

# **Fifteen years of research in the field of hydrogen technologies at the ICT Prague**

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## Characteristics of ICT Prague

- + one of 26 public universities in the Czech Republic
- + character of the research university
- + largest university establishment focused on technical chemistry in the Central Europe
- + founded as an independent university in 1952
- + roots going back to 1807 – first course on chemistry delivered at Prague Polytechnic



## ICT Prague structure

**RECTOR**

**Department of**

**Foreign  
Relations**

**Studies**

**Research and  
Development**

**Development  
and Building**

**Central Library**

**Central Labs.**

**Common Departments**

**Faculty of  
Chemical  
Technology**

**Faculty of  
Environmental  
Technology**

**Faculty of Food  
and Biochemical  
Technology**

**Faculty of  
Chemical  
Engineering**

**Departments**

## Hydrogen economy related research in Czech

### “old” history

- ✎ research of alkaline fuel cells in ČKD in sixties
- ✎ not conform with this time state ideology
- ✎ research in this field stopped by the political decision
- ✎ caused break in the tradition and significant delay on a national level

### “recent” history

- ✎ search for new themes in nineties
- ✎ connected with structural changes of the Czech industry
- ✎ several activities have been initiated
- ✎ most of them focused on characterization of the available technology
- ✎ research on components and cell design initiated later on
- ✎ ICT Prague focused on this point

## Hydrogen economy related research at ICT Prague

### + basic directions

- cell and its components design
- fuel processing and storage
- safety issues

### + cell and components design

- 1996 - first trial in PEM FC polymer electrolyte project application
- 1998 – Alexander von Humboldt Fellowship
- 1999 – first national research project on polymer electrolyte development
- 2001 – EU Project APPLON (FRTH/ICE-HT, Patras)
- since that continuous development

## Hydrogen economy related research at ICT Prague

### structure of the research topics

- ☞ PEM fuel cells initial topic
- ☞ followed by high temperature PEM fuel cells
- ☞ water electrolysis – PEM and alkaline
- ☞ water electrolysis – high temperature

### typical progress of the work

- ☞ study of the individual components
- ☞ single cell systems
- ☞ mathematical modelling and more fundamental understanding
- ☞ stack systems envisaged

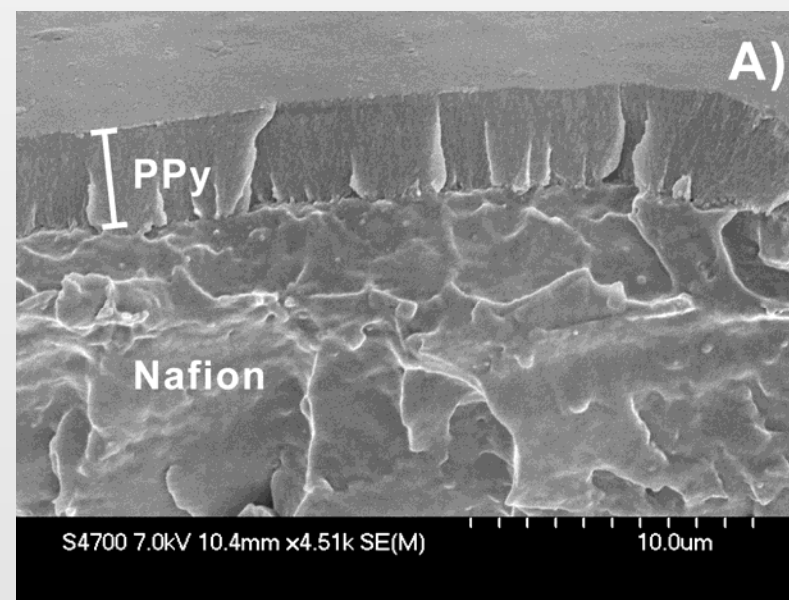
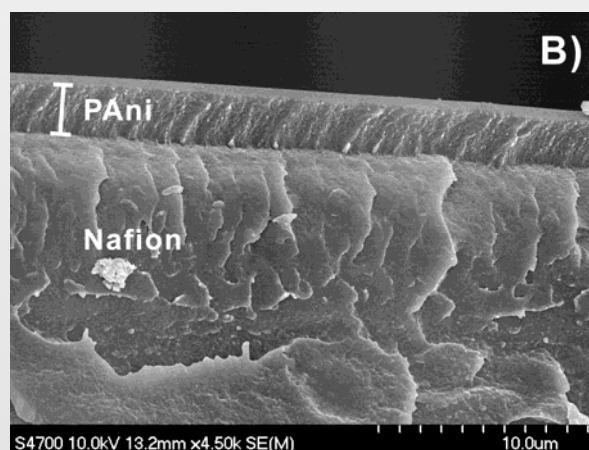
## PEM type fuel cells

