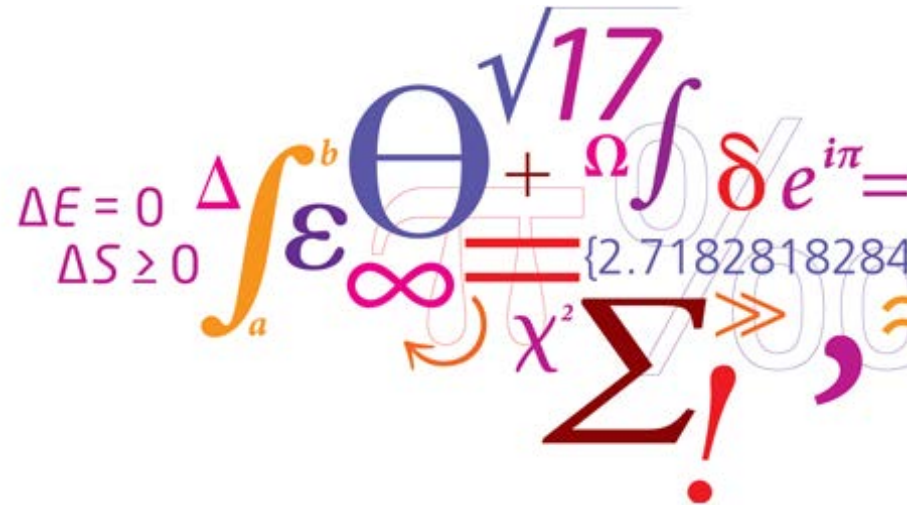


PEMFC activities at DTU Energy Conversion

Jens Oluf Jensen

*Proton Conductors
Department of Energy Conversion
and Storage
Kemitorvet 207
Technical University of Denmark
DK-2800 Lyngby
Denmark
jojen@dtu.dk*



Technical University of Denmark (DTU)

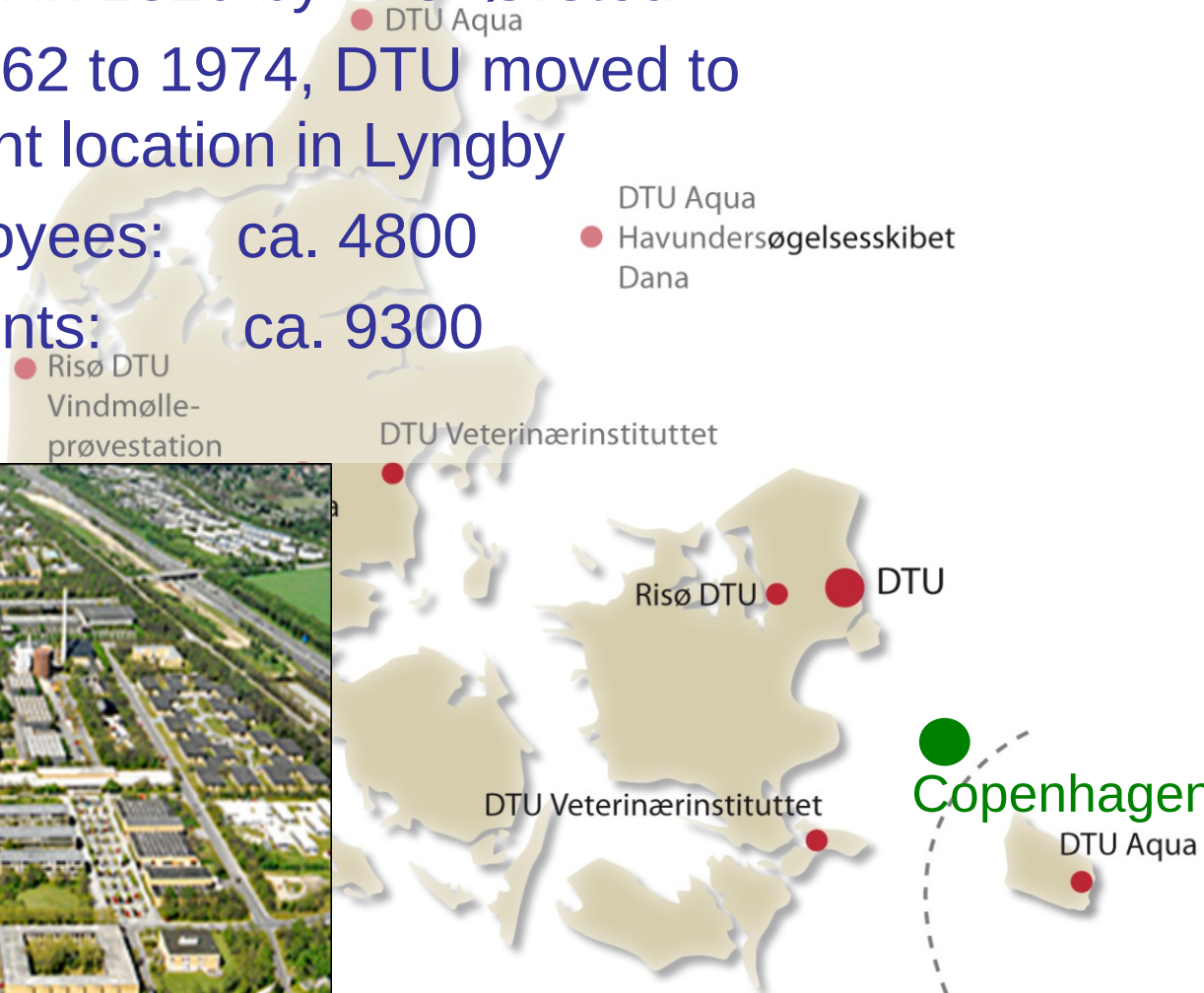
Founded in 1829 by H.C. Ørsted

From 1962 to 1974, DTU moved to its current location in Lyngby

- Employees: ca. 4800
- Students: ca. 9300



Lyngby Campus



Risø (Risoe)

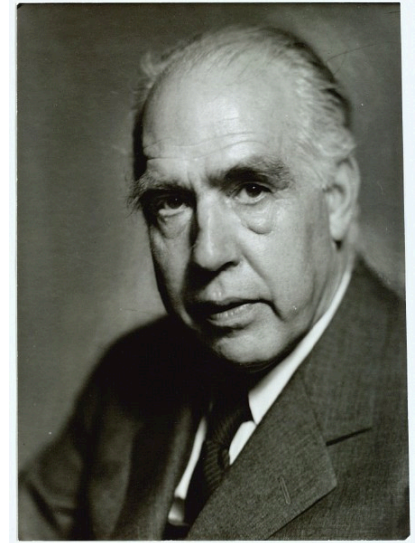
1958 Founded in by Niels Bohr and others as a nuclear research institution.

