



Impedance Studies of Composite Electrolyte with Mixed Ion Conductivity

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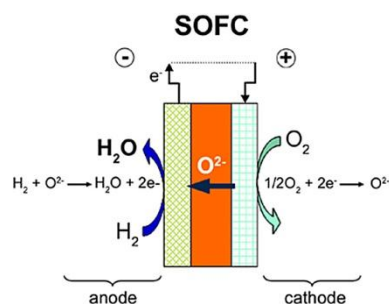
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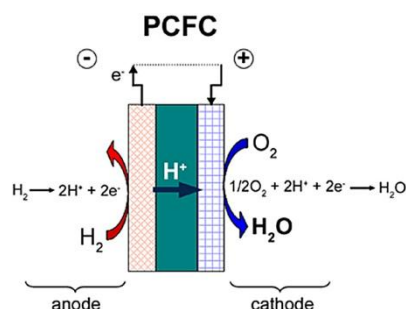
²Centre des Matériaux, Mines-ParisTech, BP 87, 91003 Evry Cedex, France



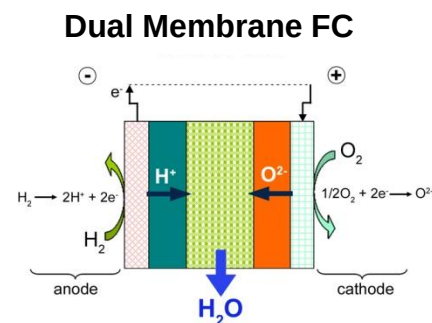
dual membrane fuel cell (dmFC)



+



=



Main disadvantages:

- Water dilutes the fuel
- Decreases electrode catalytic activity
- Impossible to use metallic materials

Main disadvantages:

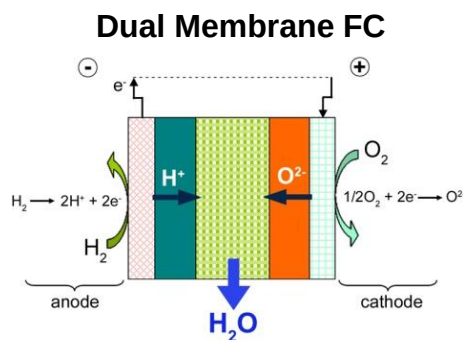
- Water dilutes the oxidizing gas
- Decreases electrode catalytic activity
- High corrosive media

Adisadvantages:

- The fuel is not diluted
- Hydrogen, oxygen and water are located in three independent chambers
- Every element of the cell plays a single role and can be optimized
- The water produced in the central membrane can be re-used for hydrogen production



Central membrane



Central membrane



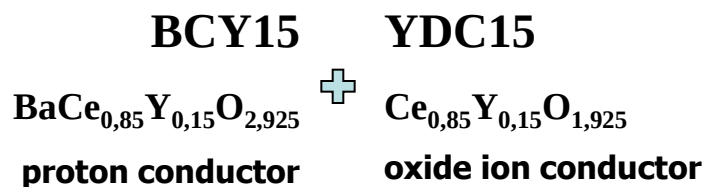
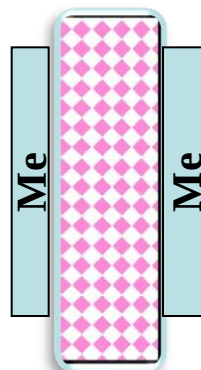
Requirements:

- high proton and oxide ion conductivity
- porosity
- thermochemical and mechanical stability



Central membrane

Electrolyte supported symmetrical half cell: Me = Ag; Pt



Conditions

50 % vol BCY15 + 50 % vol YDC15

Poreformer: starch/graphite (2, 5, 7%)

Sintering T: 1300-1350°C



Measurement conditions:

> Frequency Response Analyser Solartron 1260

- × Frequency range from 10 MHz - 0.1 Hz with 5 p/decade
- × Amplitude: 200 mV and 50 mV(potentiostatic)
5-20 mA (galvanostatic)

