FC/BT Center for Fuel Cell & Battery Technologies

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www.fcbt.gatech.edu

Vision for Center

- ***Catalyst*** for revolutionary advances in fuel cell and battery technologies through world-class research integrated across disciplines and transitioning fundamental discovery to system-level innovations.

- ***Partnership*** with leading industry & government organizations to provide enabling technologies and to assist in commercial product realization.

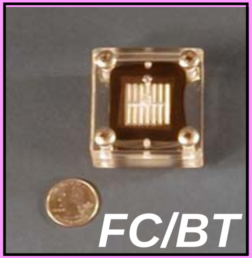
- ***Educational service*** to a broad range of clients, including industry professionals, university students, and aspiring (K-12) scientists & engineers.

Market Focus

Distributed stationary power supplies

Courtesy of IFC

Compact power sources for portable and remote applications



Ultra-low emission vehicles

Core Capabilities

- Electrochemistry and materials science
- Nanostructured materials & MEMS fabrication
- Fluid dynamics, acoustics, and controls
- Simulation and modeling
- Advanced manufacturing processes
- Power electronics, transmission, and distribution (joint with NEETRAC)
- Systems-level integration and applications

New Electrode Materials for Low-Temp SOFCs

C. Xia, X. Lu, and M. Liu

Georgia Institute of Technology

DOE – University Coal Program

DARPA/DSO - Palm Power Program

SWPC - SECA Core Technology Program - TBN

Advantages of SOFCs

The cleanest, most efficient & versatile system
for chemical to electrical energy conversion

Challenge: Cost Reduction

- Materials selection: inexpensive materials
- Fabrication processes: simple & cost-effective

Approach I: Lower operating Temp

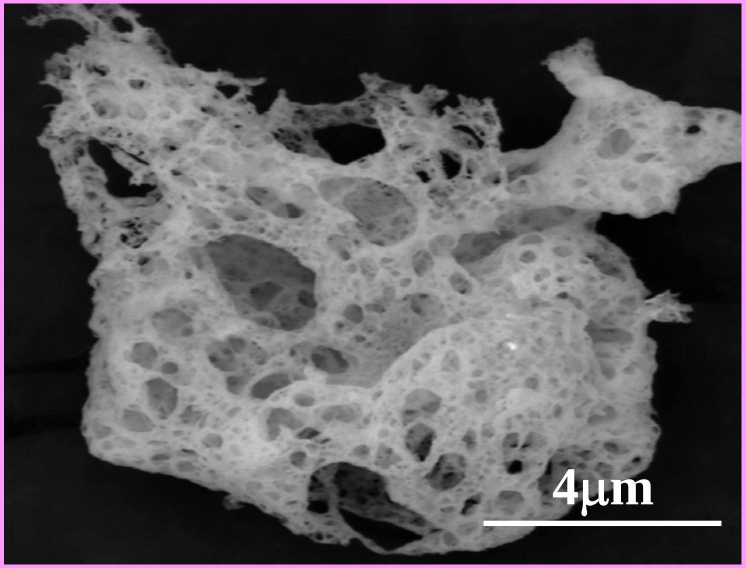
- Advantages
  - Inexpensive metallic components may be used for interconnect, heat exchanges, and other components
  - Greater system reliability & longer optional life
  - Potential for mobile applications
- Challenges
  - Conductive electrolytes
  - **Catalytically active electrodes**
  - **Macro- & meso-porous electrodes/interfaces**

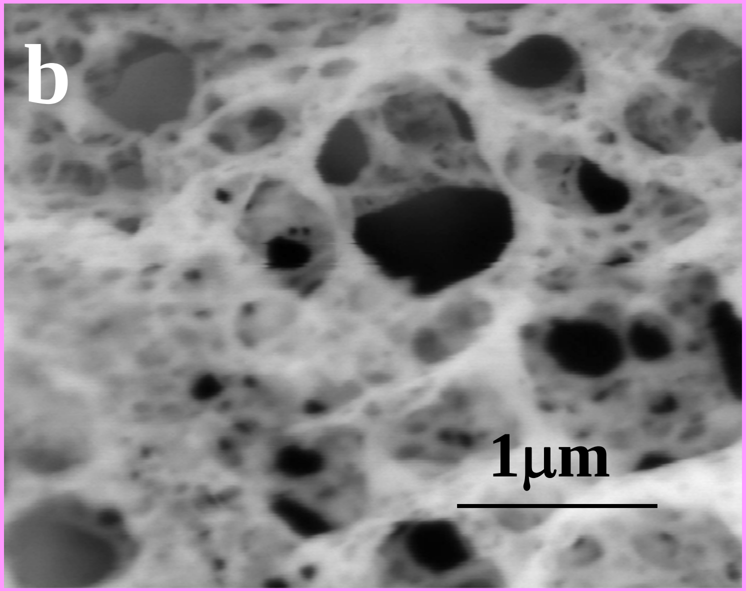
Approach II: Cost-Effective Fabrication

- Fabrication Techniques
  - Screen Printing
  - Dry Pressing
  - Co-Extrusion
- Advantages
  - Simple, inexpensive, reproducible
- Challenges
  - How to retain competitive performance

Solid Oxide Fuel Cells Fabricated by GNP and Screen-Printing & Dry-Pressing

Characteristics of GDC Powder by GNP





Large surface area

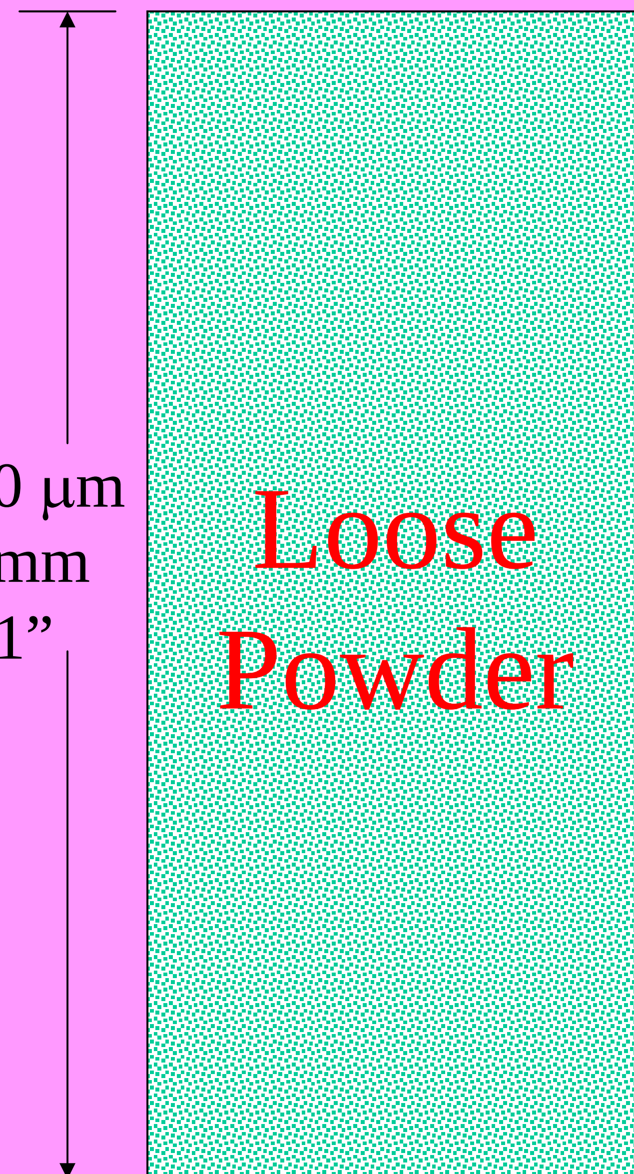
Compositional homogeneity

Loose agglomerates
Foam-like structure
Fill density 0.059 g/cm^3
120th of theoretical value

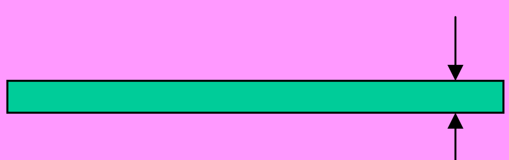
Easy to densify
92% at 1250^{o}C/5 hrs
95% at 1350^{o}C/5 hrs