1985 Nuclear power officially given up
Risø becomes *Research Centre Risø*

2007 Risø becomes part of DTU
Risø DTU National Laboratory for Sustainable Energy
ca. 700 employees

2012 DTU Energy Conversion is formed: 90% Risoe + 10% Lyngby

Ca. 230 employees

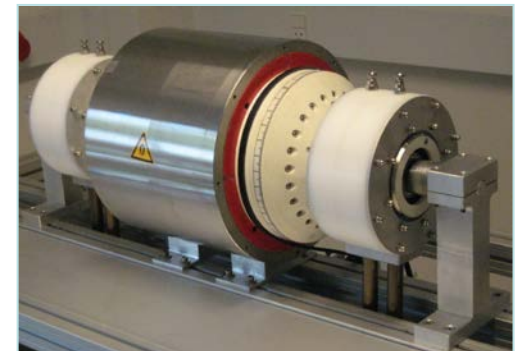
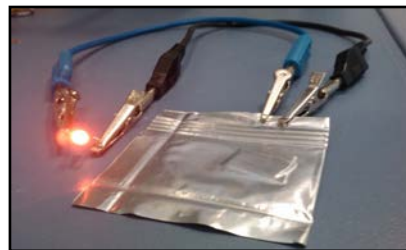
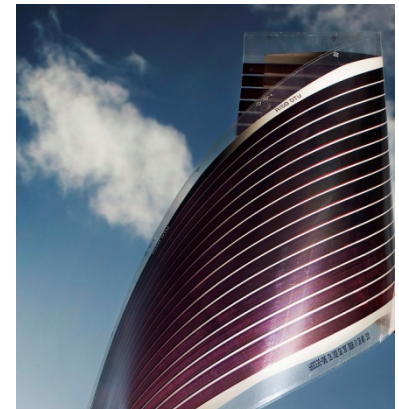
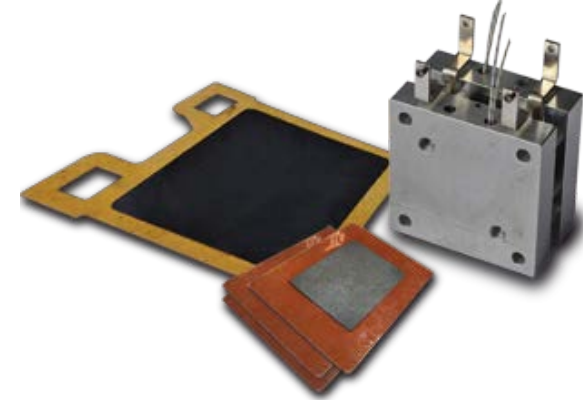


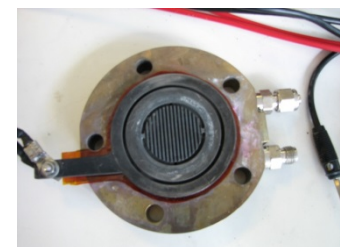
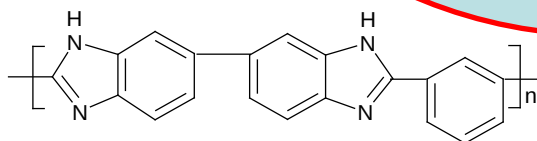
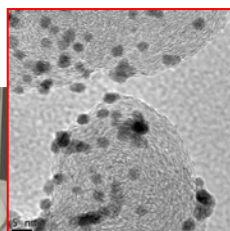
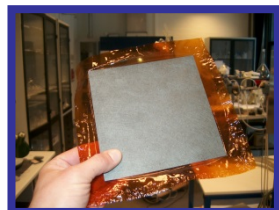
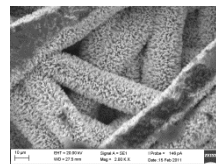
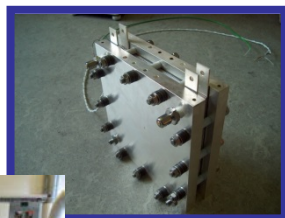
Niels Bohr



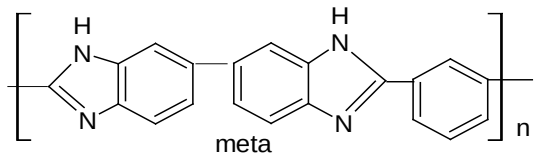
Technologies

- Solid oxide fuel cells
- High-temperature PEM fuel cells
- Electrolysis
- Polymer solar cells
- Batteries
- Solid state storage of hydrogen and ammonia
- Membranes for oxygen or hydrogen separation
- Magnetic refrigeration
- Thermoelectric components
- Flue gas purification using electrochemical cells
- Superconducting components

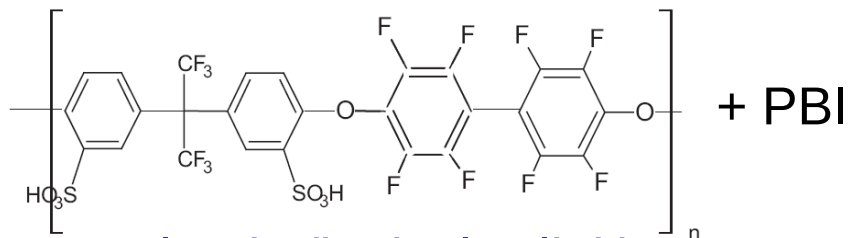
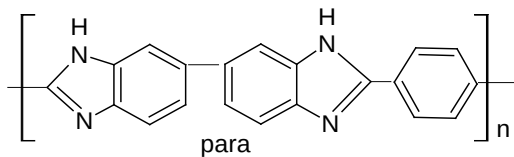




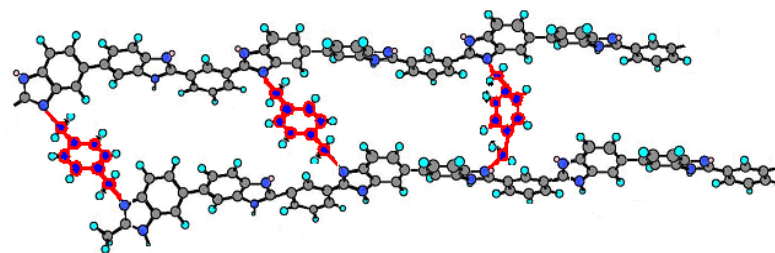
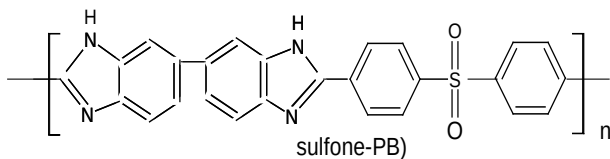
Polymer chemistry (PBI)



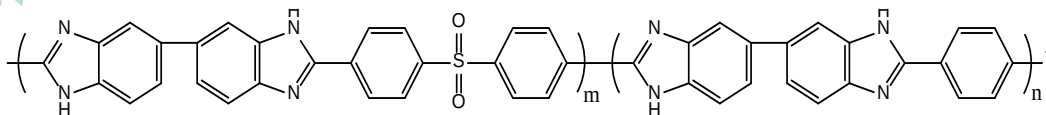
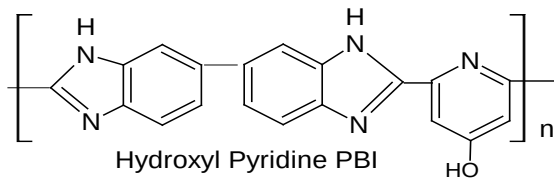
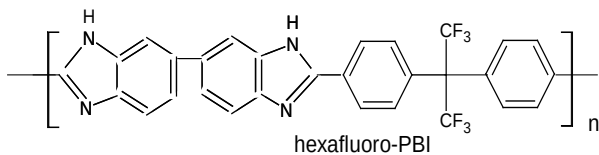
Varying molecular weight