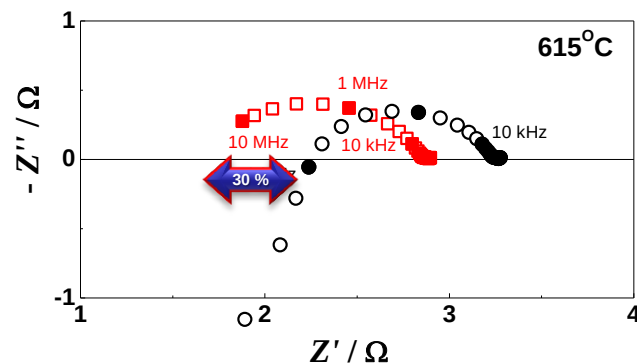
> Atmosphere

- × Hydrogen
- × Oxygen

> Temperature range 100 – 800°C

Impedance studies

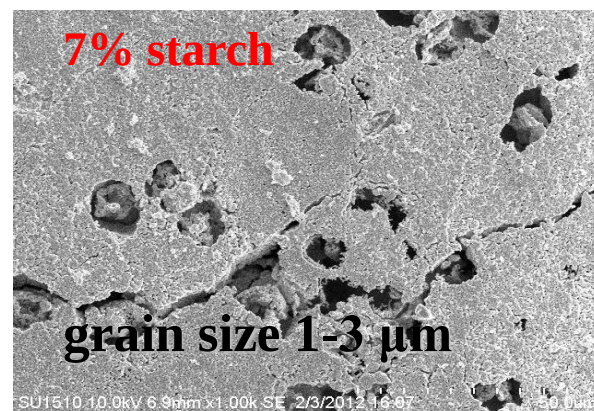
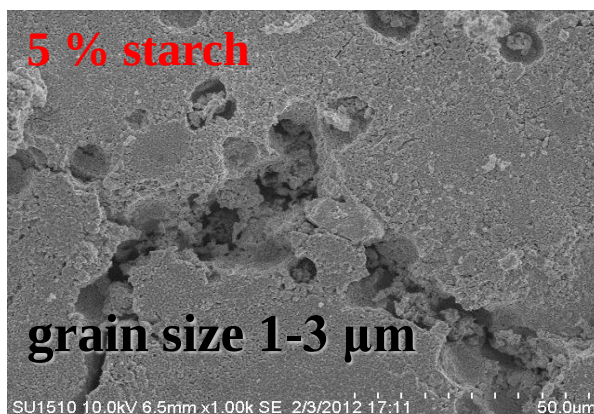
L - Correction :





Results

SEM observations:



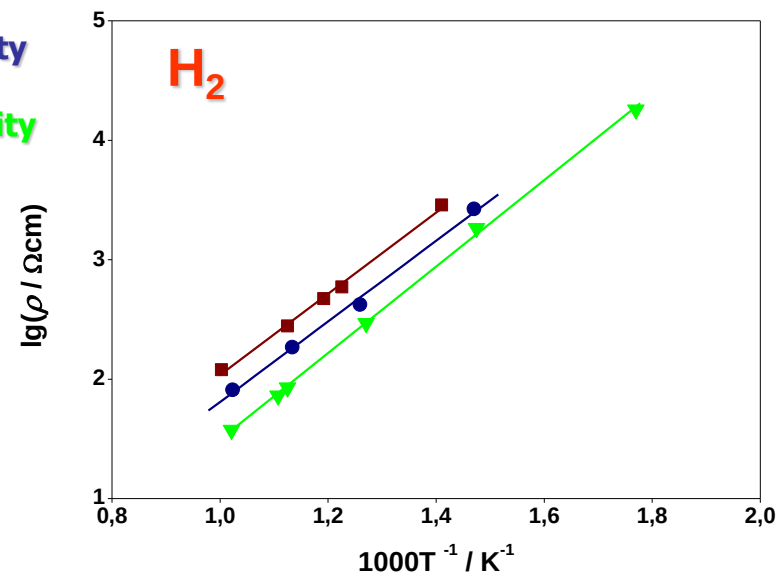
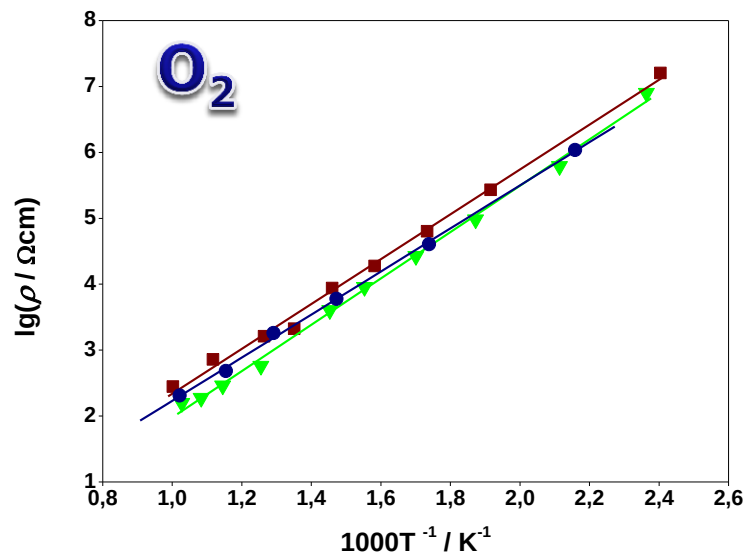


