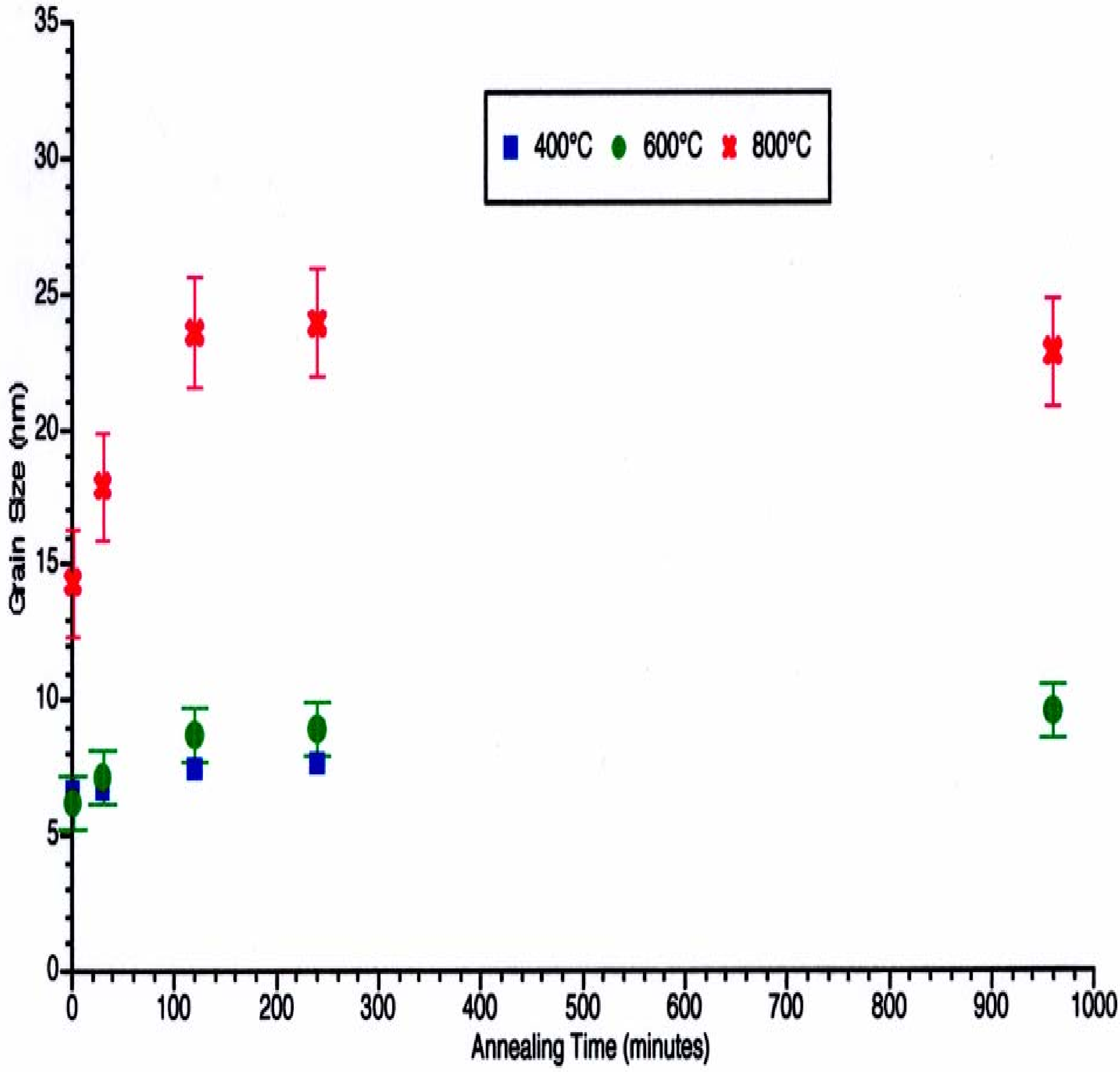

Grain size versus time for unsupported YSZ thin films at different annealing temperatures.