Dry Pressing of GNP Powder

The thickness of the loose powder is about 120 times that of the dense film

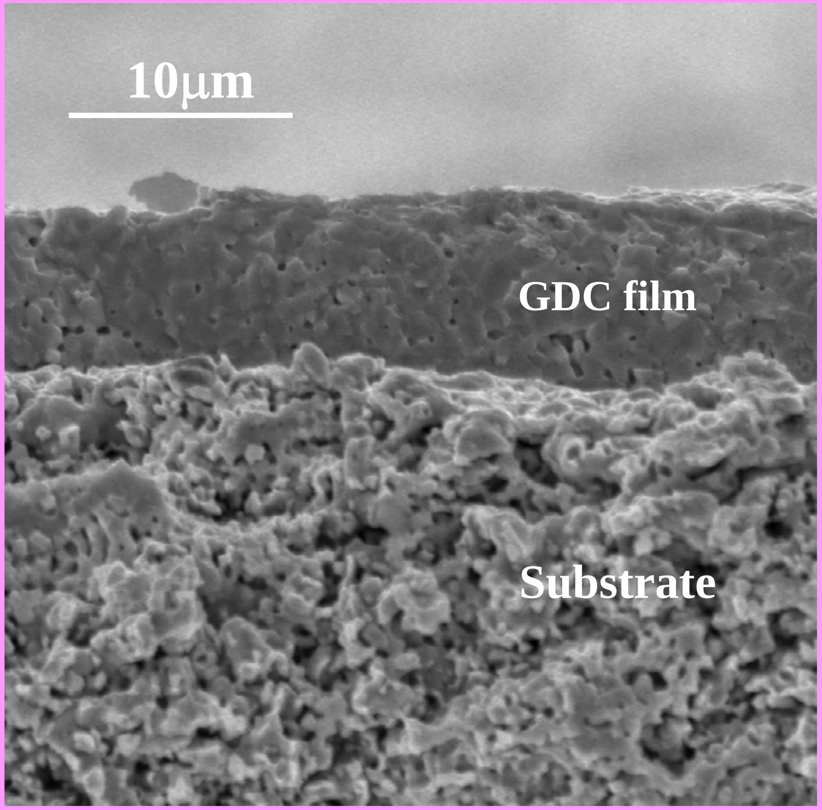


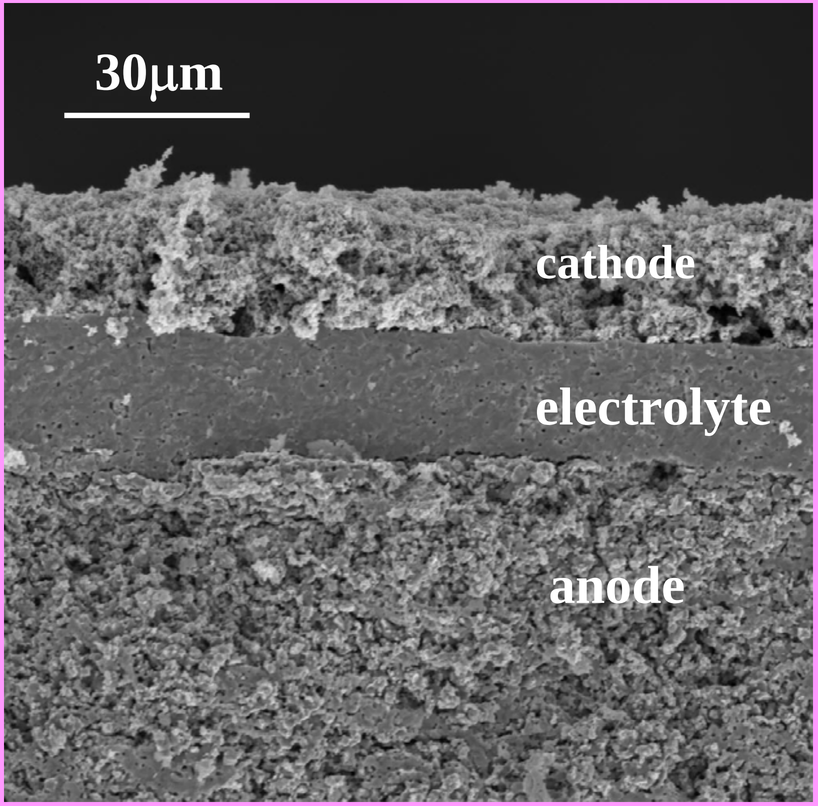
Dense Film



The thinnest: 8 μm

Microstructures of Dry-Pressed Films



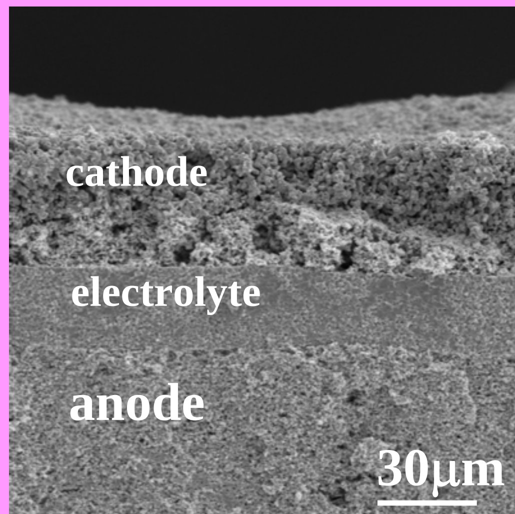


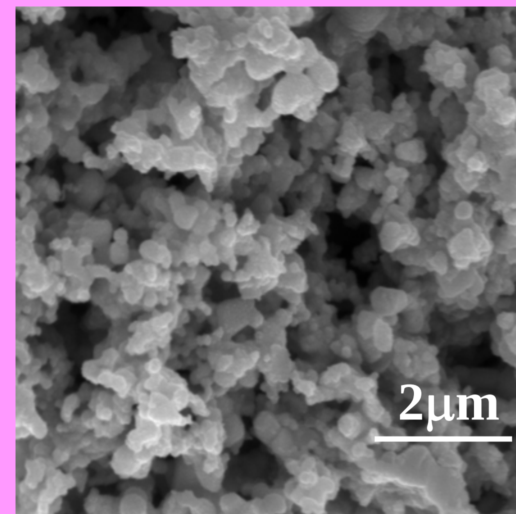
~8 μm

~15 μm

SOFCs Fabricated by Screen-Printing

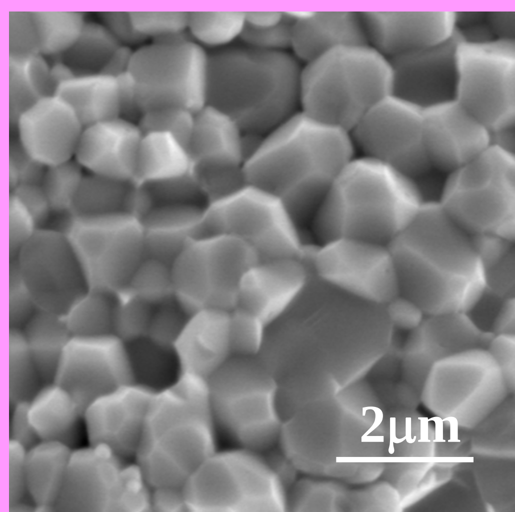
A single cell

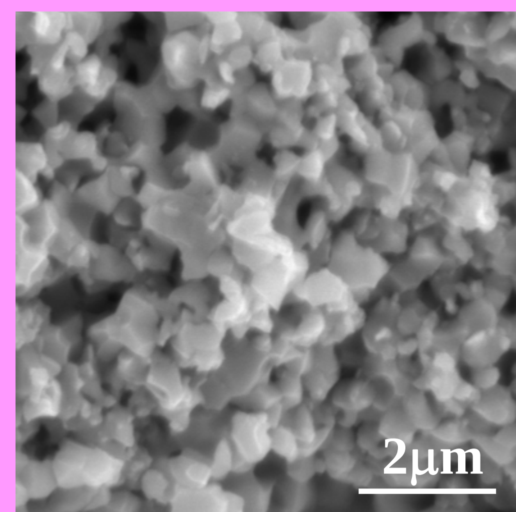




Porous SSC and 10 v%SDC Cathode

Dense SDC