Conductivity studies:

42 % porosity

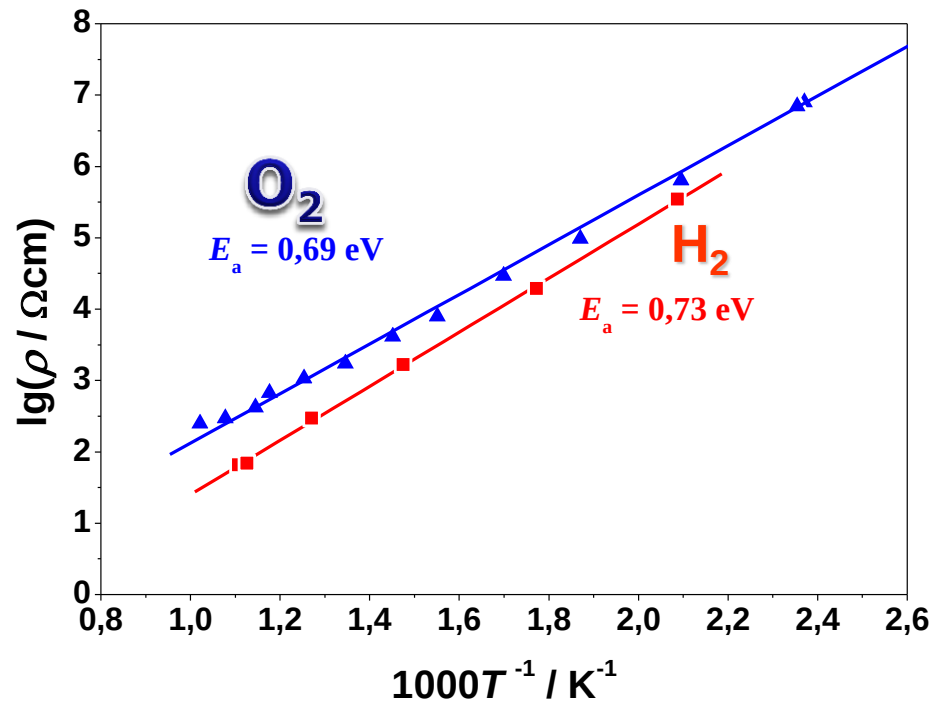
35% porosity

28 % porosity





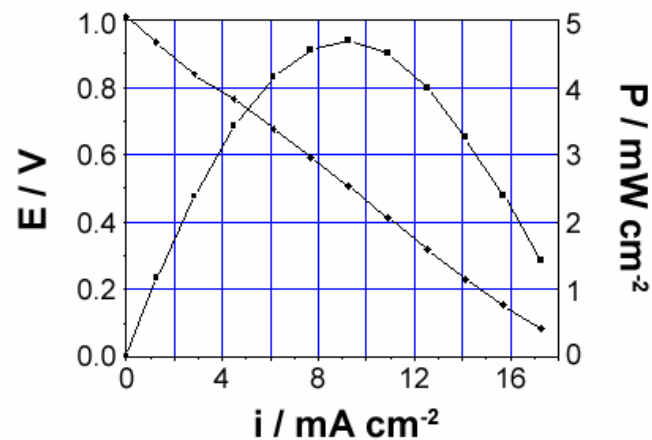
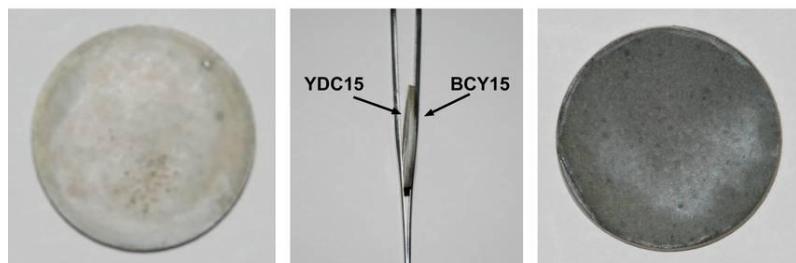
Conductivity studies:



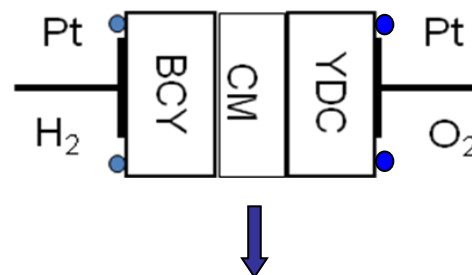
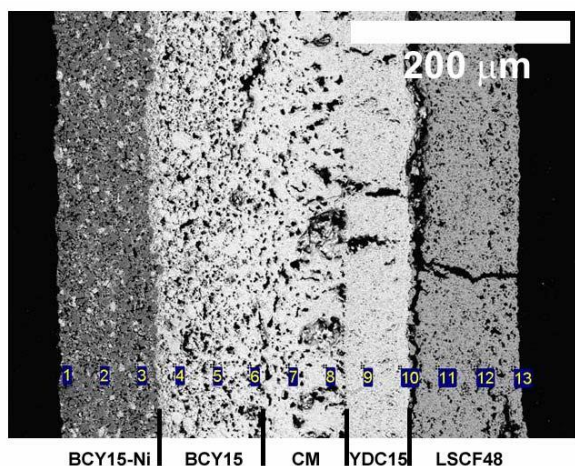


Conductivity studies:

Results



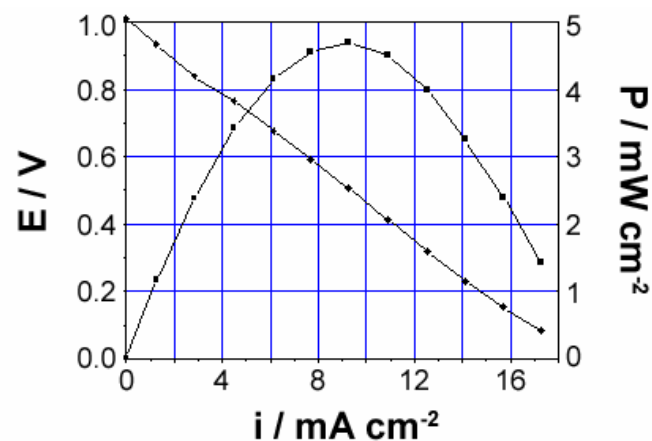
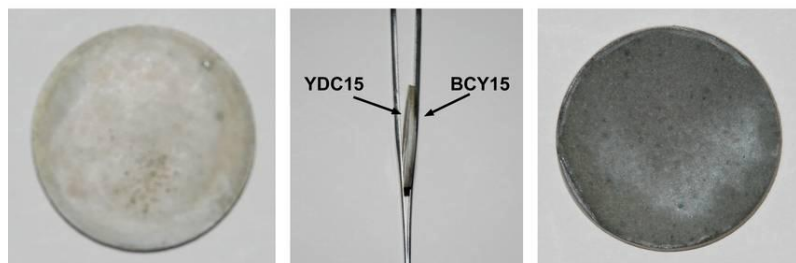
PoC sample
/Proof of the Concept/