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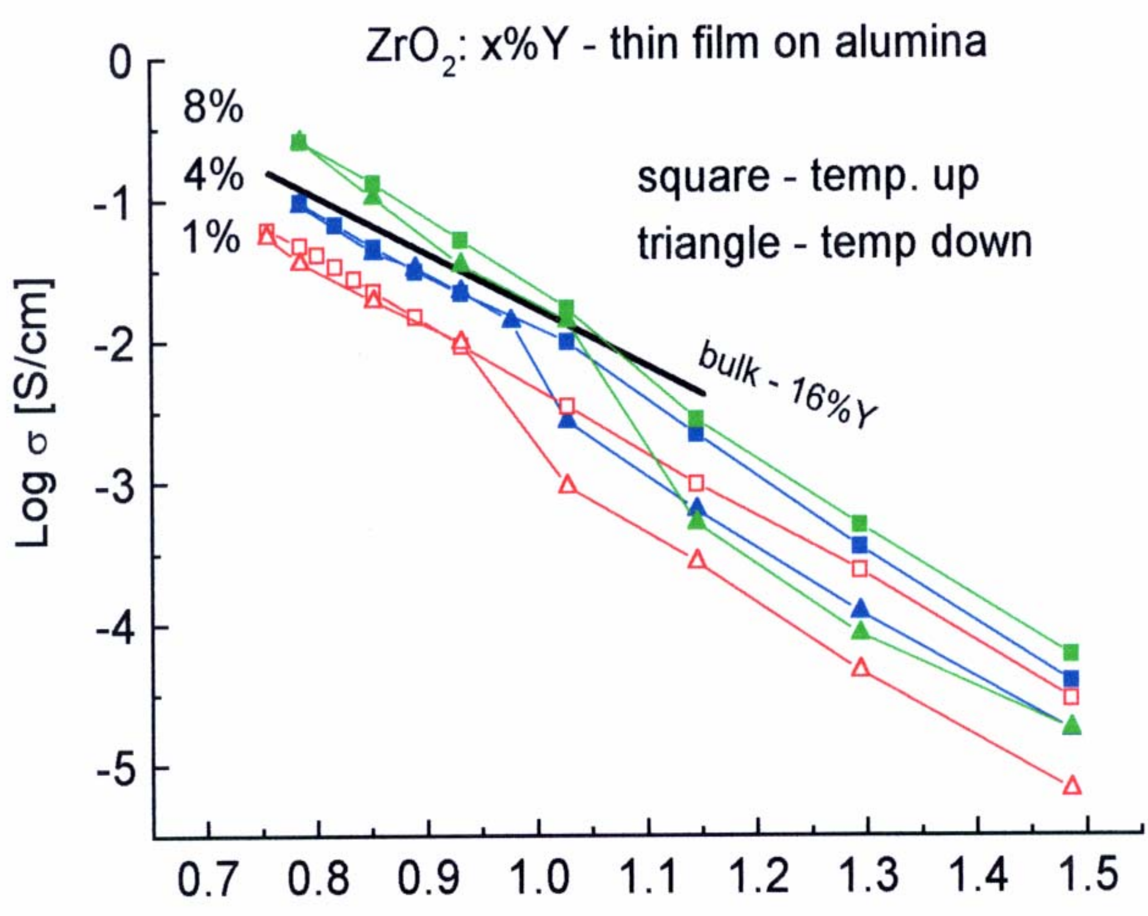
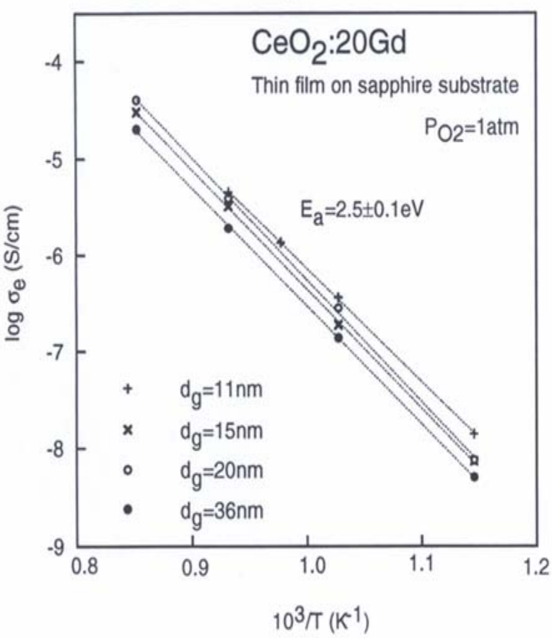

ZrO2: x%Y - thin film on alumina
8%
4%
1%
square - temp. up
triangle - temp down
bulk - 16%Y
Log σ [S/cm]
0
-1
-2
-3
-4
-5
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5