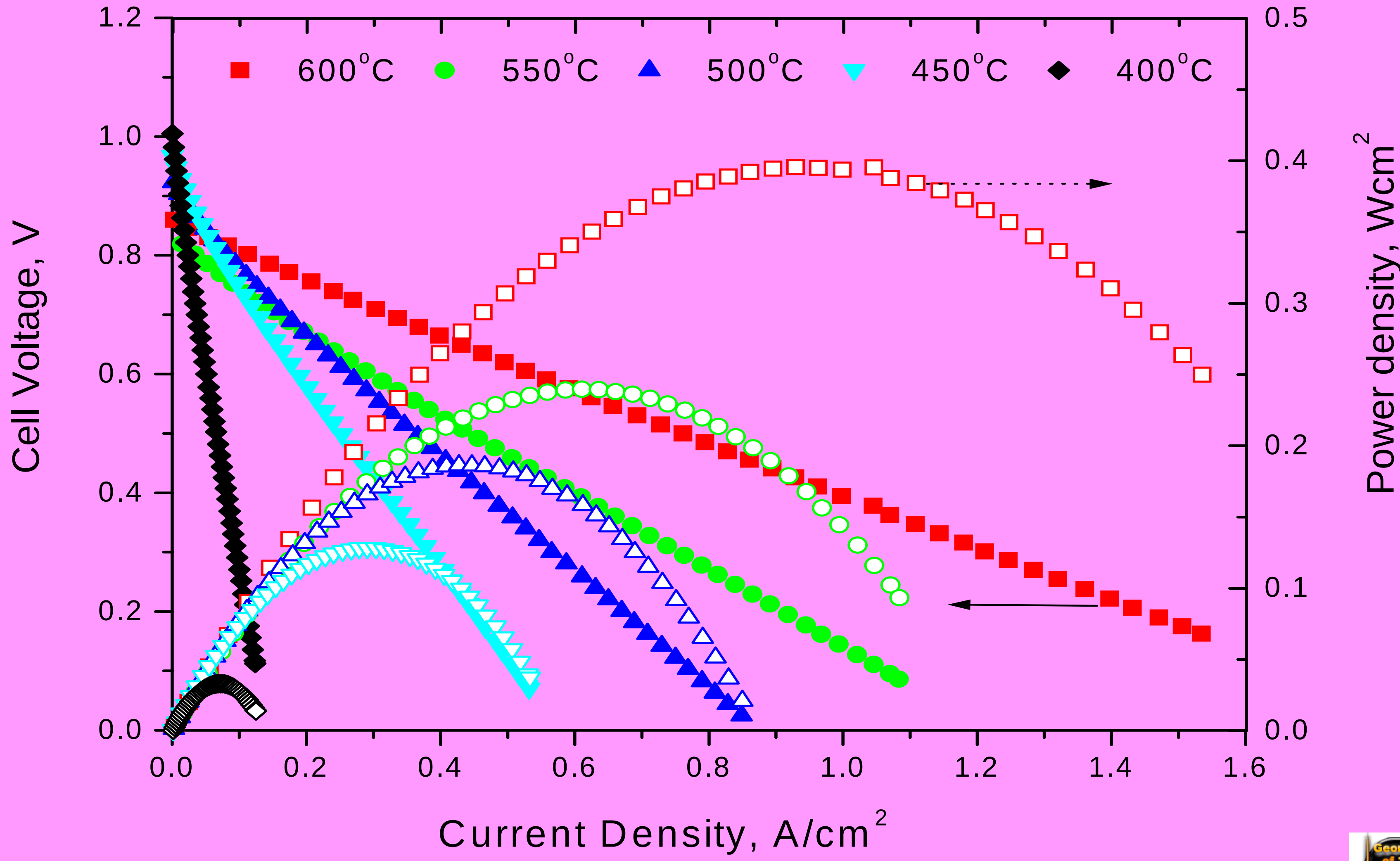




Porous Ni-SDC Anode

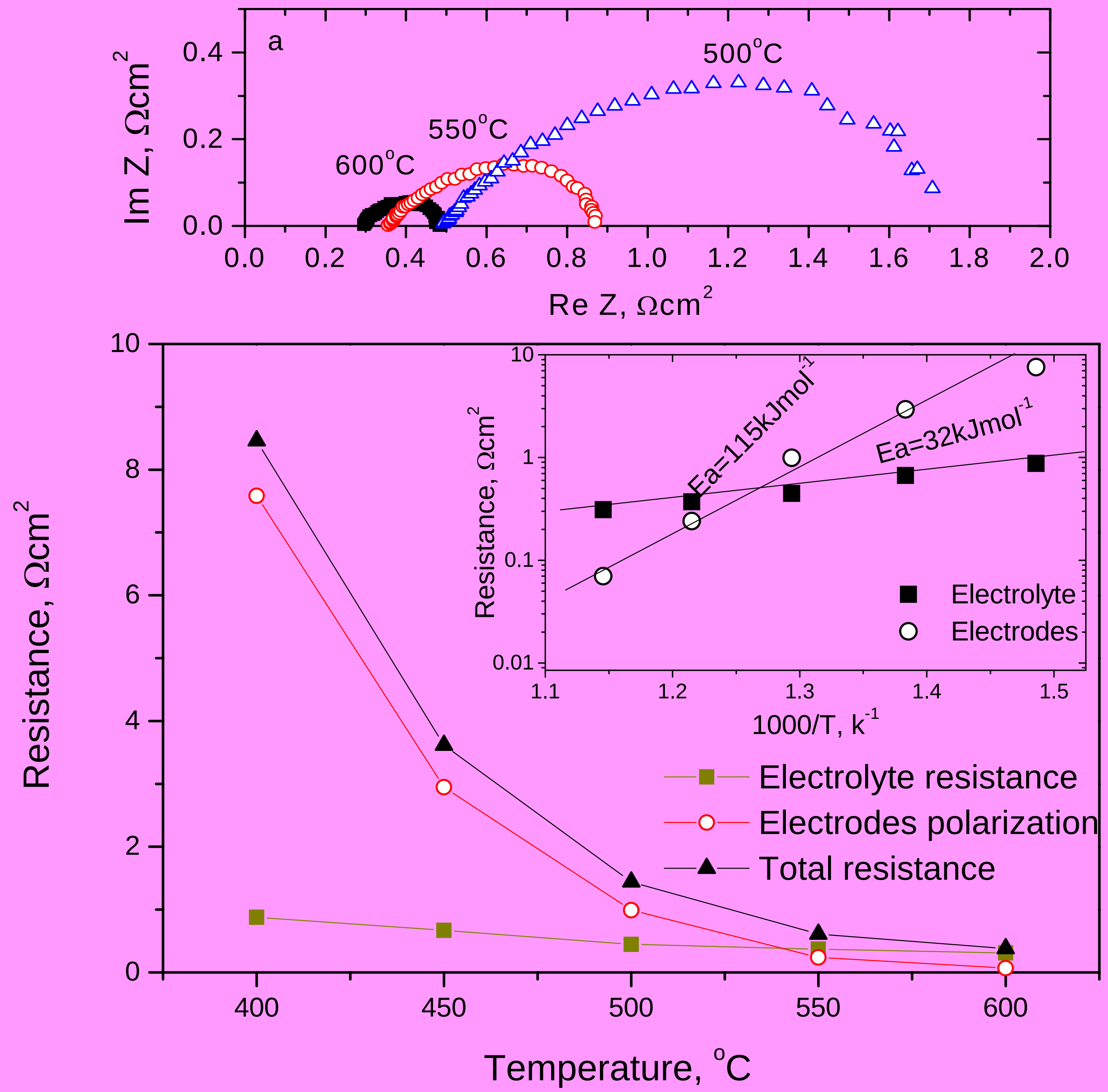
Changrong Xia, Fanglin Chen and Meilin Liu, Electrochemical and Solid State letters, 4(5) A52-A54 (2001).

Single Cell Performance at 400-600ºC



Fuel: humidified (3 v% H_2O) hydrogen; oxidant: air

Significance of Interfacial Resistances



Nano-structured Electrodes and Interfaces for Solid Oxide Fuel Cells

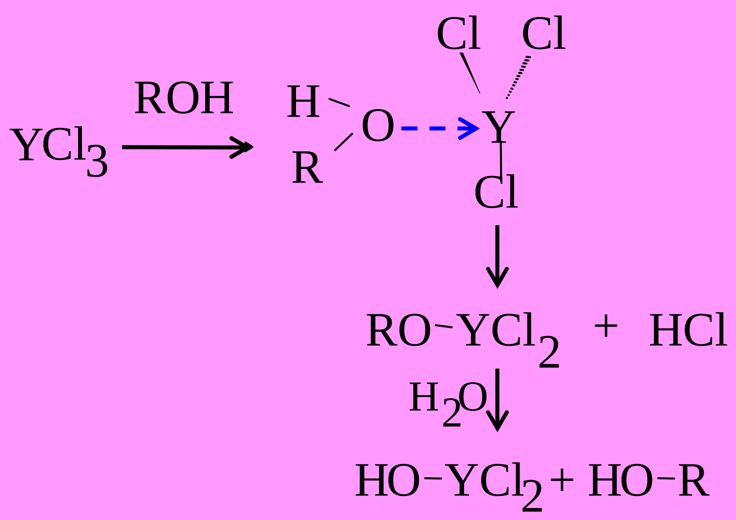
Preparation of Mesoporous YSZ-NiO

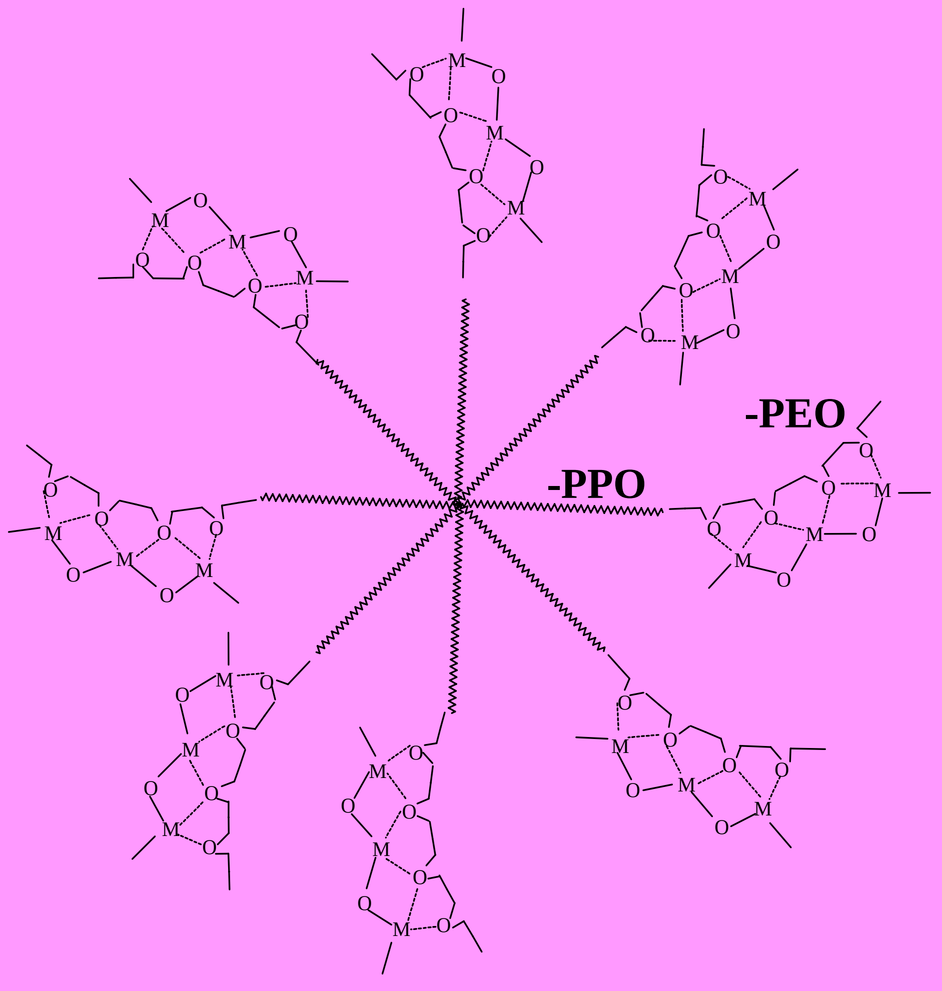
$(PEO)_m(PPO)_n(PEO)_m$

(Surfactant)