Conductivity studies:

Results



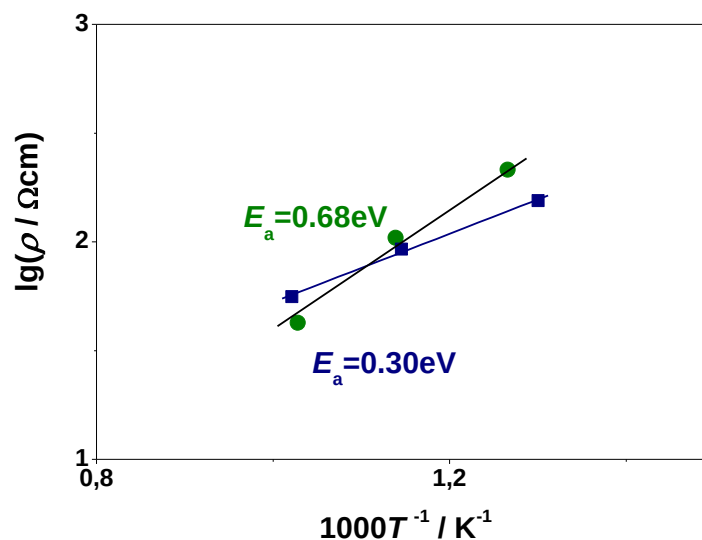
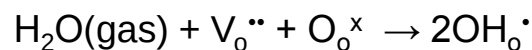
Advantages of monolithic CM:

- replacement of the triple phase boundary with two phase boundary (BCY/pore),
- decrease of the CM resistance,
- fasciliation of the technology,
- improvement of the thermo chemical and thermo mechanical stability.



Results

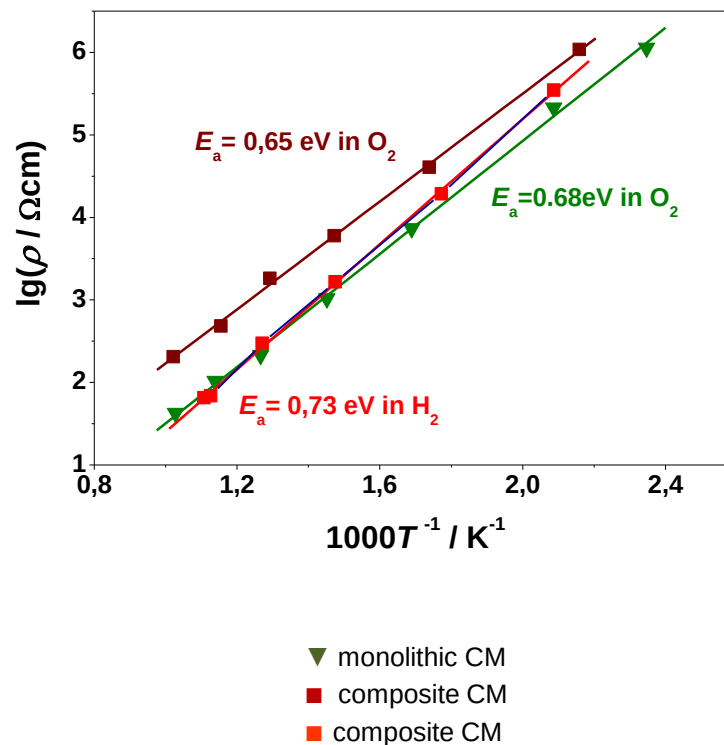
Conductivity studies:

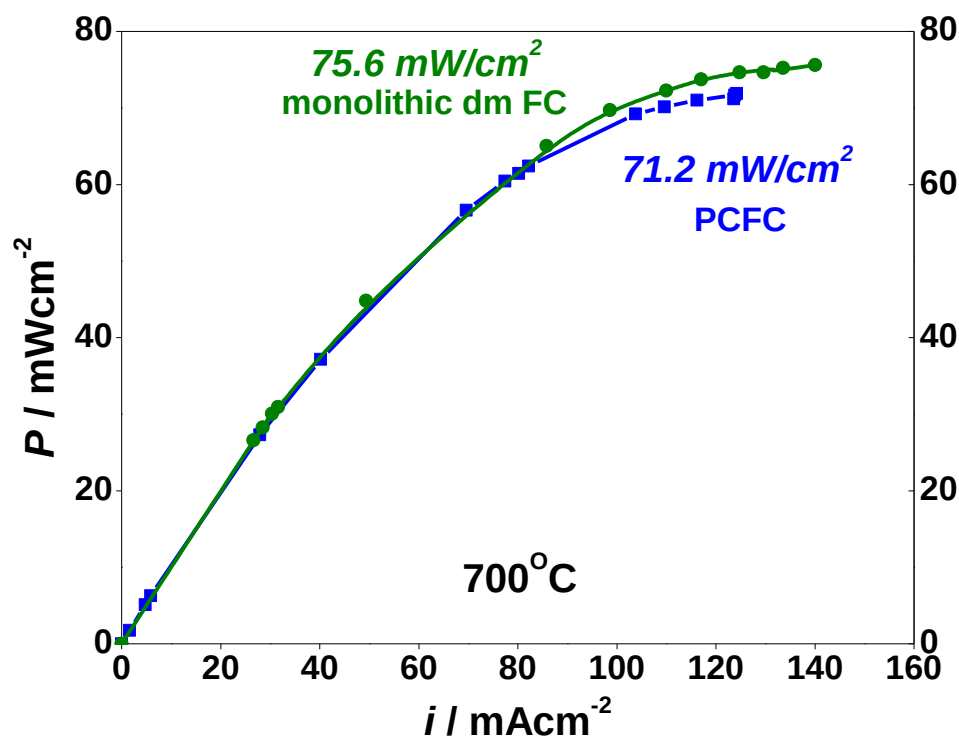


Arrhenius plots of monolithic BCY15 central membrane in:
(●) dry oxygen and (■) wet hydrogen.



Conductivity studies:







Acknowledgments

The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement N° 213389.

The samples were fabricated by ARMINES.

Thanks to my Bulgarian colleagues and the French team presented by Prof. A. Thorel.

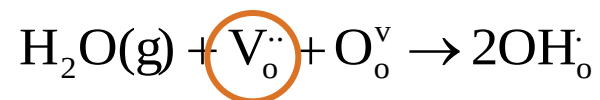


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Thank you for the attention



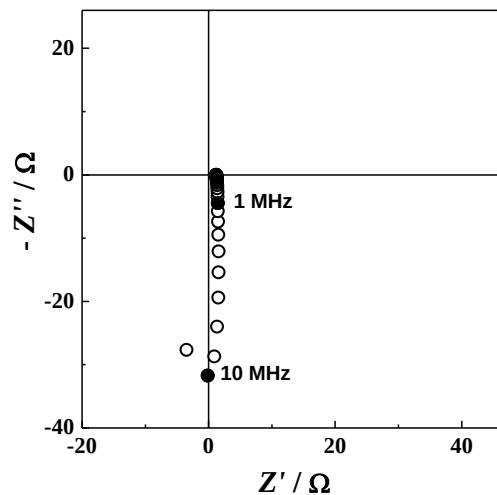
- BCY has good protonic conductivity
- Proton conducting mechanism:



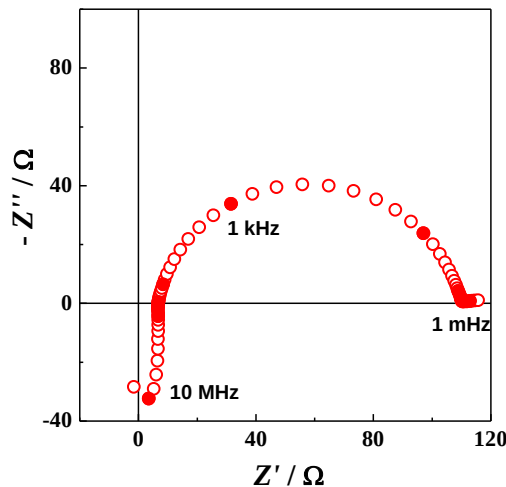
- Hypothesis: oxygen vacancies leads to oxide ion conductivity