Blends (ionical X-link)

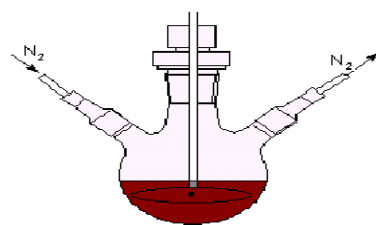
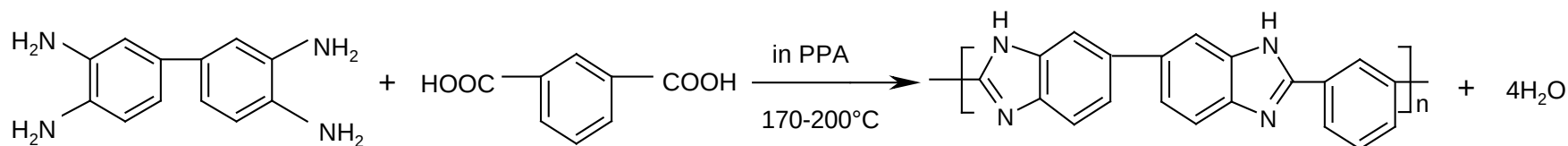


Crosslinking

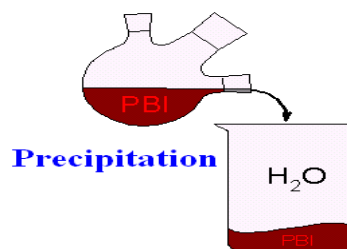


Co-polymers

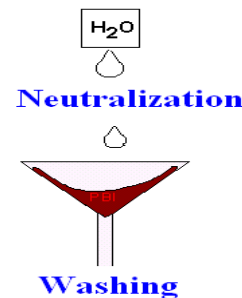
Preparation of PBI membranes



Synthesis

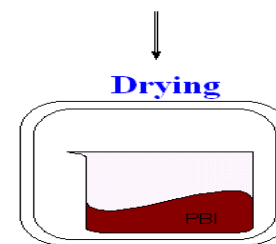


Precipitation

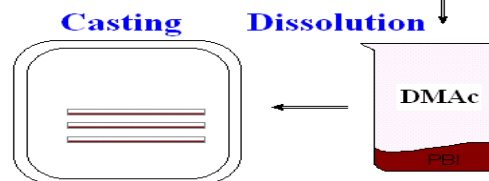


Neutralization

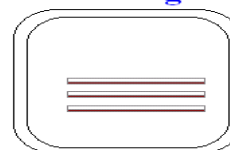
Washing



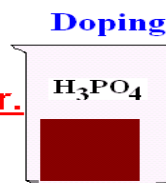
Drying



Dissolution



Casting



Doping



Acid doped PBI

Benicewicz et al. (2005)

Direct casting
A sol-gel process

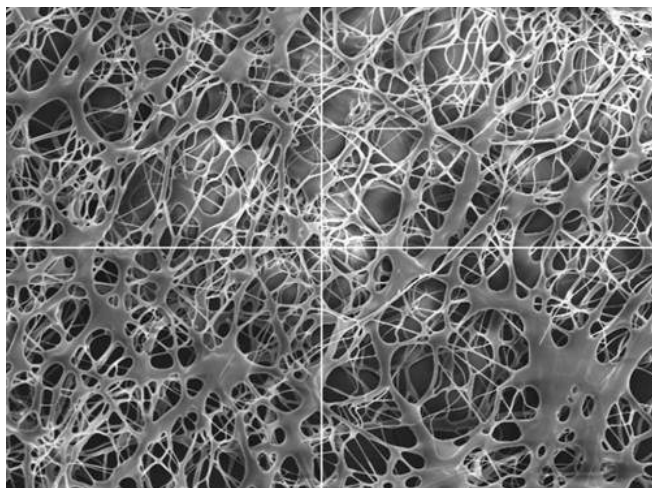
Hydrolysis

PPA-membr.

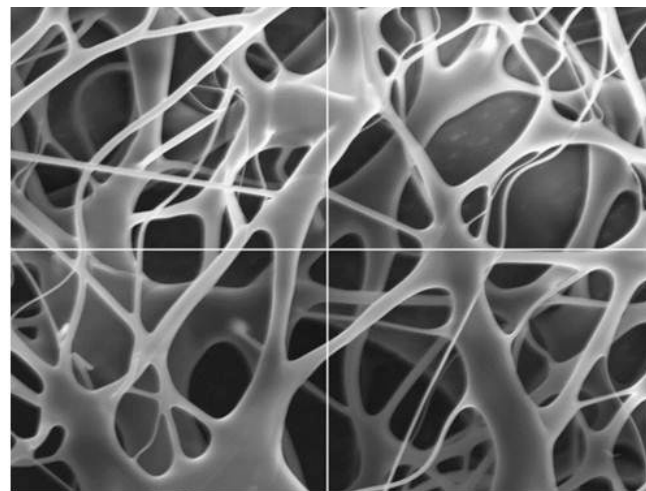
DMAc membr.