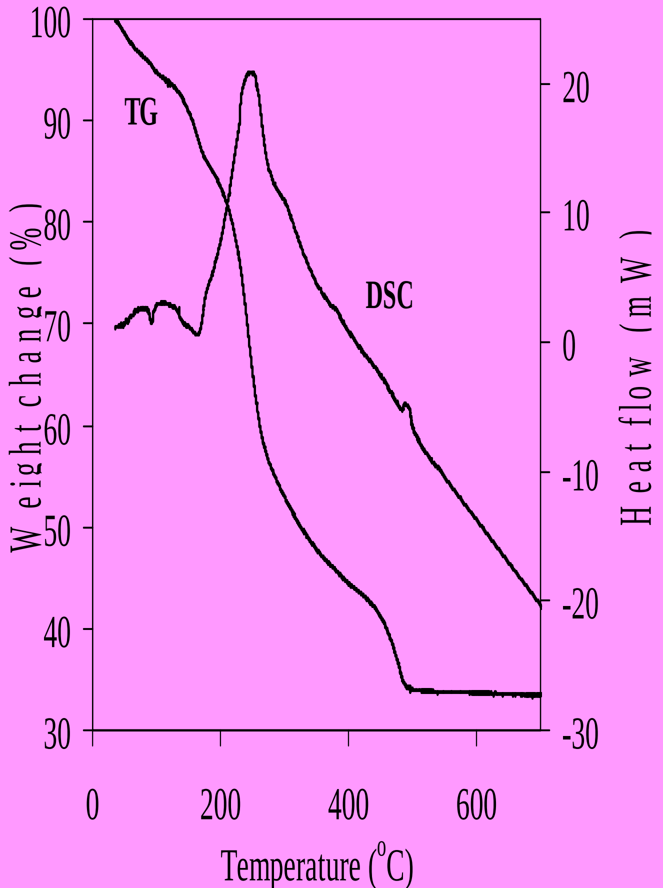
$ZrOCl_2$ + YCl_3 + $NiCl_2$

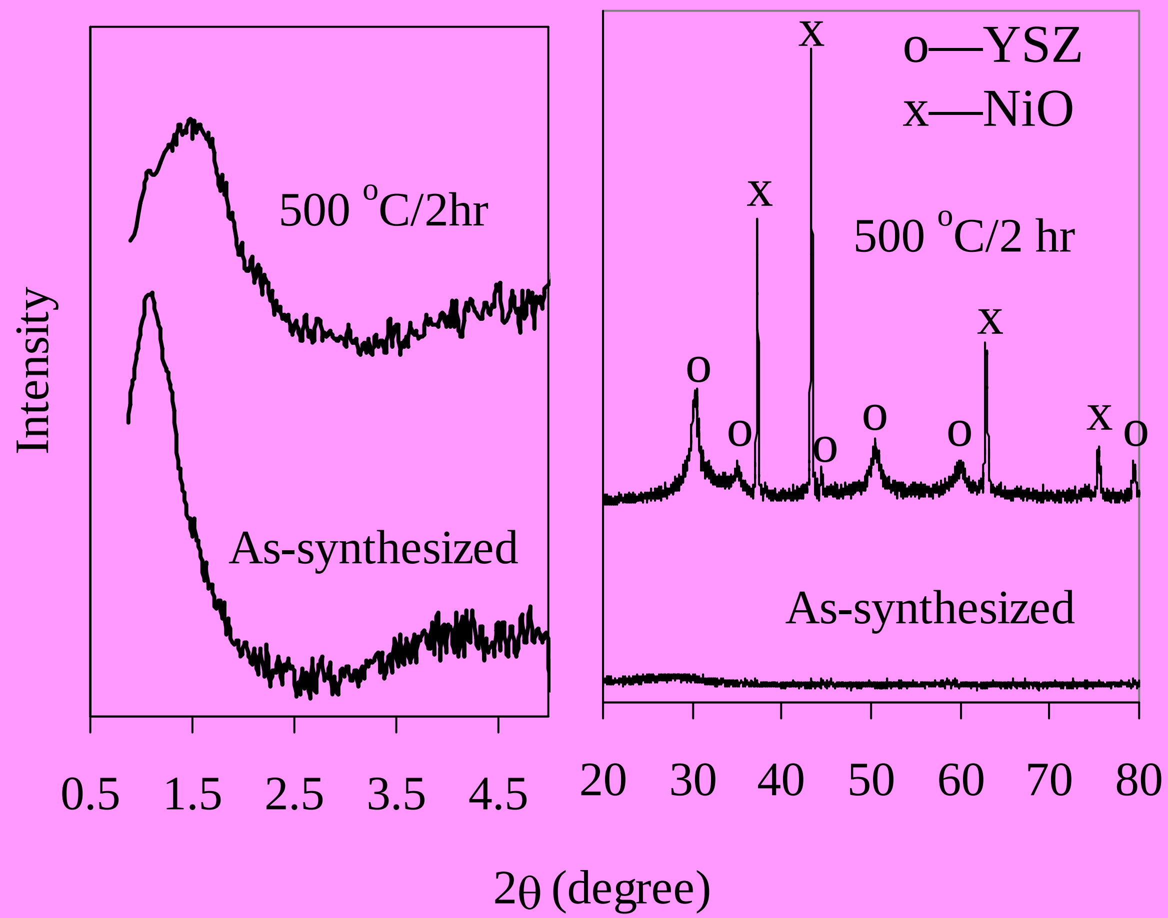
(Inorganic species)