### + polymer electrolyte development

- search for new polymer electrolytes based on non-fluorine chemistry
- both homogeneous and heterogeneous materials studied
- establishment of relevant experimental equipment and procedures

### + alternative catalyst support on the base of conducting polymers

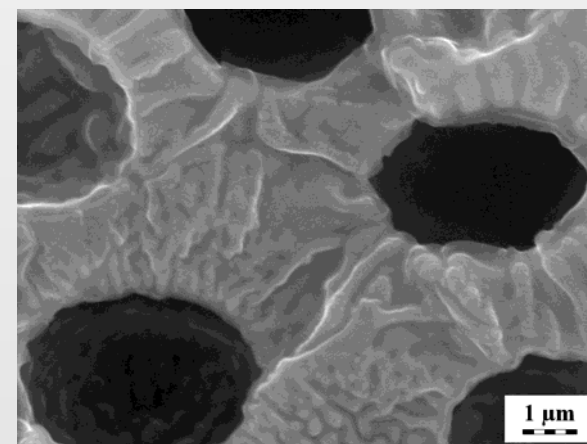
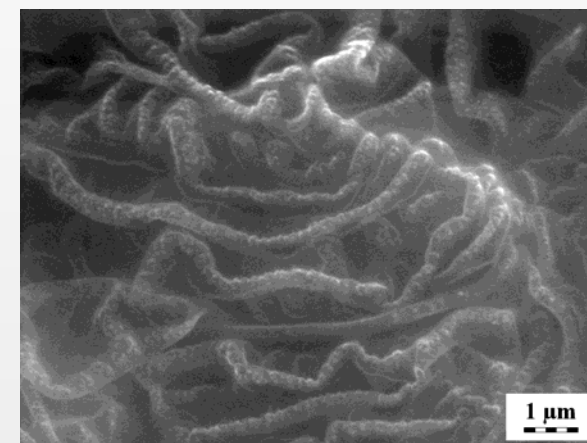
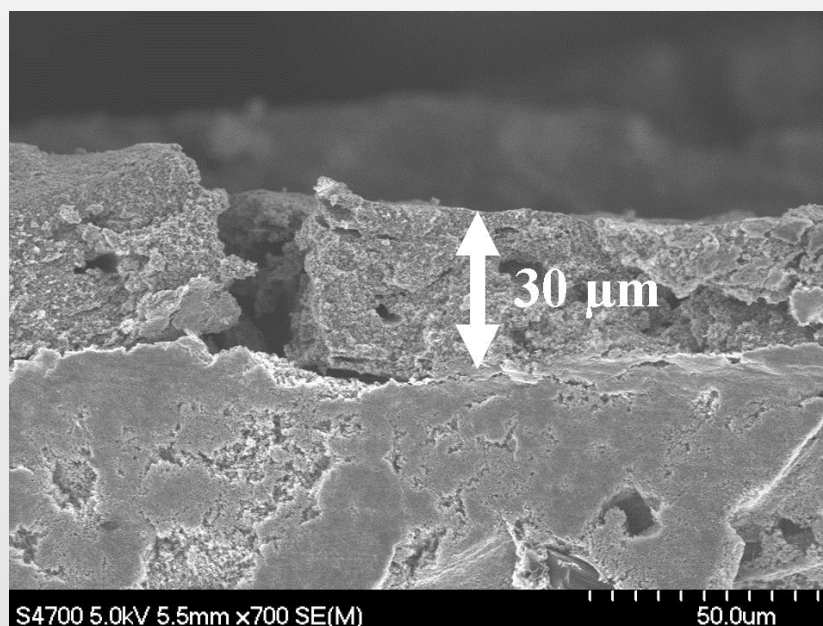
- an alternative approach to the GDE construction
- Pt catalyst utilization enhancement
- stability and gas permeability issues



## HT PEM type fuel cells

### + optimization of the cell components and its testing

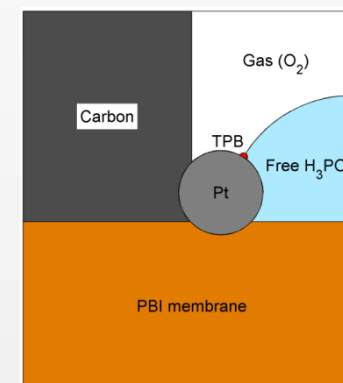
- main focus on the GDE (CL) optimization
- influence of the membrane doping
- polymer supported ionic liquids
- cell stability testing under broad range of conditions