H_3PO_4

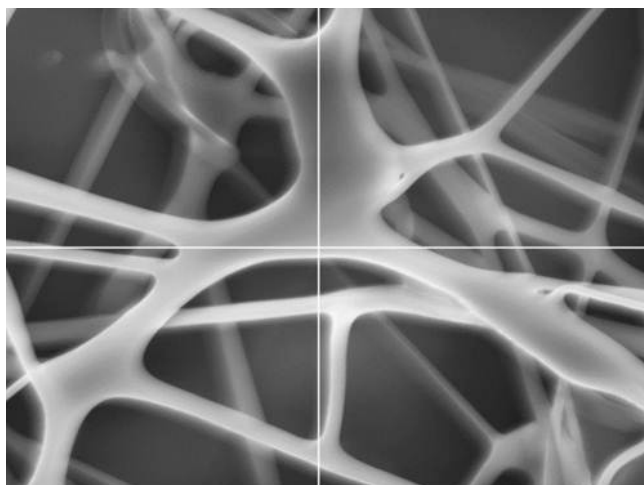
Electro spinning of PBI



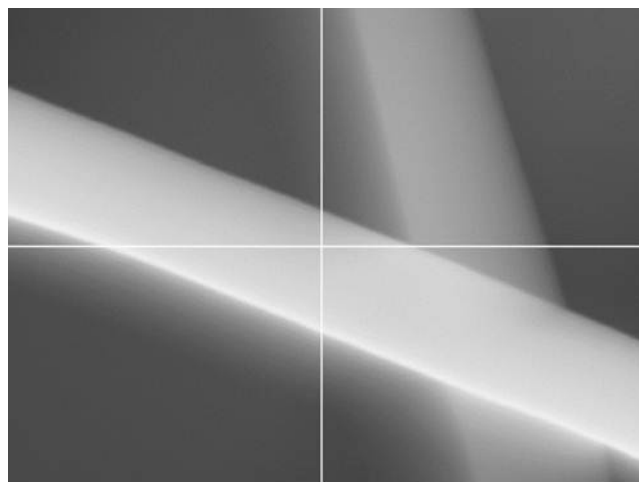
— 20 μm



— 10 μm

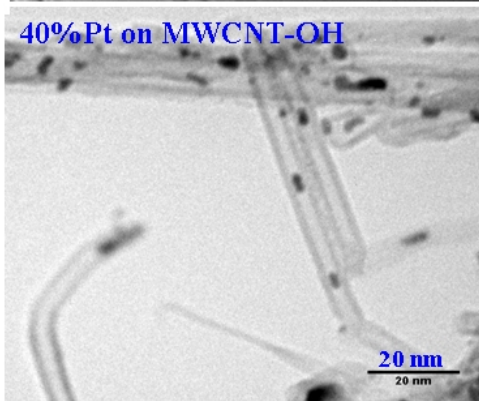
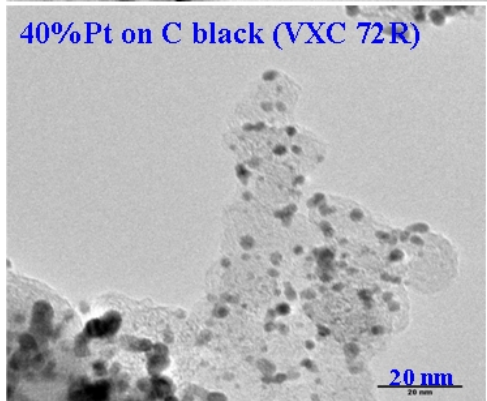
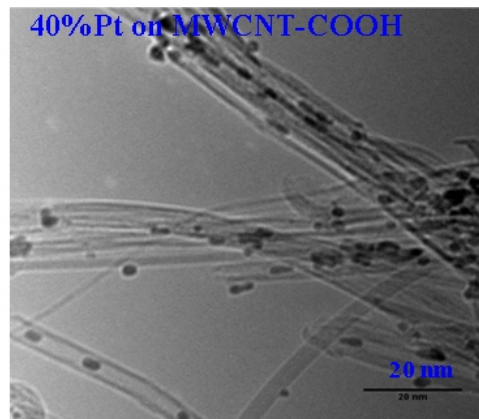
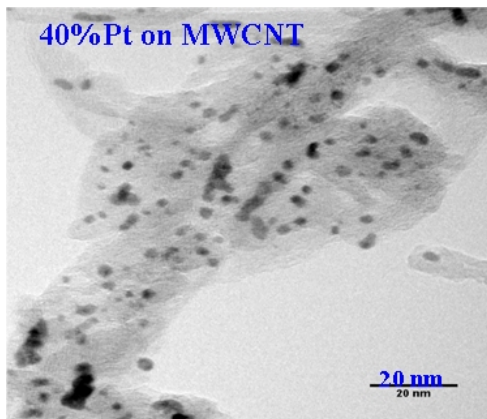


— 2 μm

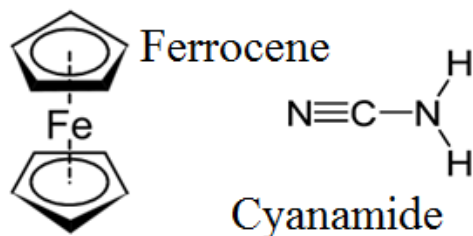


— 200 nm

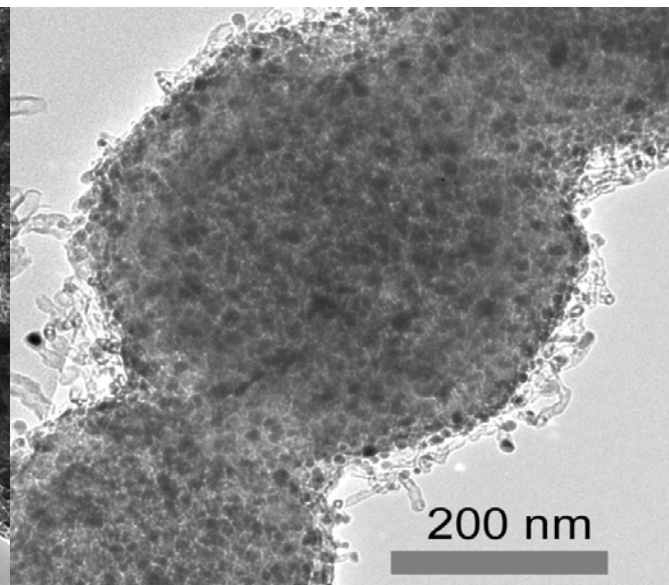
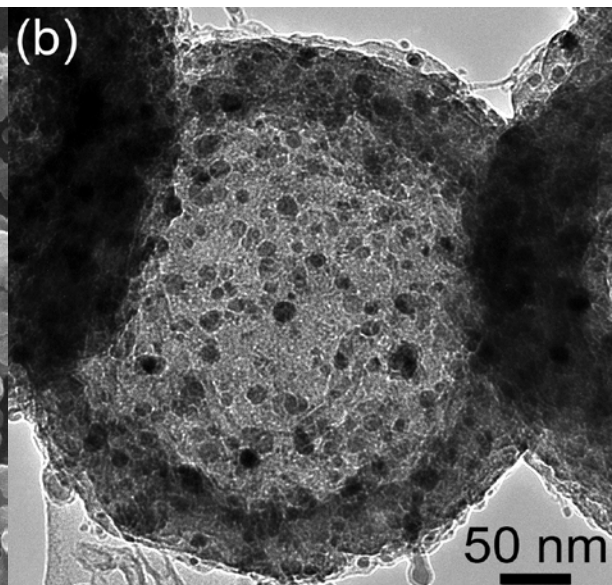
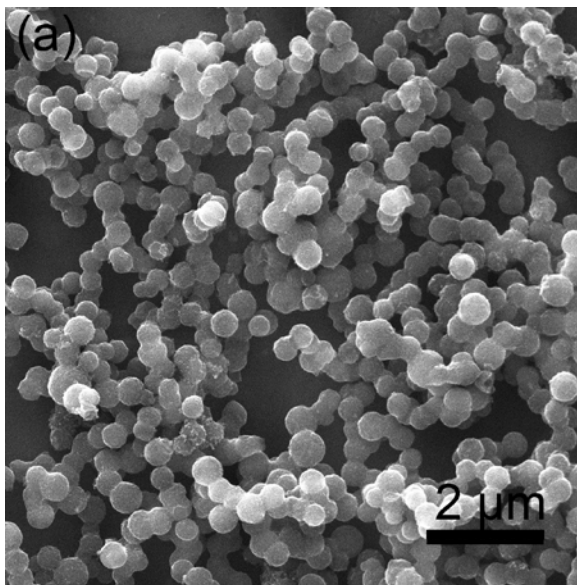
Fuel cell catalysts