TG-DSC, XRD of Mesoporous YSZ-NiO





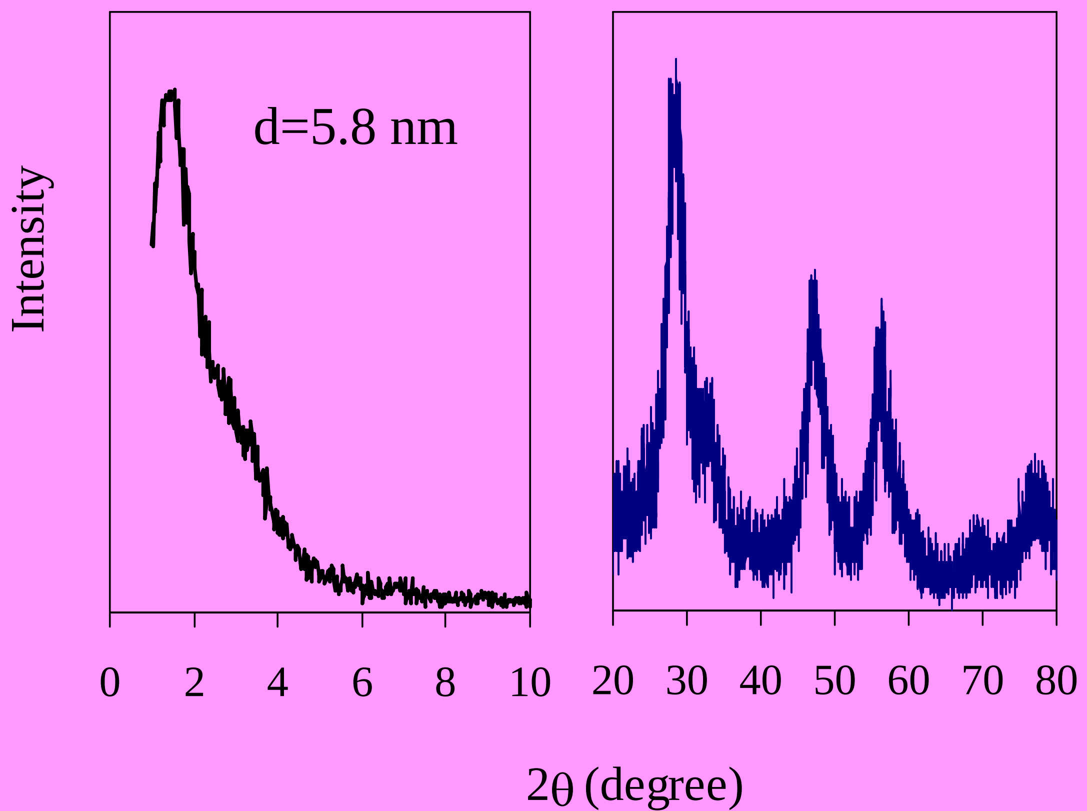
Formation of Mesoporous CeO_2

$(NH_4)_2Ce(NO_3)_6$

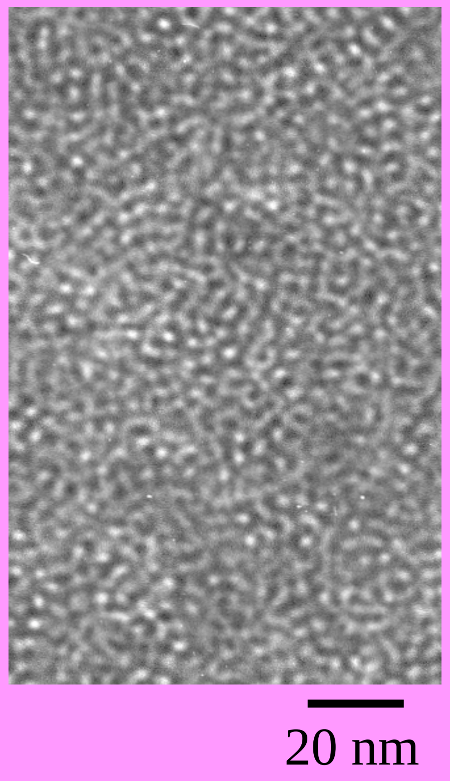
$CH_3(CH_2)_{15}N(CH_3)_3Br$

} $CH_3(CH_2)_{15}N\ (CH_3)_3{}^{+}\quad {}^{2-}Ce(NO_3)_6$

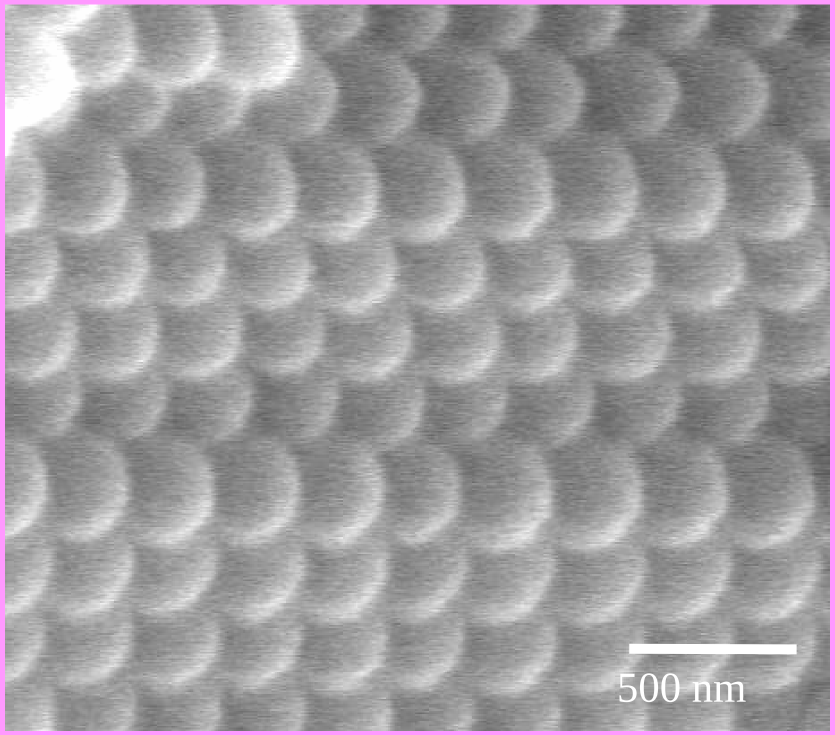
XRD

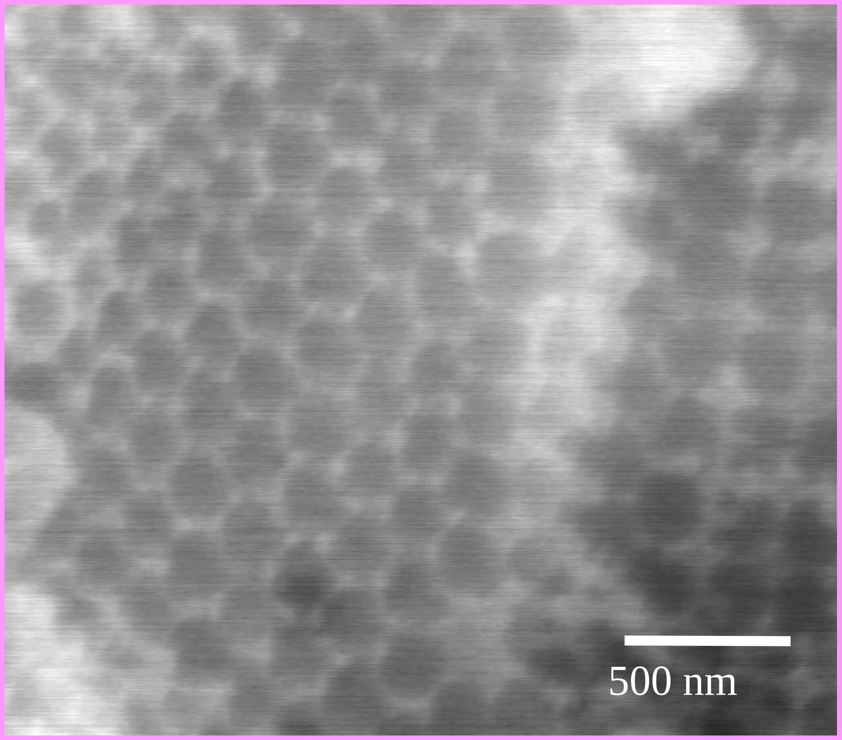


TEM



Micrographs of PS & $Sr_{0.5}Sm_{0.5}CoO_3$