## HT PEM type fuel cells

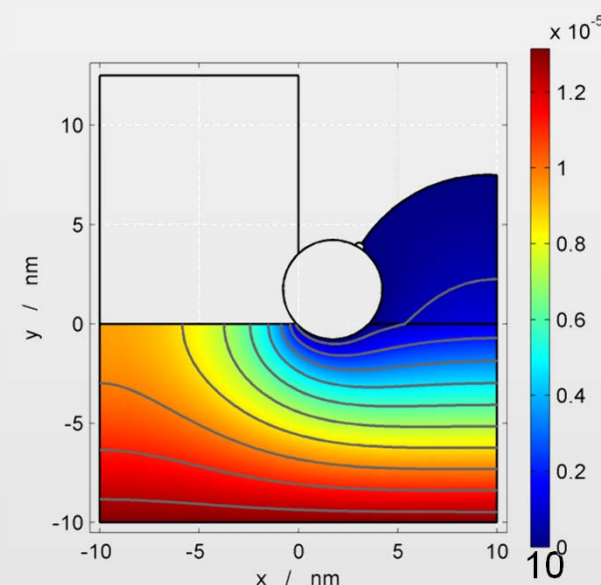
### deeper understanding of the phenomenon occurring

- hydrogen oxidation and oxygen reduction in  $\text{H}_3\text{PO}_4$  environment
- mechanism of the Pt catalyst poisoning
- impact on the catalyst activity screening
- kinetics of the processes related to the Pt catalyst degradation
- evaluation of an amount of the Pt catalyst corroded



### mathematical modelling

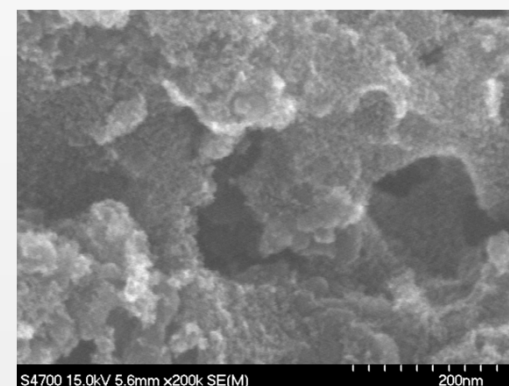
- evaluation of the kinetic parameters on the base of global experimental data
- complex modelling of the catalyst degradation in the GDE catalytic layer
- optimization of the cell components (flow-fields)
- fuel cell stack model



## PEM water electrolysis

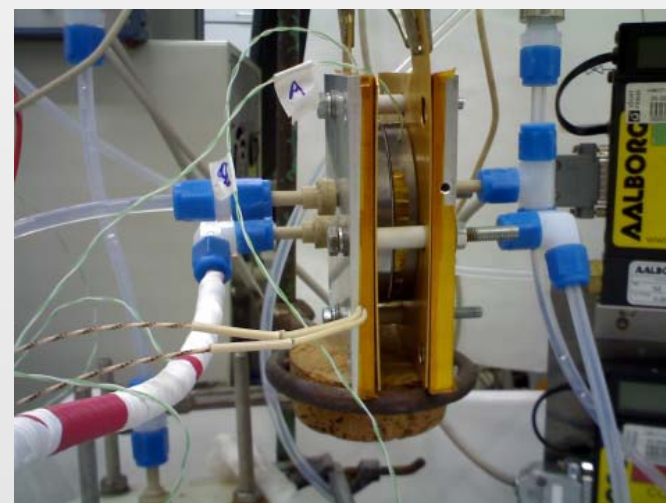
### + polymer electrolyte properties and durability

- application of alternative polymer materials
- impact of elevated temperature and pressure on PFSA
- determination of changes induced
- determination of PFSA durability in electrolysis cell
- possible ways to the stability enhancement



### + anode optimization

- mainly reduction of required IrO<sub>2</sub> loading
- impact of the catalyst support on the anode performance
- impact of the catalyst support conductivity



## Alkaline water electrolysis

### + polymer electrolyte development

- ✎ novel polymer electrolytes using quaternary ammonium group
- ✎ stability in alkaline environment at elevated temperature
- ✎ both homogeneous and heterogeneous materials tested
- ✎ catalytic layer binder an important issue
- ✎ testing under water electrolysis conditions

### + Non-platinum metals based catalysts

- ✎ originally Ni-Co based spinel oxides studied for anodic oxygen evolution
- ✎ gradually extended to the materials of more complex composition
- ✎ cathodic hydrogen evolution studied as well

## High temperature water electrolysis

### + materials synthesis, development and characterization

- ✓ CERMET hydrogen electrode
- ✓ LSM oxygen electrode
- ✓ YSZ electrolyte
- ✓ electrolyte supported systems
- ✓ hydrogen electrode supported systems