Non-noble Fe_3C catalyst for ORR



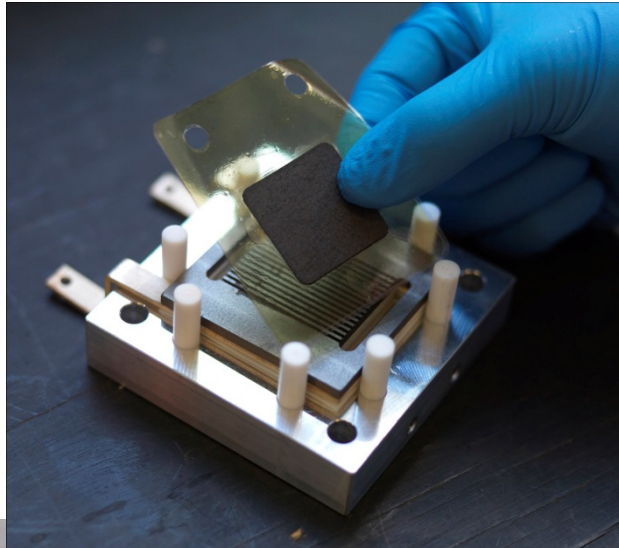
High temperature/pressure
reaction



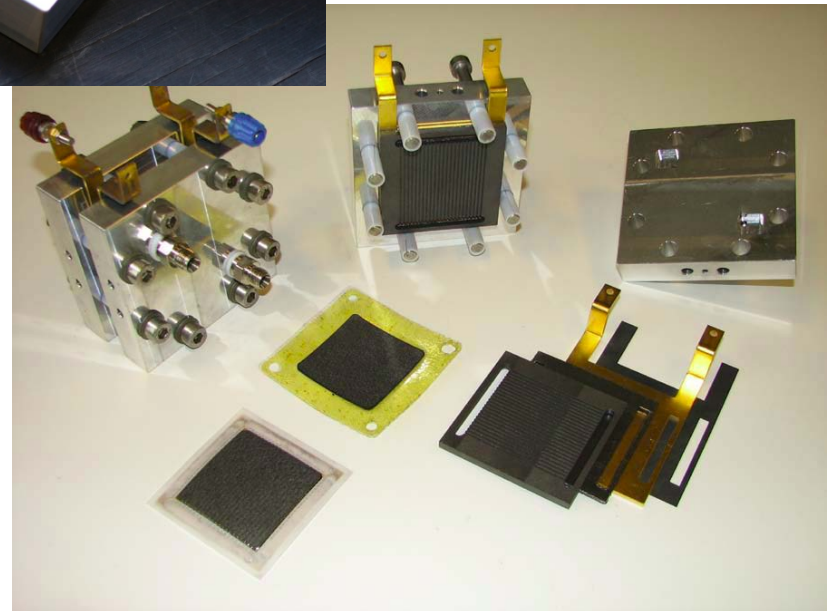
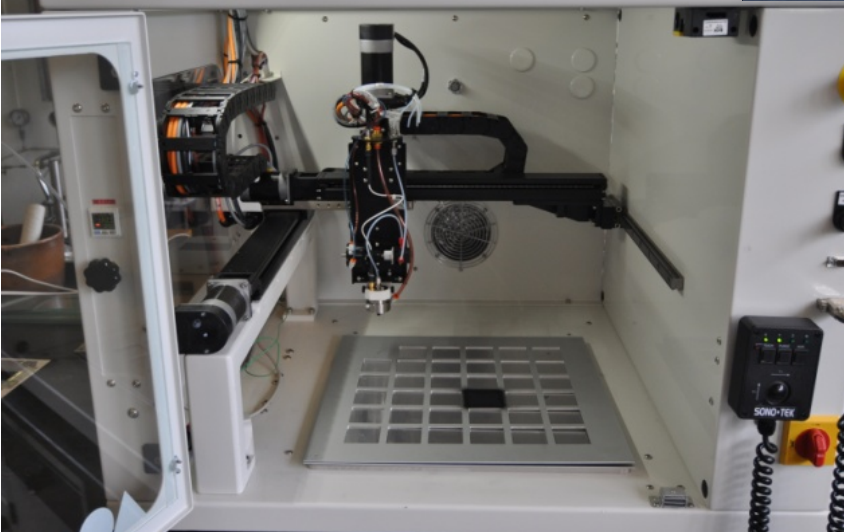
Yang Hu et al. submitted