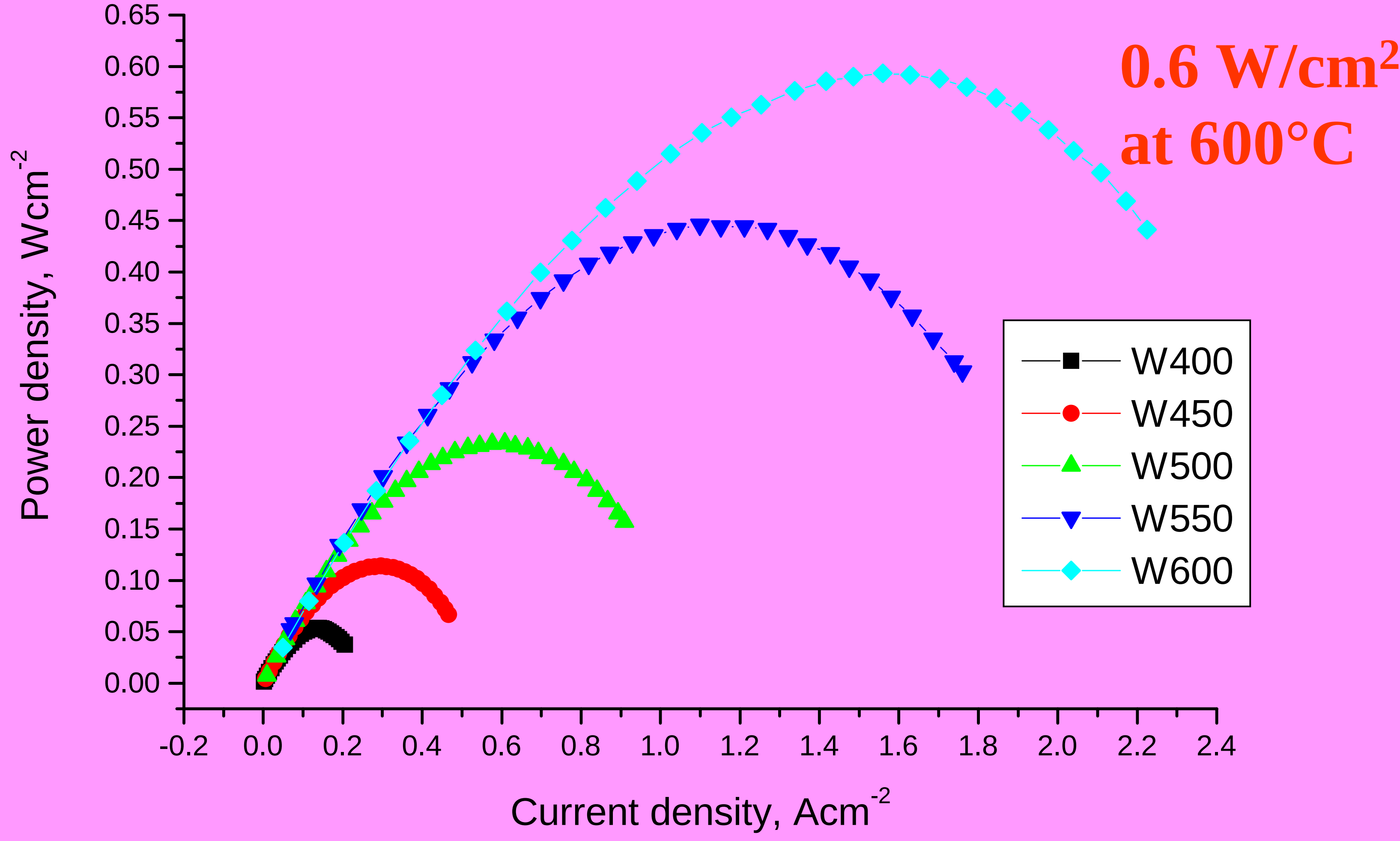




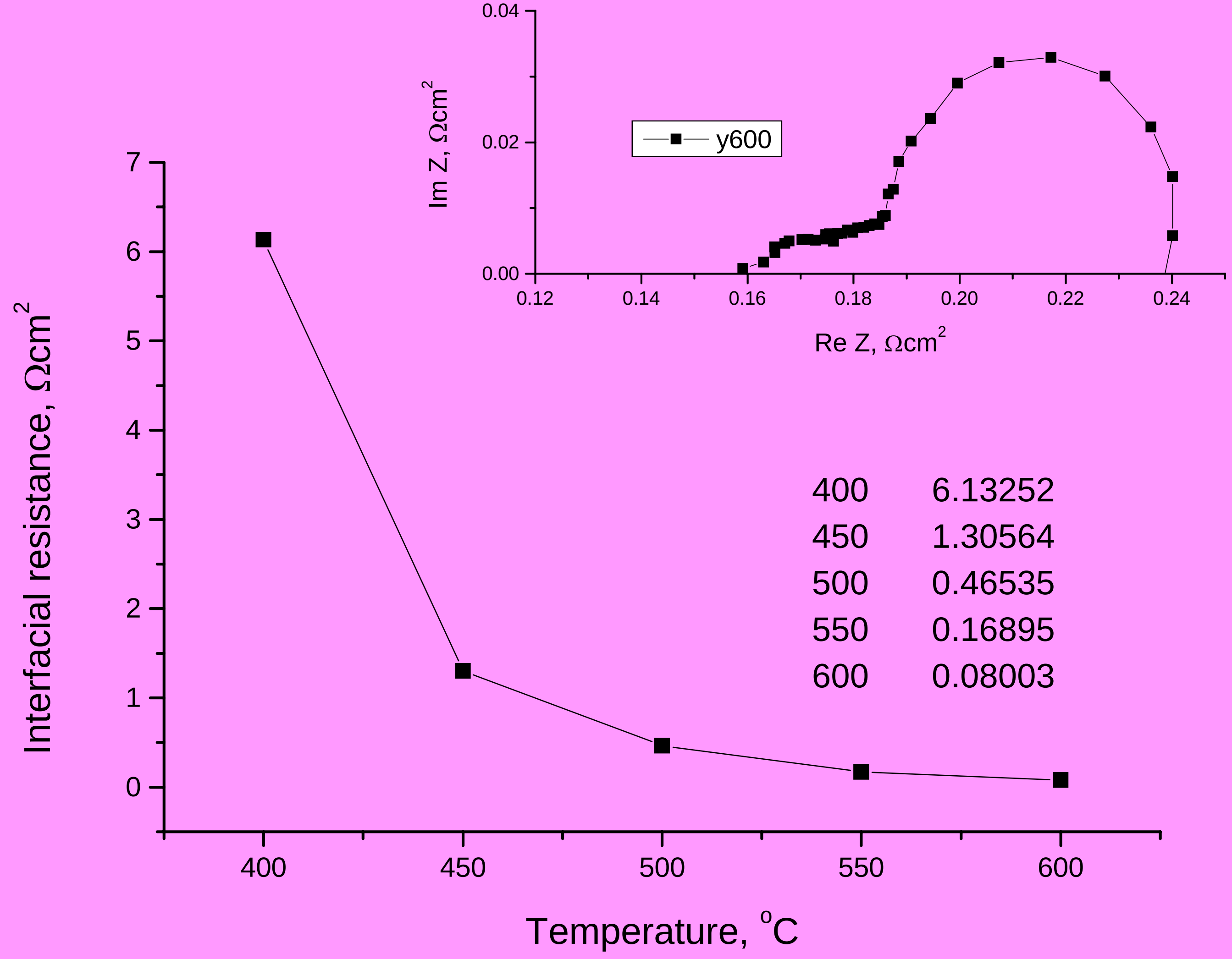
Polystyrene Spheres

$Sr_{0.5}Sm_{0.5}CoO_3$

Performance of a SOFC at 400-600°C



Interfacial Resistances



Developments of Anodes Insensitive to Contaminants in Hydrocarbon Fuels

Materials Investigated

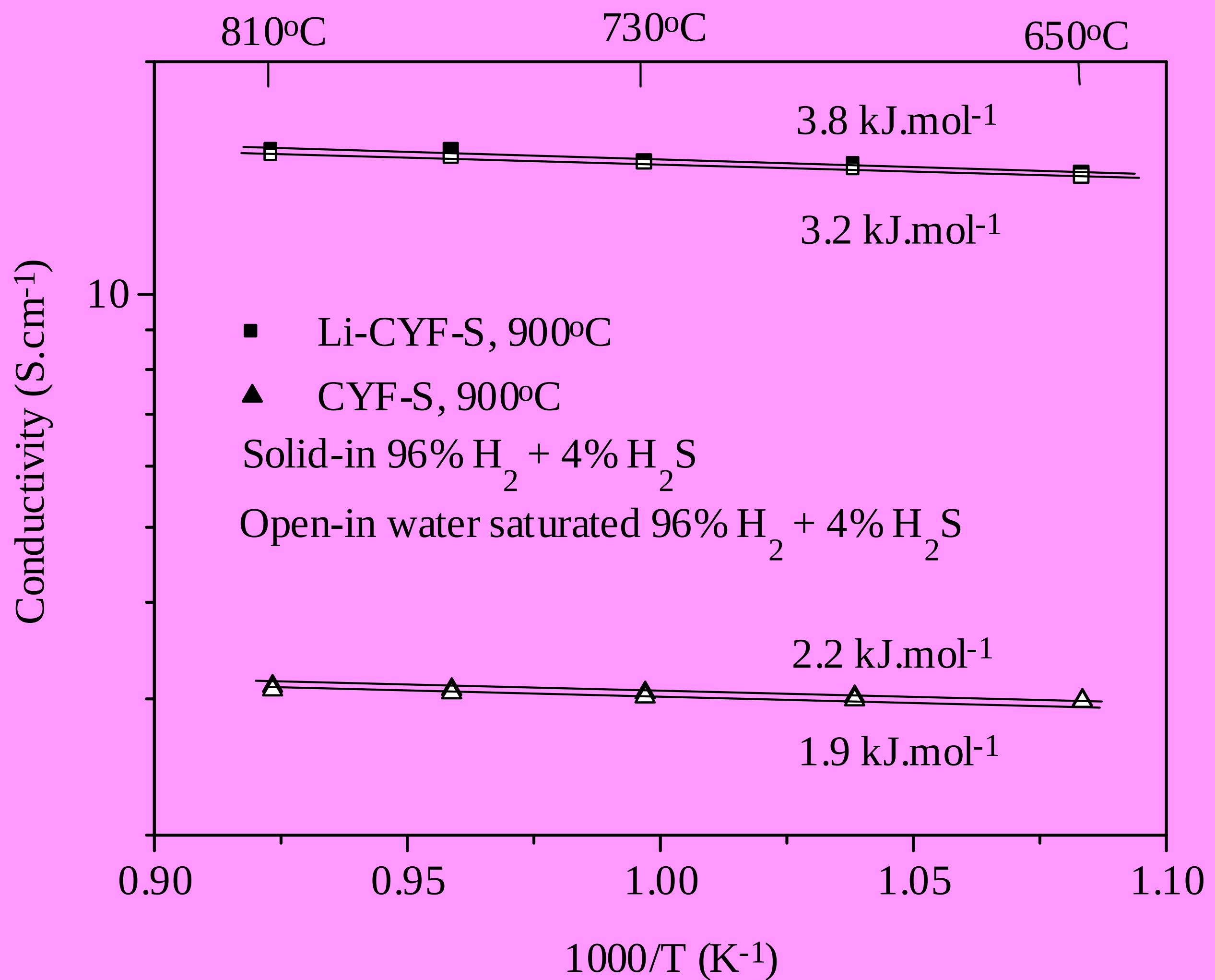
LSGC: $La_{0.9}Sr_{0.1}Ga_{0.8}Cr_{0.2}O_3$; LSGC-S; Li-LSGC-S