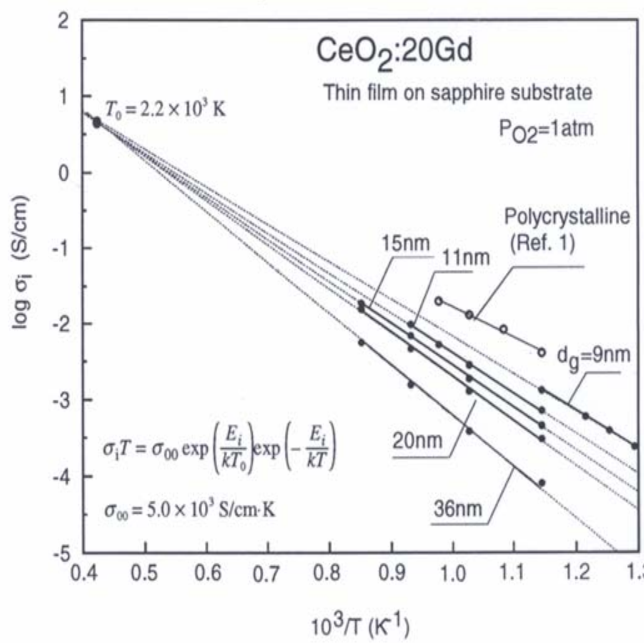
- **Films of Undoped and Gd Doped CeO_2 Characterized**
  - **The electrical conductivity of both doped and undoped CeO_2 show grain size dependence**
  - **Ionic conductivity of nanocrystalline Gd doped CeO_2 less than that of the microcrystalline**
  - **Electronic conductivity enhanced as grain size decreases below 50 nm**

Electronic & Ionic Conductivity of CeO_2:20Gd

Elecronic conductivity



Ionic conductivity



σ_i (microcrystalline) > σ_i (nanocrystalline)