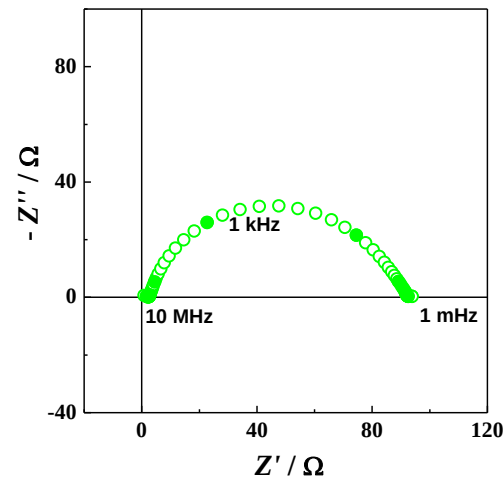
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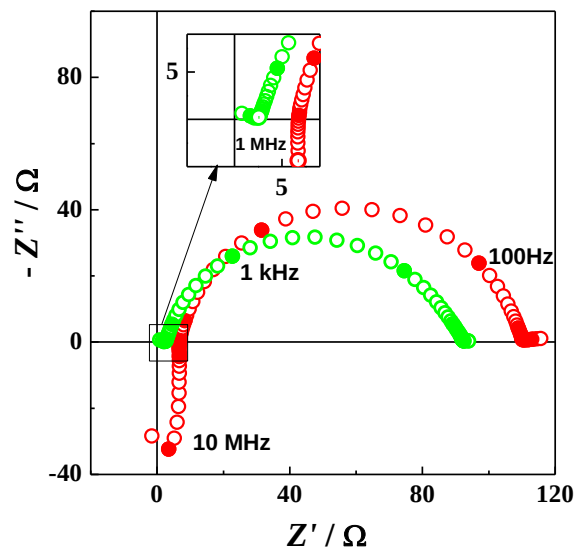
calibration measurement at short circuit