LCT: $LaCr_{0.9}Ti_{0.1}O_3$; LCT-S; Li-LCT-S

YCF: $Y_{0.9}Ca_{0.1}FeO_3$; YCF-S; Li-YCF-S

Composites

Arrhenius Plots of Electrical Conductivities



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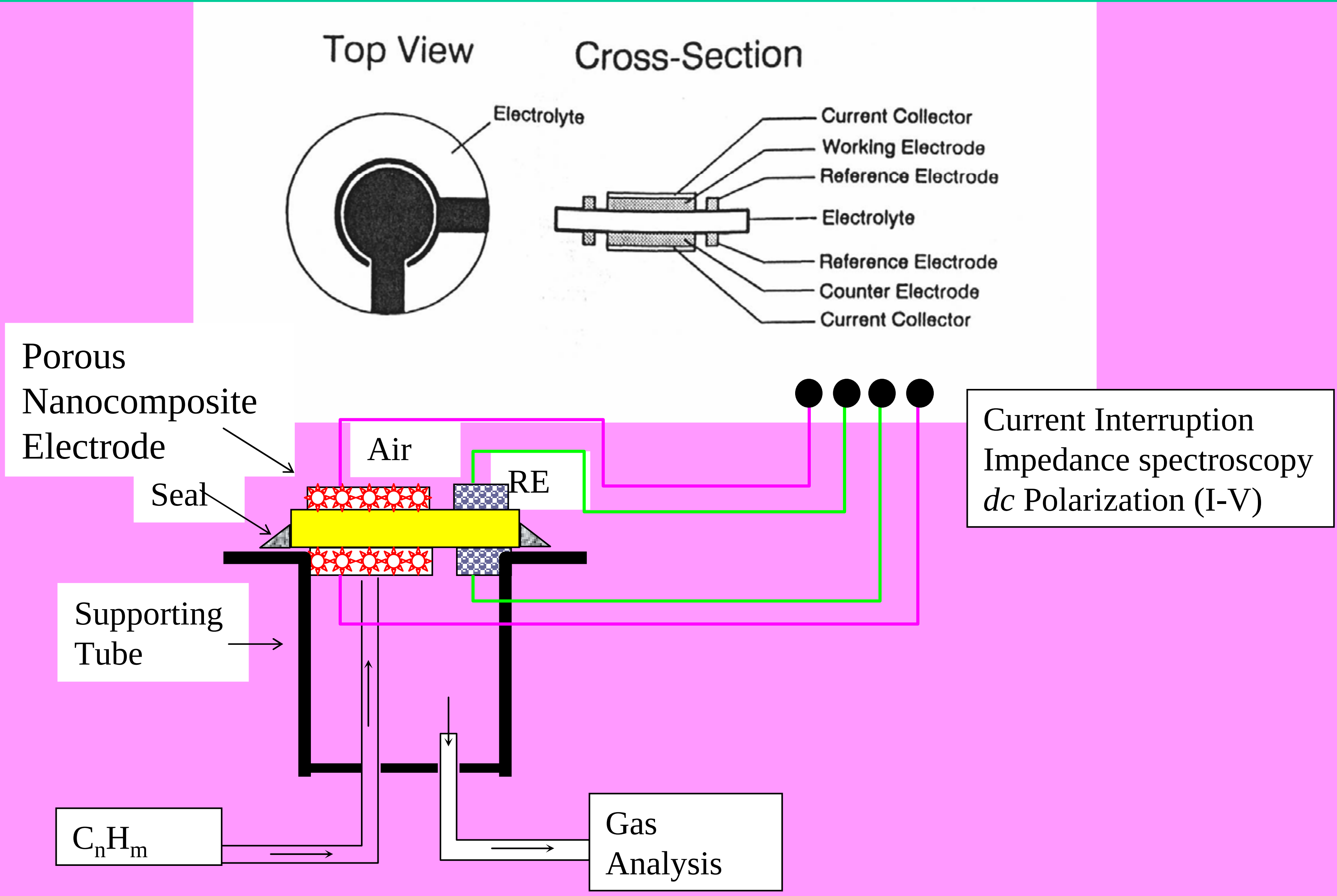
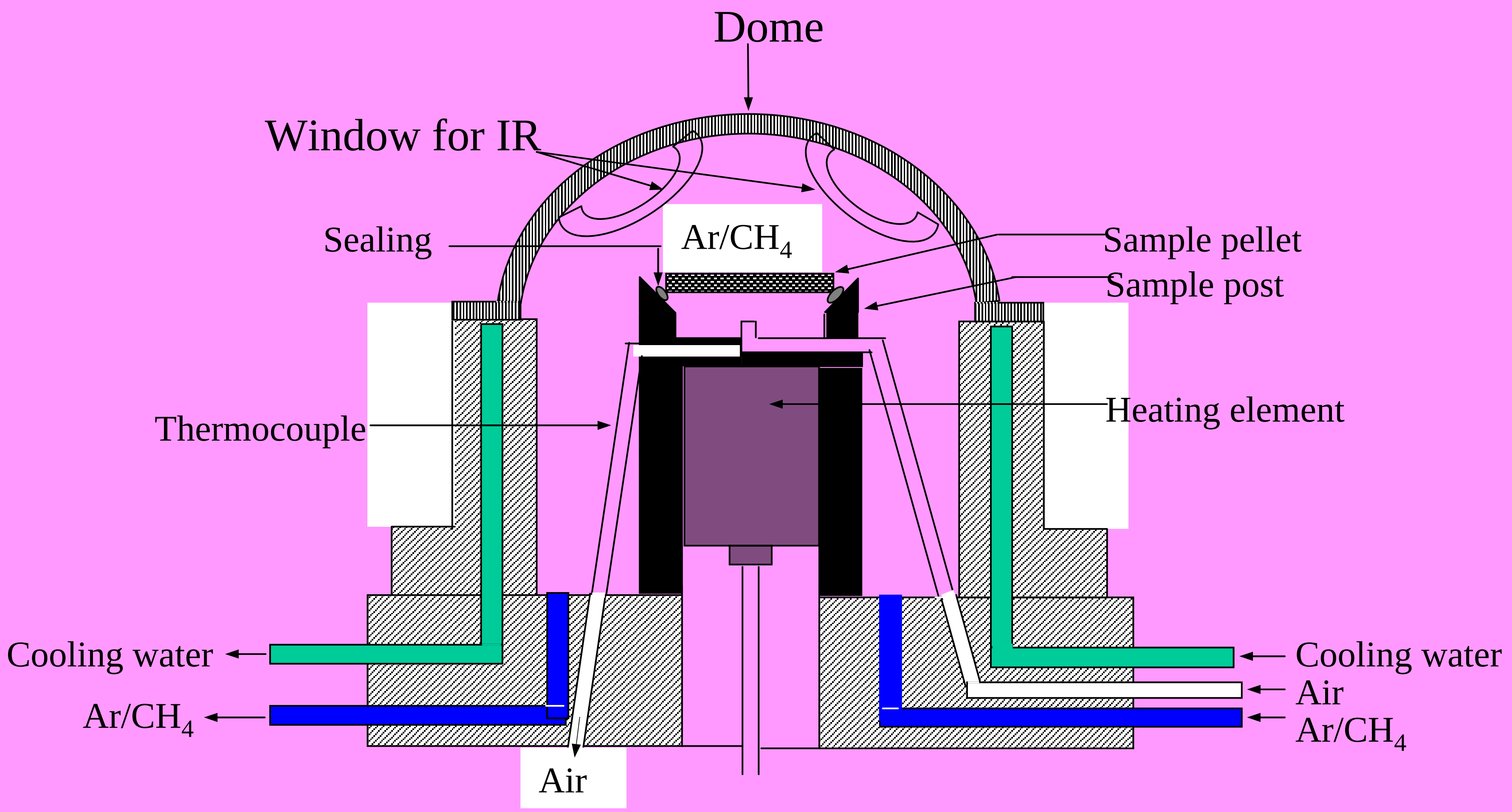
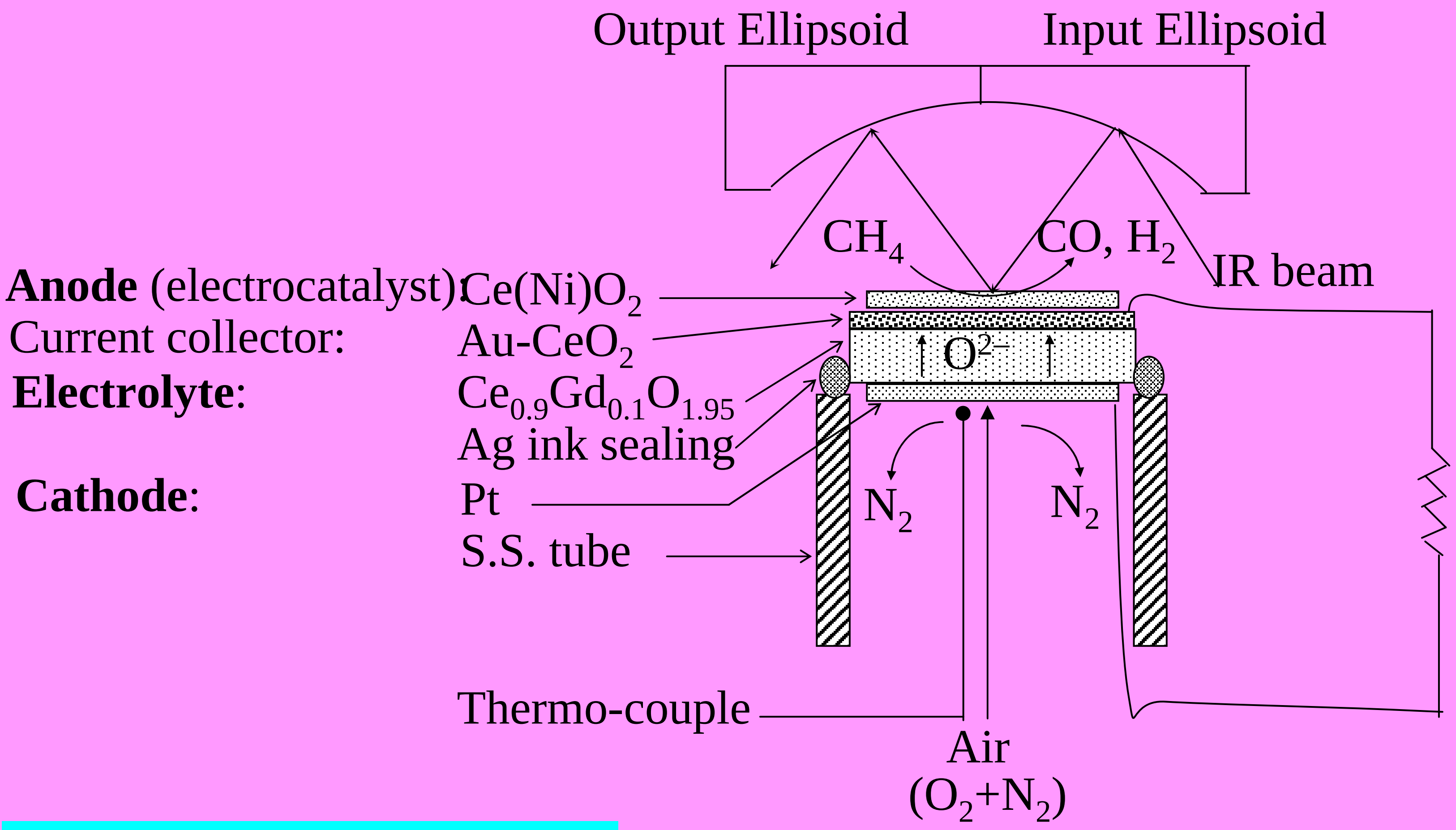
Detailed configuration of
Solid-State Electrochemical Cells



DRIFTS accessory for *in-situ* FTIR analysis



Details of the cell for in-situ DRIFTS



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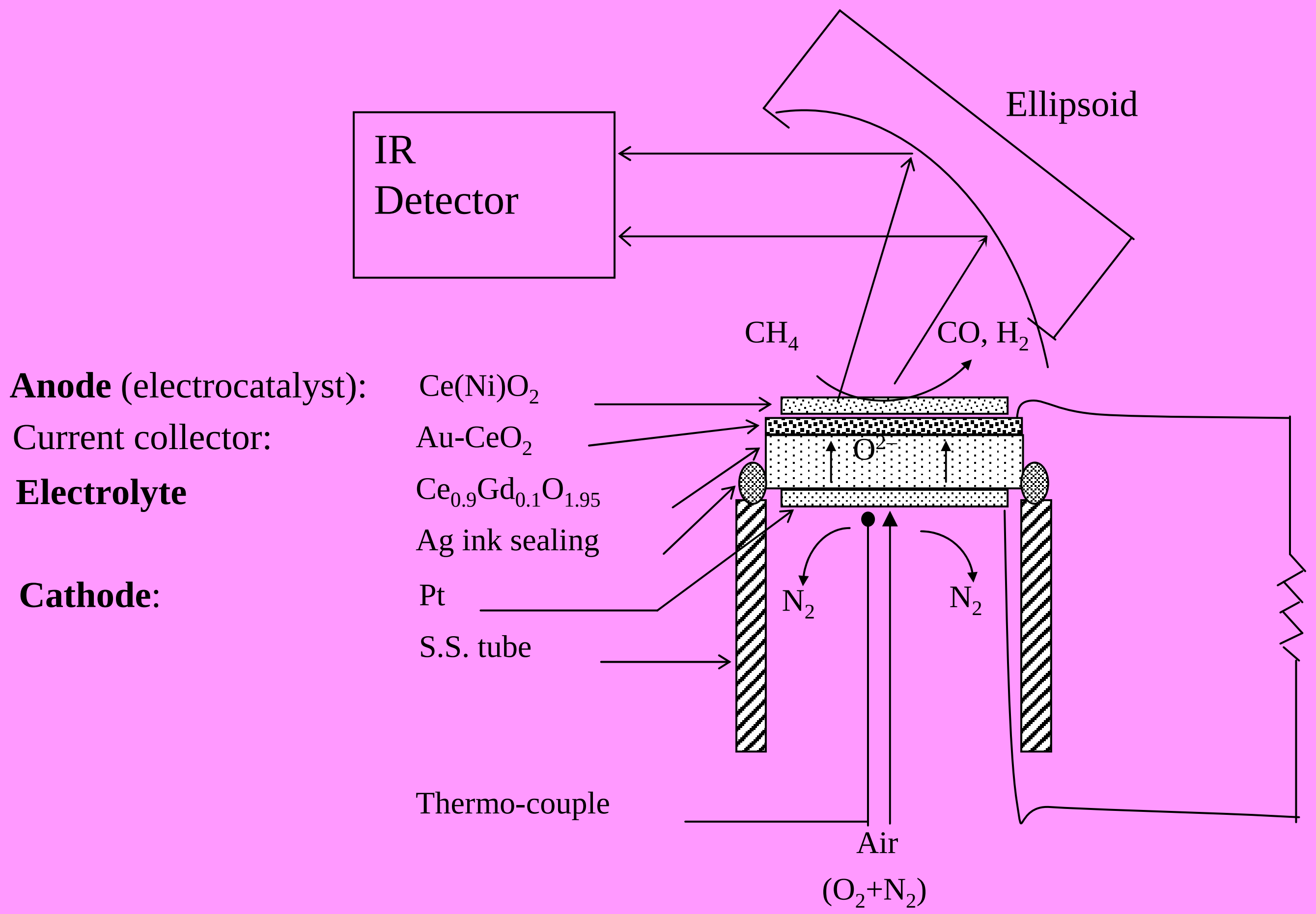
In-Situ IR Emission Spectroscopy