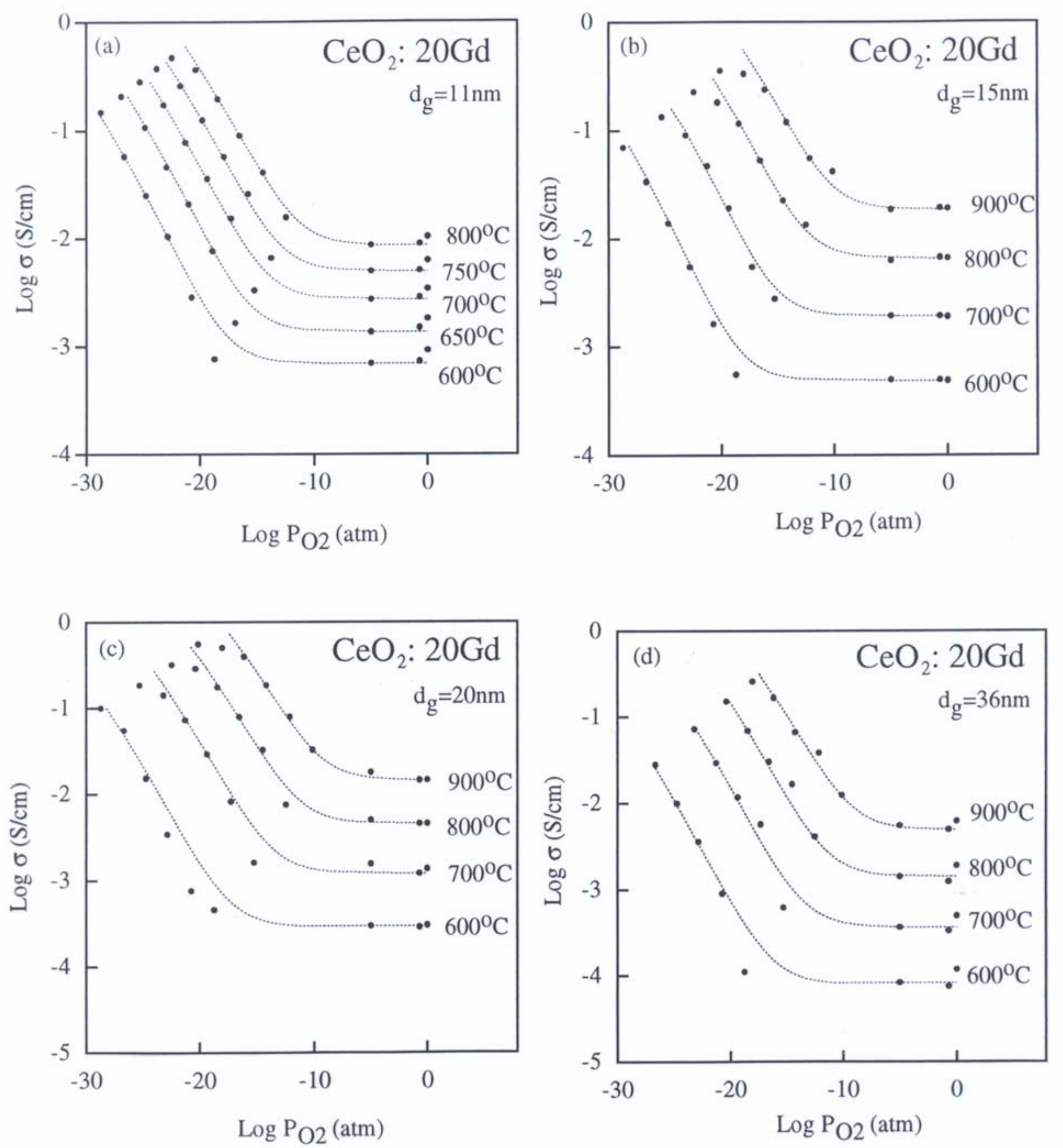
E_i = 0.8eV

E_i = 1.3 → 1.0 eV

(d_g = 36 → 9 nm)

grain boundary conductivity

Ref.1 S. Lubke and H. D. Wiemhofer. Solid State Ionics, 117:229-243, (1999).



The electrical conductivity of CeO_2 :20Gd thin films as a function of oxygen partial pressure and temperature. (a) d_g = 11 nm (b) 15 nm (c) 20 nm (d)36 nm. Film thickness = 300 - 400 nm.

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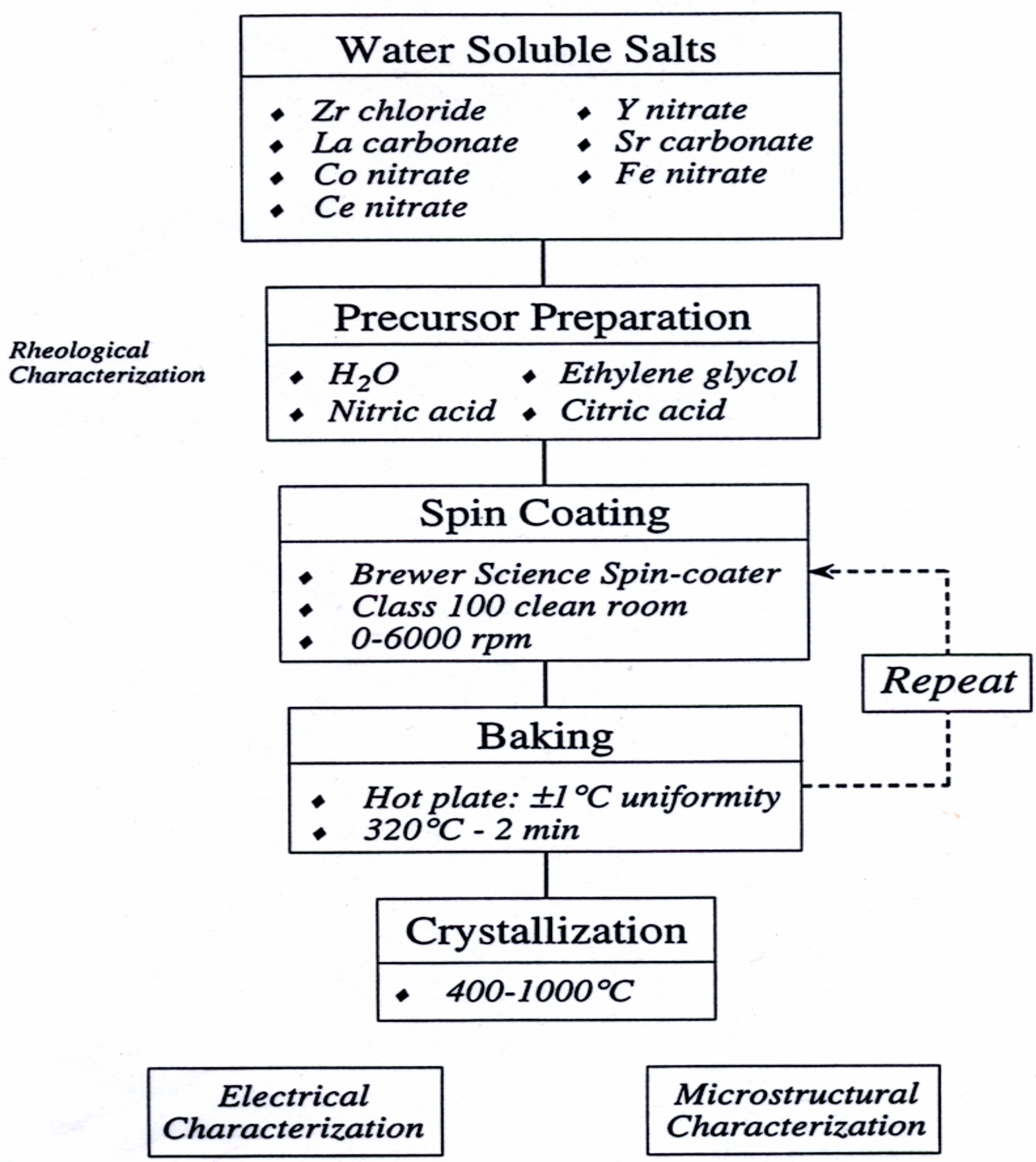