Electrodes and cells

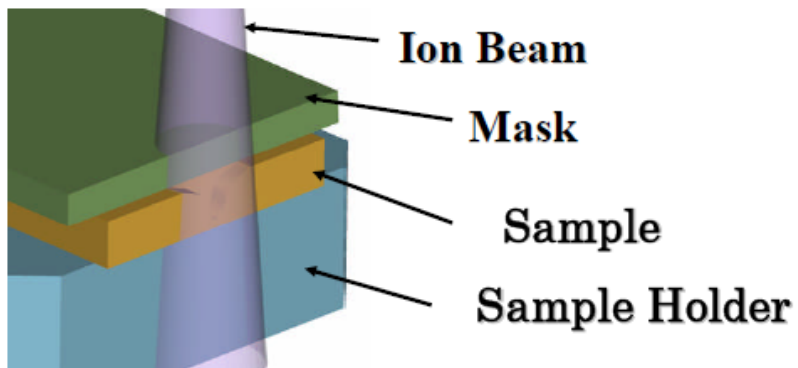
Ultrasonic spray robot



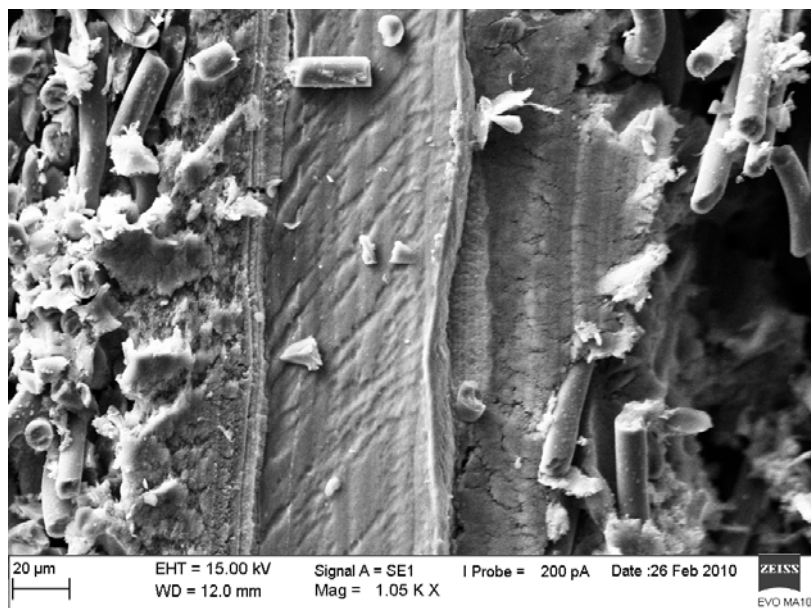
Test cells



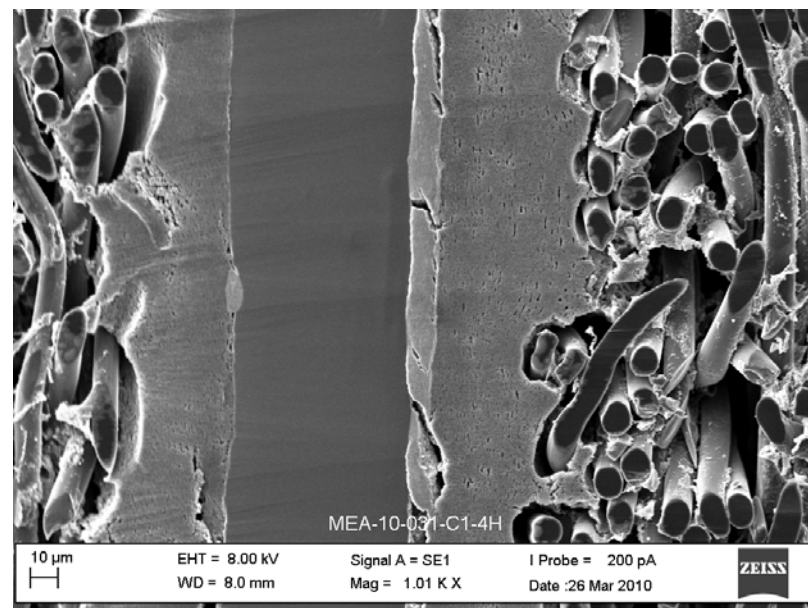
Ion milling



Scalpel

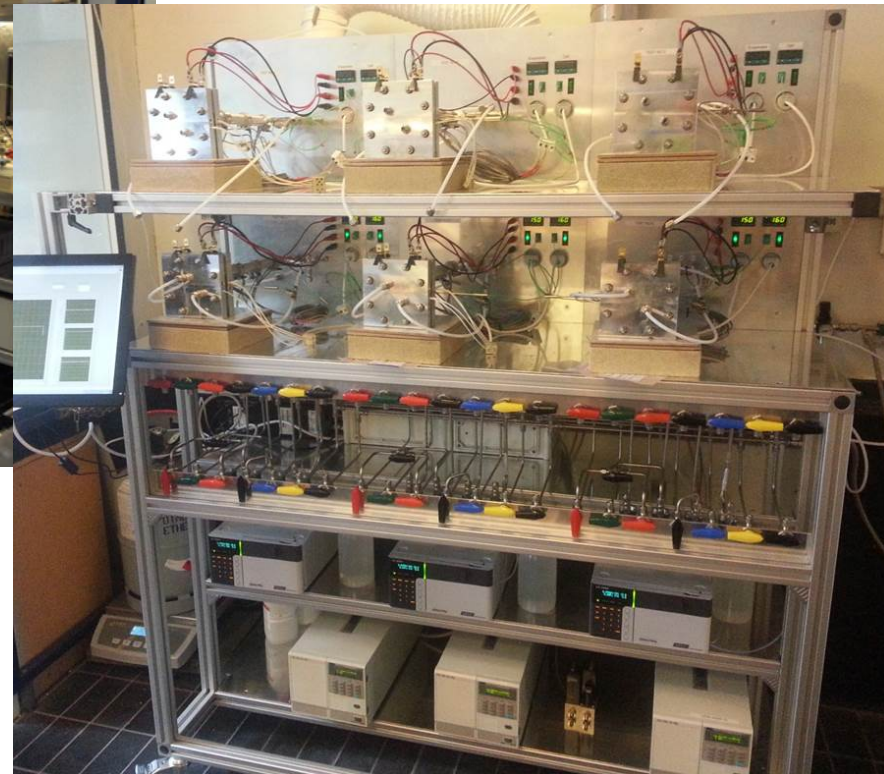
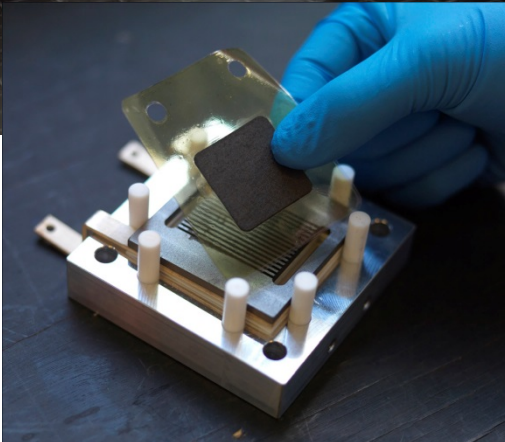