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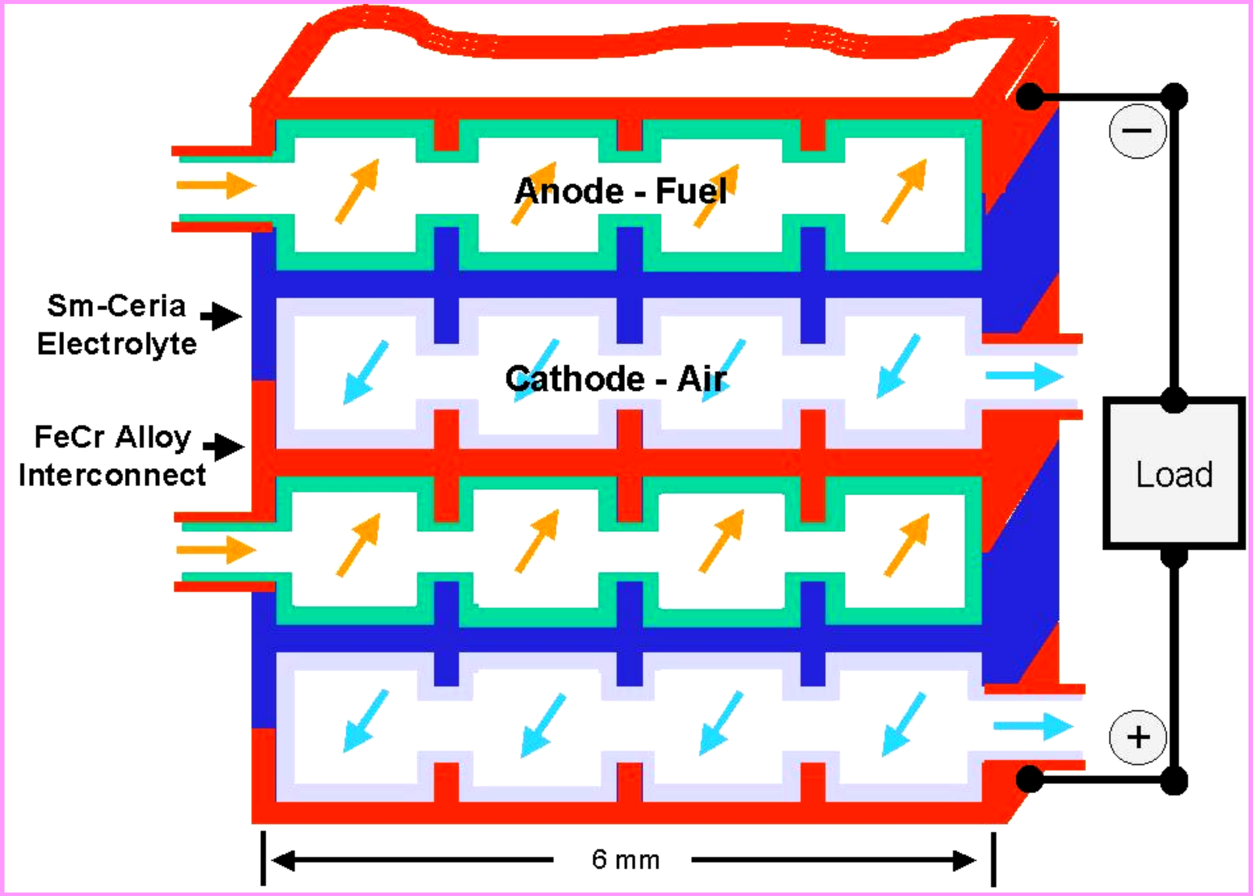
Hybrid Metal/Ceria Monolithic Solid Oxide Fuel Cells

Supported by

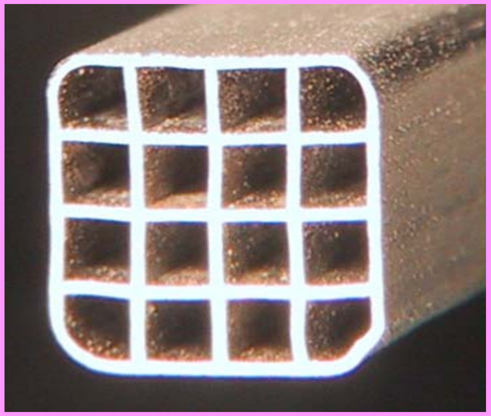
DARPA/DSO - Palm Power

(with J. Cochran, J. Lee, D. McDowell, T. Sanders)

Hybrid Metal/Ceria Monolithic Low Temperature SOFCs



FeNiCoMo LCM



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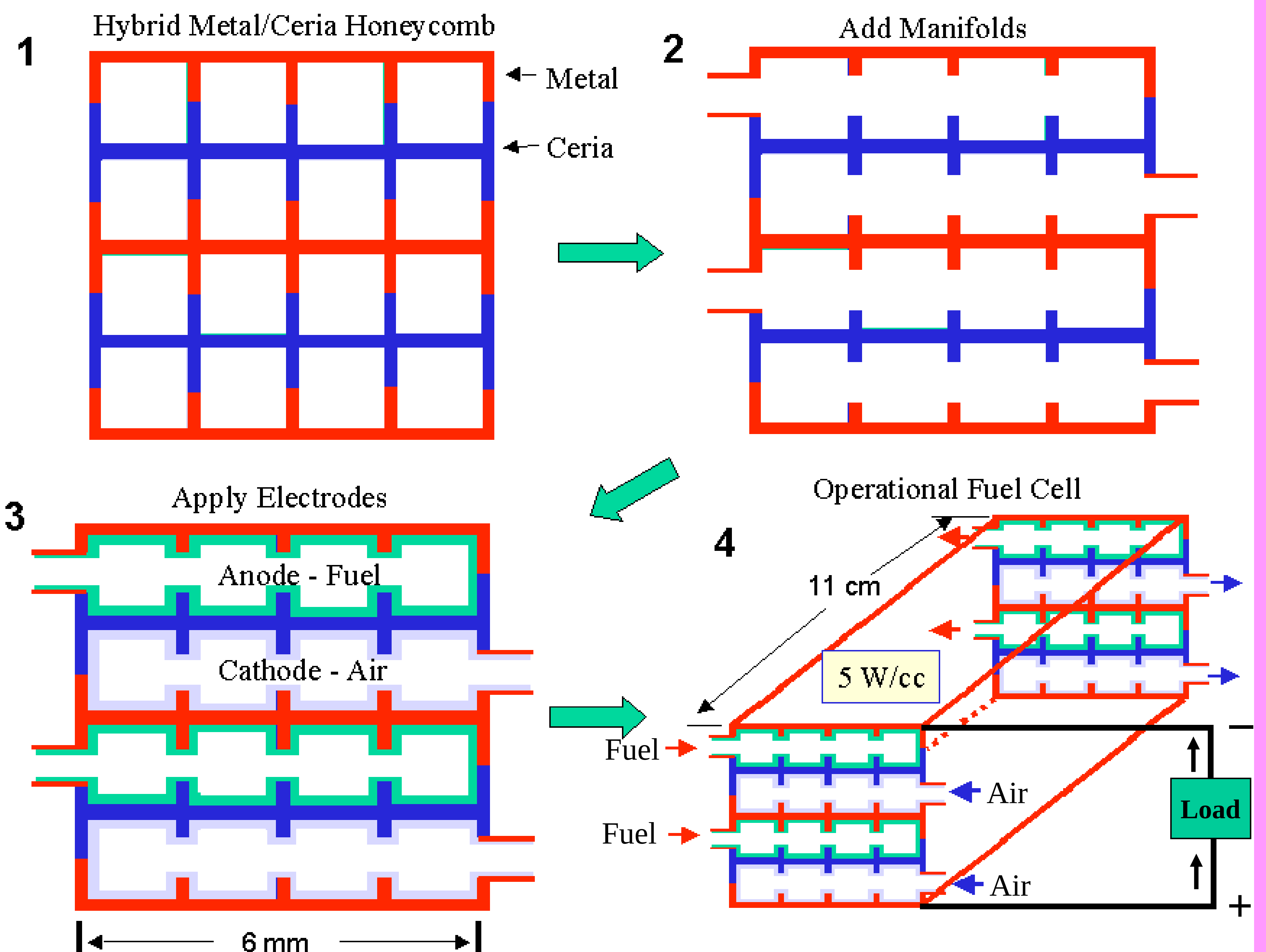
Hybrid Metal/Ceria Monolithic SOFC



Projections for Hybrid Metal/Ceria Monolithic SOFC

1. Operation Fuels -- Hydrogen, Natural Gas, Propane, Coal Gas, Methanol, Ethanol, and Reformed Gasoline and Diesel; potentially insensitive to contaminants such as H_2S in reformed fuels.

2. Power Density – 1 Watt/cc in Near Future, 5 Watts/cc in 3-4 Years

3. Operating Temperature – 400-600^{0}C

4. Fuel Cell Size – 6 X 6 mm square by 11cm long. (This Is 4 Watts at 1 W/cc and 20 watts at 5 W/cc. (This Is Not Palm Power. It Is Finger Power)

5. Materials – Samaria Doped Ceria (SDC) Solid Electrolyte, CoCr Doped Ni Metal Interconnect, Anode of Porous Ni-SDC, and a Cathode Layer, Consisting of $Sm_{0.5}Sr_{0.5}CoO_3$ and 10wt.% SDC. Catalysts Will be Added as Needed Depending on Fuel.

6. Fuel Cell Cost -- $500/kW in One Year, $50/kW in 3-4 Years