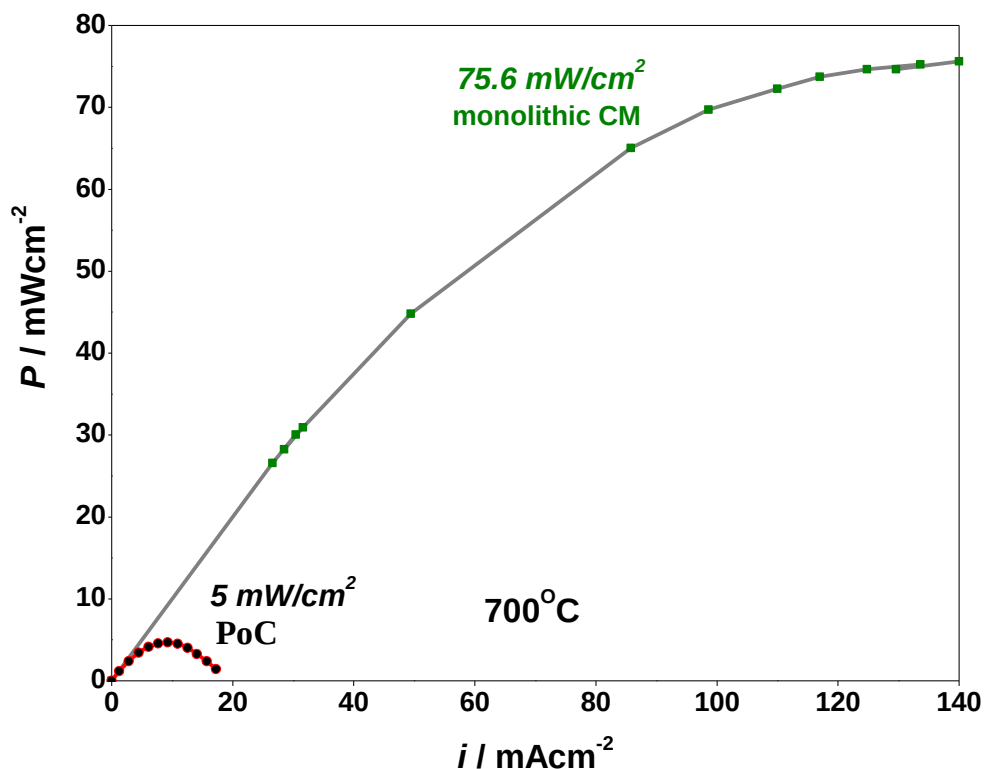
measurement of the cell with the sample



complex plain impedance diagram of
the sample after the correction

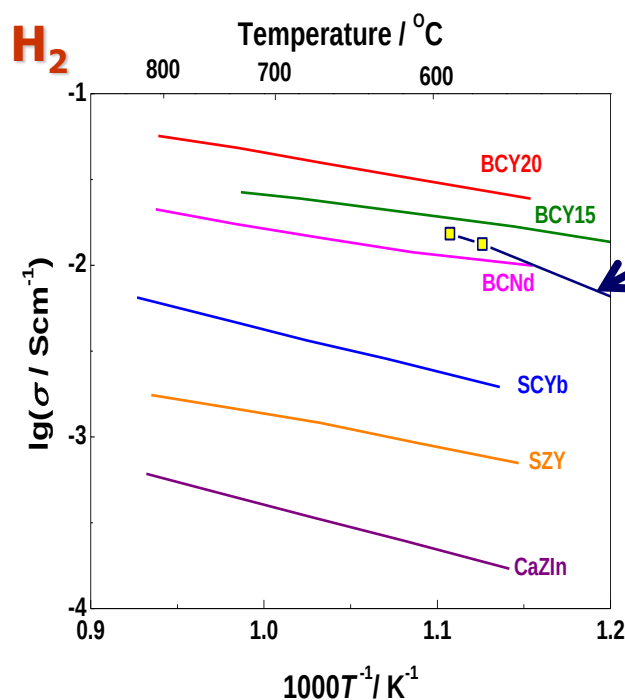


zoomed high frequency part

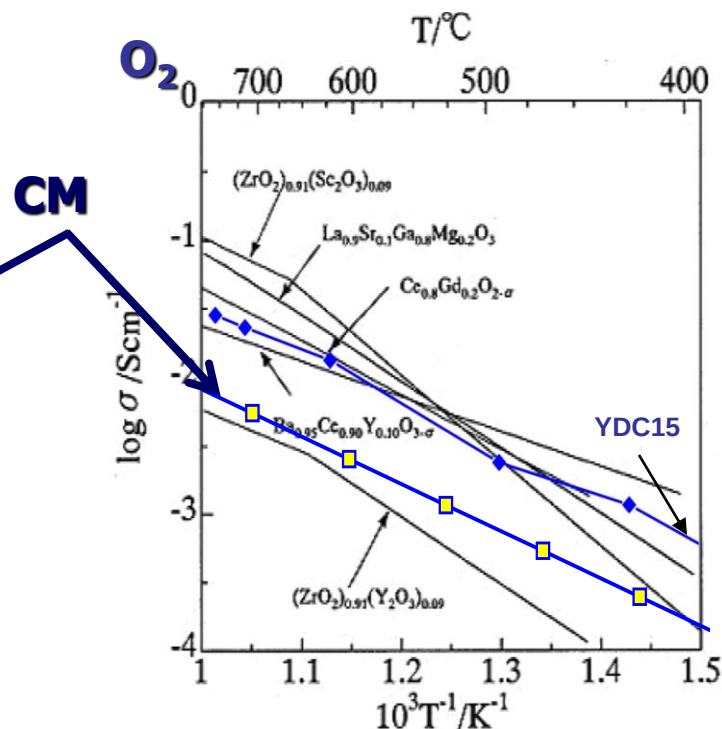




Conductivity studies:



H. Iwahara, *Solid State Ionics* 86-88, 9 (1996).



S. C. Singhal, K. Kendall, *Solid Oxide Fuel Cells: Fundamentals, Design and Applications*, Elsevier, 2003.