Ion milled

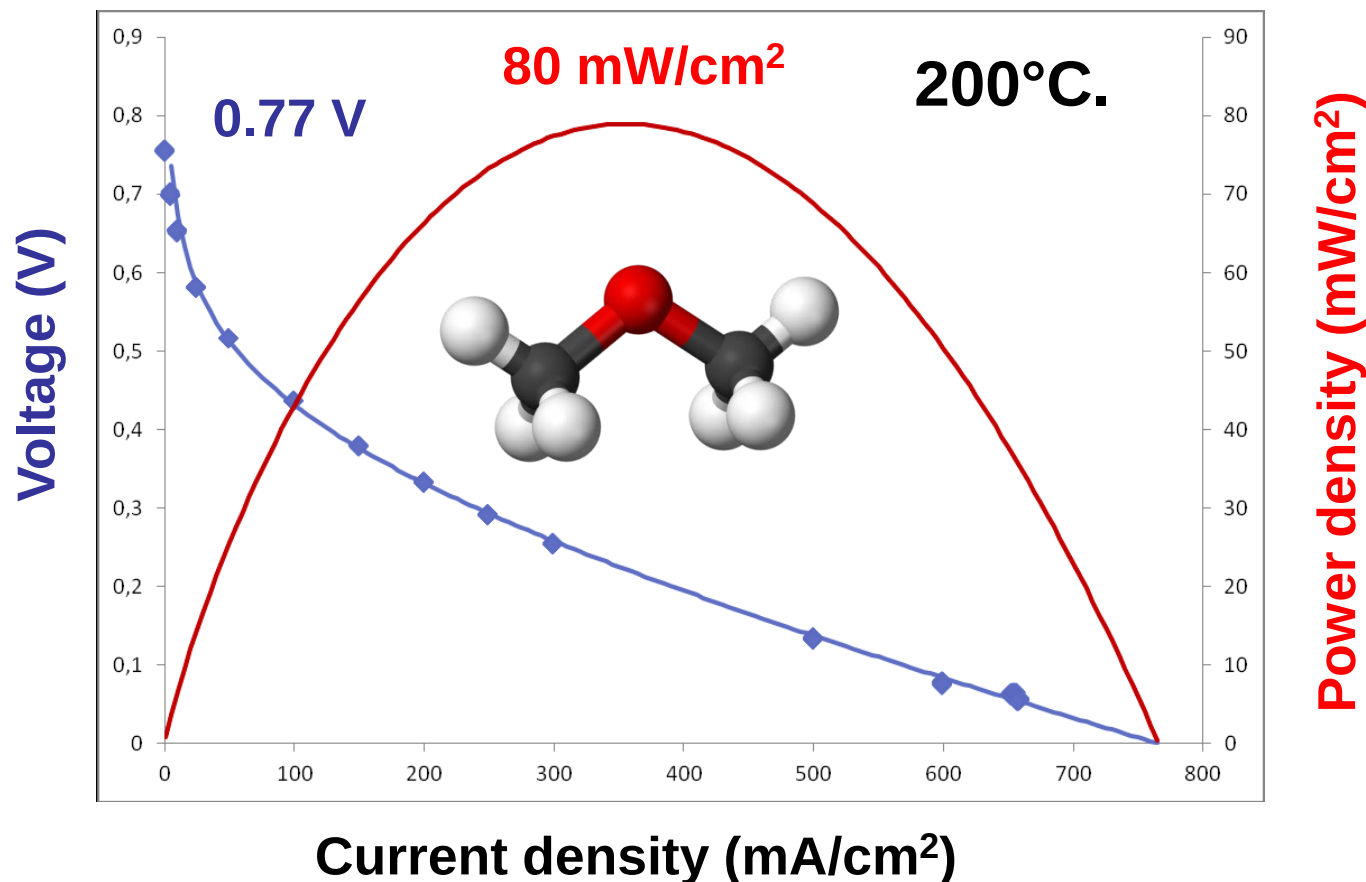


Durability testing

$12 + 12 + 6 = 30$ channels



Latest performance with direct DME



Anton Vassiliev

J. O. Jensen et al. *J. Power Sources* **211** 173-176 (2012)

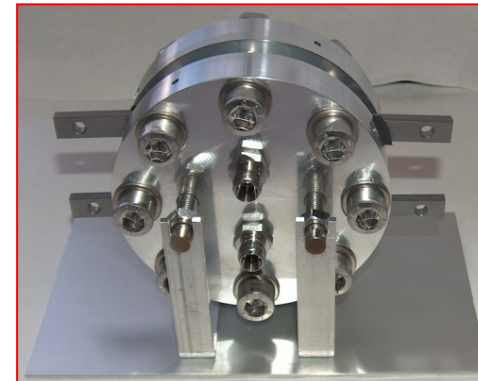
Cell: 25 cm², **Membrane:** 40 µm before doping

Anode: 40% PtRu/C (JM), 4.2 mgPtRu/cm², DME/Water 1:3

Cathode: 1.0 mgPt/cm² air at ambient pressure.

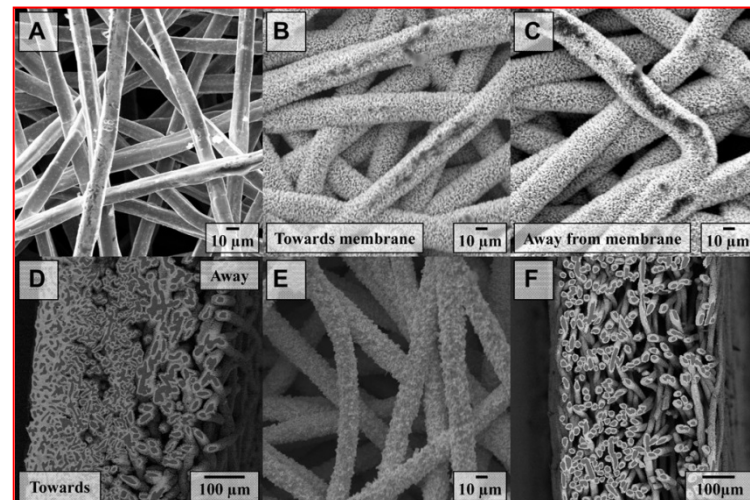
HT-PEM electrolysis – a sister to HT-PEMFC?

- Membranes
- Electrodes
- Channel plates
- Testing

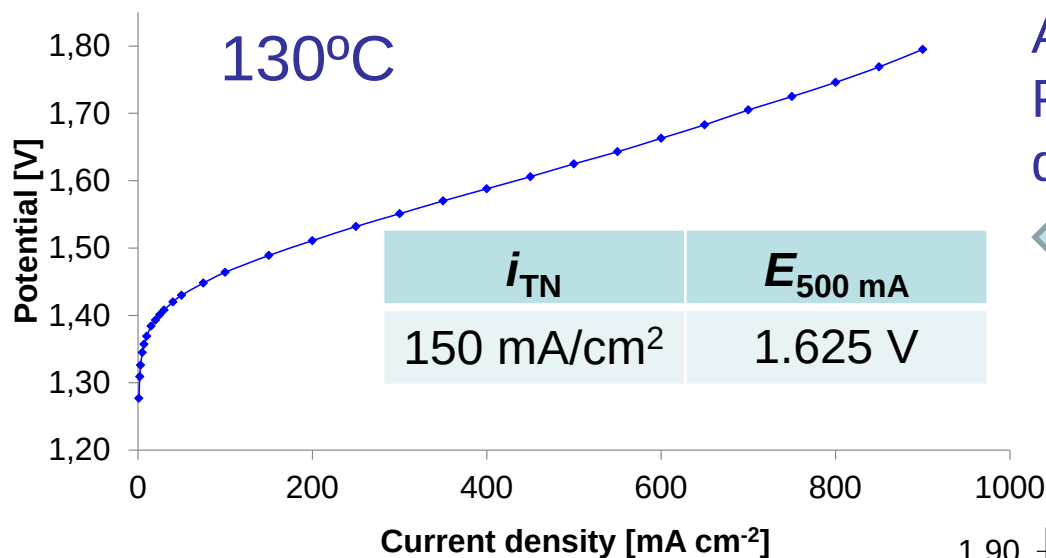


M. K. Hansen et al.
Int. J. Hydrogen Energy 37
10992-11000 (2012)

Ta by CVD: Chemical Vapour Deposition

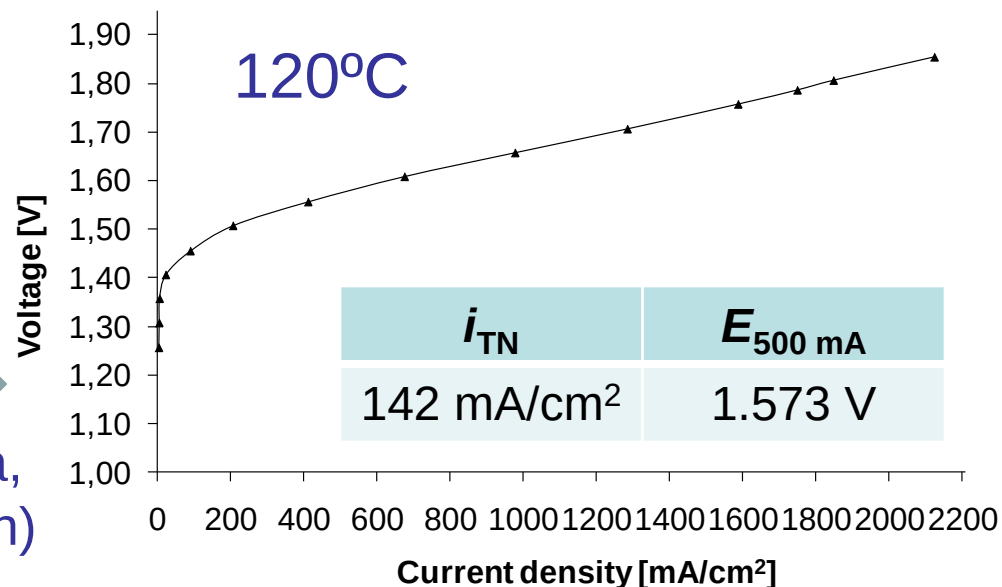


Steam electrolysis, PFSA membrane



Ambient pressure,
PFSA membrane (Aquivion)
doped with H₃PO₄

Pressure: 3 bara,
PFSA membrane (Aquivion)