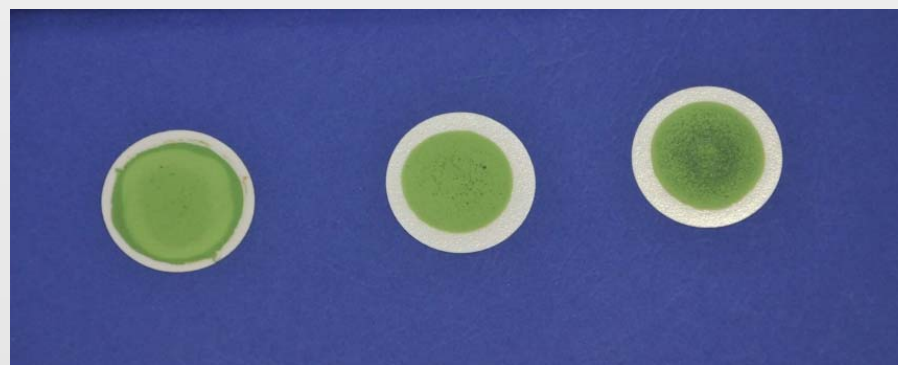
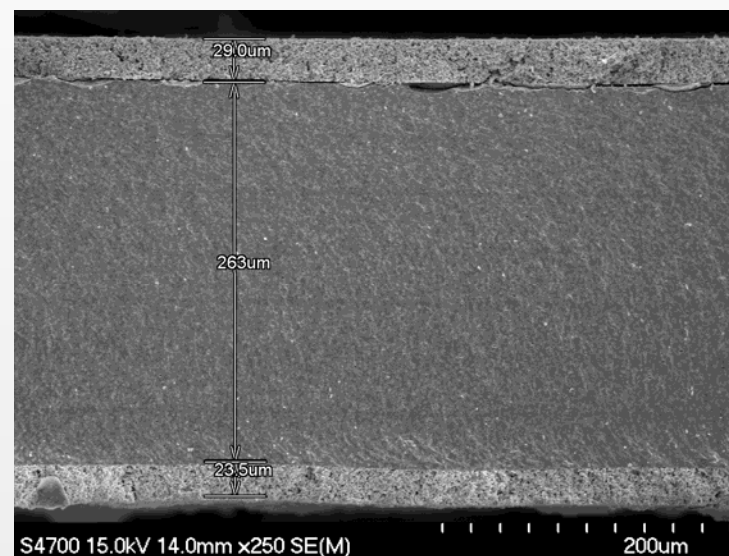
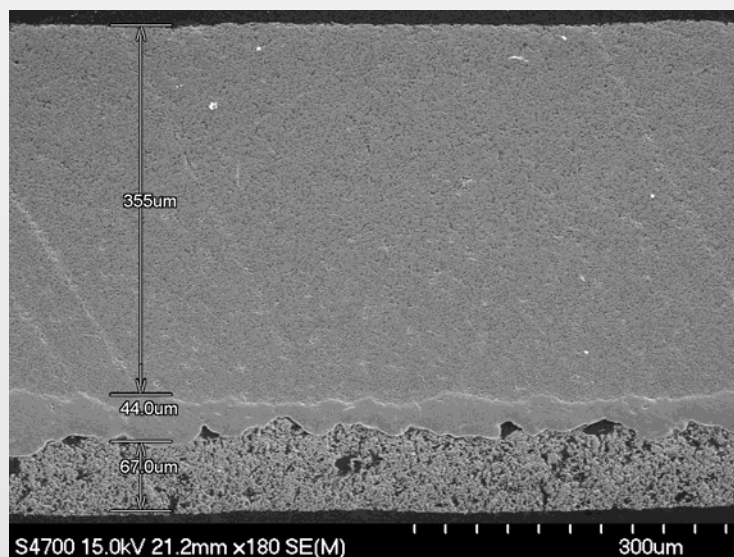
### + mathematical modelling of the process

- ✓ determination of kinetic parameters on the base of global experimental data
- ✓ obtaining local information hardly accessible experimentally
- ✓ simulation of the dynamic behavior of the system of the real dimensions
- ✓ obtaining information needed for integration of the electrolysis cell to the more complex systems

## High temperature water electrolysis




### laboratory size stack development

- know-how in the unit construction
- validation of the mathematical model
- information for the scale-up process





## Other topics studied at ICT Prague

### hydrogen production

-  thermal processes (biomass, waste materials)
-  biological processes
-  fossil fuels based processes

### hydrogen purification

-  sorption processes
-  membrane processes

### hydrogen storage

-  pressure vessels – safety issues
-  metal hydrides



## Conclusions

- ✚ although history of hydrogen processes in the Czech is long, it still lags behind technology state in Western Europe, US, ...
- ✚ significant progress achieved in the last decade
- ✚ first demonstration activities subject of subsequent presentation
- ✚ ICT Prague inseparable part of this development
- ✚ integration to the broader European network necessary
- ✚ number of subjects involved increasing
- ✚ recognition as an important field on the national level still missing

***Thank you for your attention!***

**Modern research team in the field of  
hydrogen technologies**



Elmempro 2012