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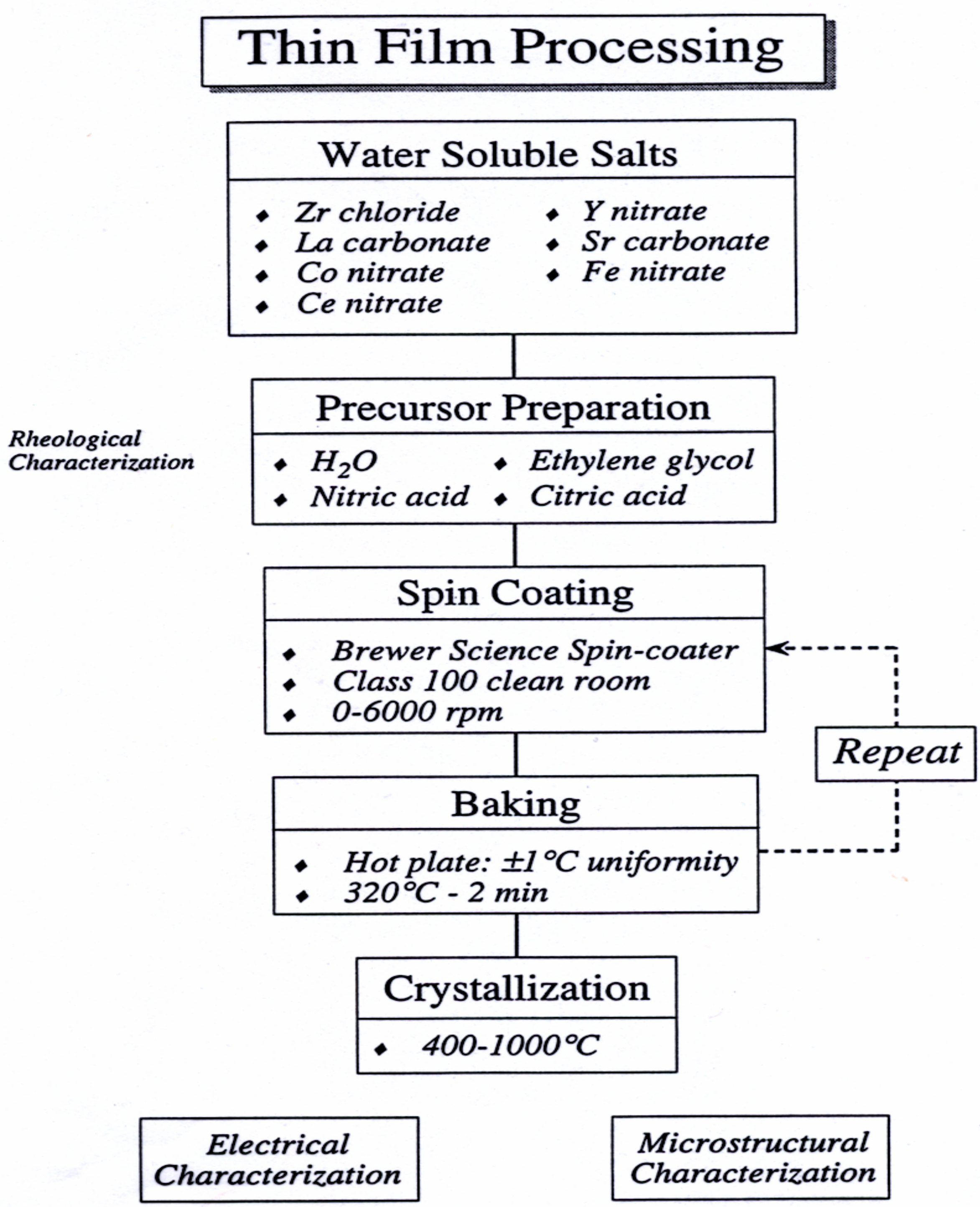

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