M. K. Hansen et al.
Int. J. Hydrogen Energy 37
10992-11000 (2012)

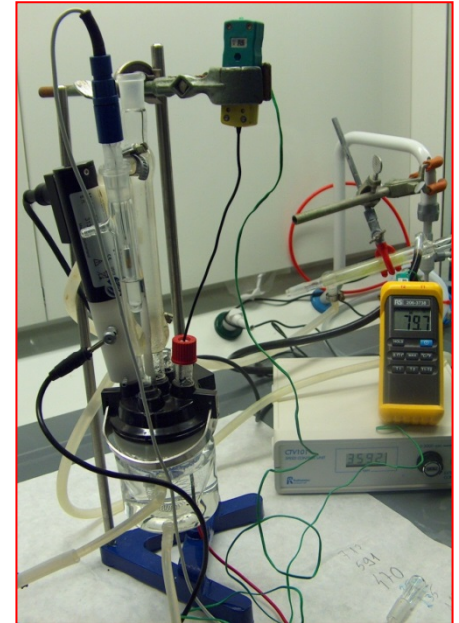
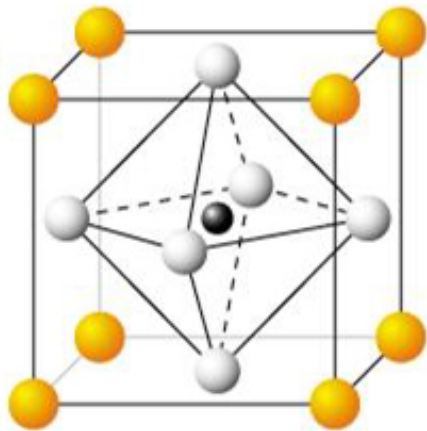
Alkaline electrolysis

Membranes (exchange/porous)

Catalysts (metal oxides)

Electrodes

Cells



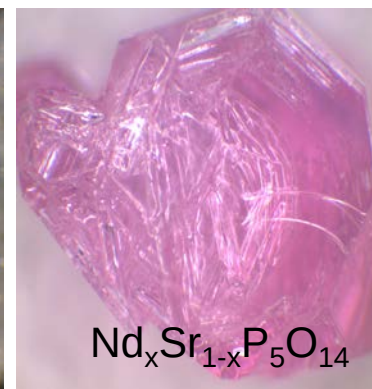
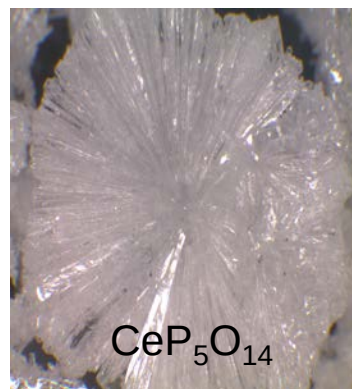
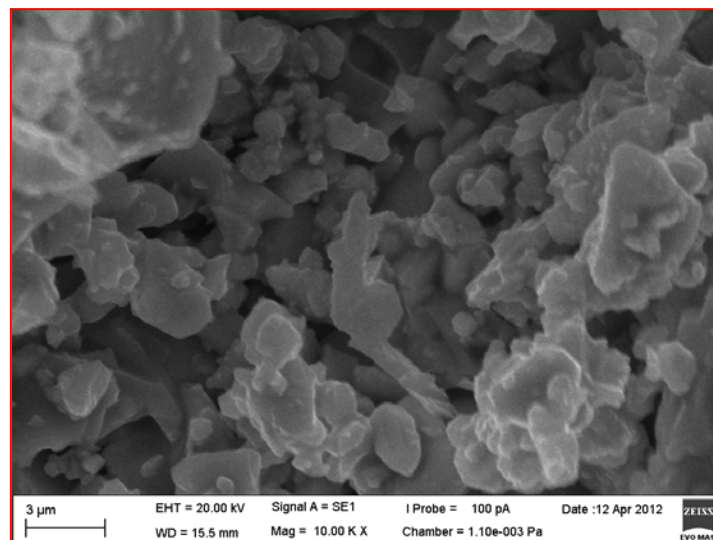
Inorganic Phosphate Electrolytes (200-400°C)

Fundamental research

Conductivity

Non-noble catalysts

Test cells



The Danish PEMFC family

The value chain

Fundamentals

Systems



SYDDANSK UNIVERSITET



DTU Physics



DTU Energy Conversion



Danish Power Systems®



AALBORG UNIVERSITET



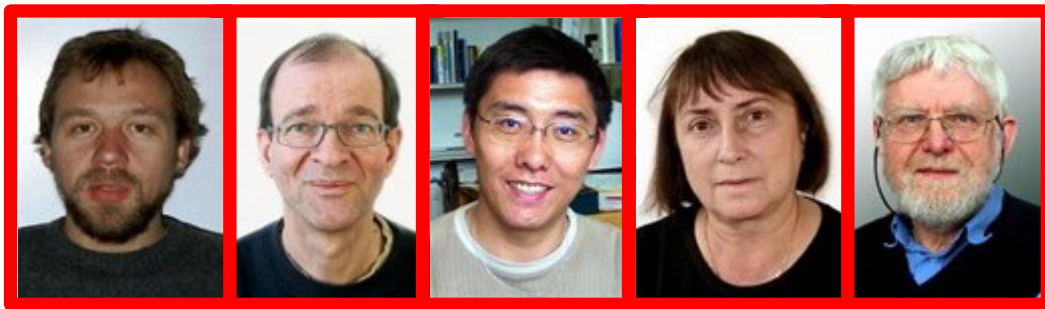
Serenergy



Partnerskabet for
brint og brændselsceller
- en dansk brancheorganisation



Proton Conductors



Seniors



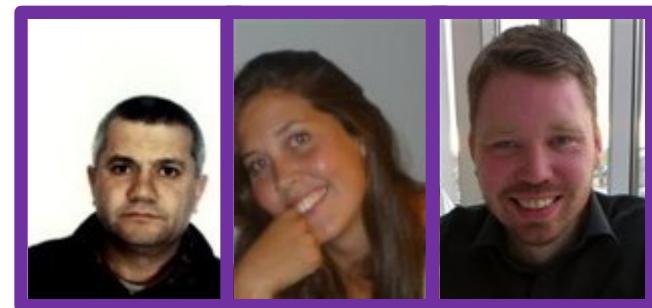
Scientists/Post docs



PhDs



Technicians



Assistants

Acknowledgements



Danish Agency for Science
Technology and Innovation

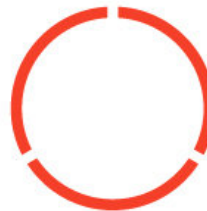
Ministry of Science, Innovation
and Higher Education



The Danish National
Advanced Technology Foundation



EUROPEAN
COMMISSION



COPENHAGEN
CLEANTECH CLUSTER

The energy crisis