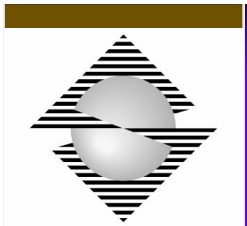
HIGH PRESSURE PEM WATER ELECTROLYSIS AND CORRESPONDING SAFETY ISSUES

Pierre Millet

International conference on Hydrogen Safety
(ICHS3-09)
Ajaccio, France, 16-18 September 2009



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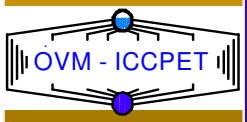
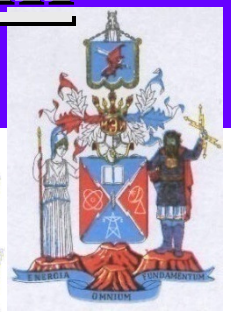


GenHyPEM project and Consortium (2005-2008)

GenHyPEM consortium



ICMMO

Institut de Chimie Moléculaire et des Matériaux, Orsay, France

UNIVERSITÉ PARIS-SUD 11

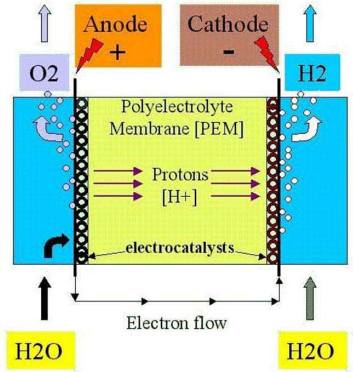
University Paris-sud – CNRS (coordination, Orsay, France)

GenHyPEM

Coordination : pierre.millet@lpces.u-psud.fr

Delta Plus Engineering (Liège, Belgium)

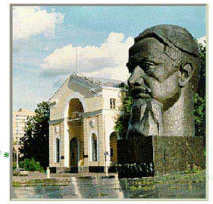
STREP n° 019802
Total cost = 2.2 M€
EC support : 1.1 M€
3 years from 10/2005



OVM ICCPET (Bucarest, Romania)

PEM water electrolysers

Compagnie Européenne des Technologies de l'Hydrogène (Marcoussis, France)



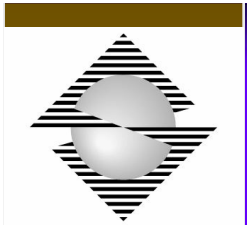
"Kurchatov Institute"

RRC "Kurchatov Institute" (Moscow, Russian Federation)

GKN Sinter Metals gmbh (Radevormwald, Germany)

H2 ECONOMY

KBSU



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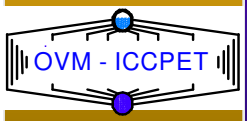
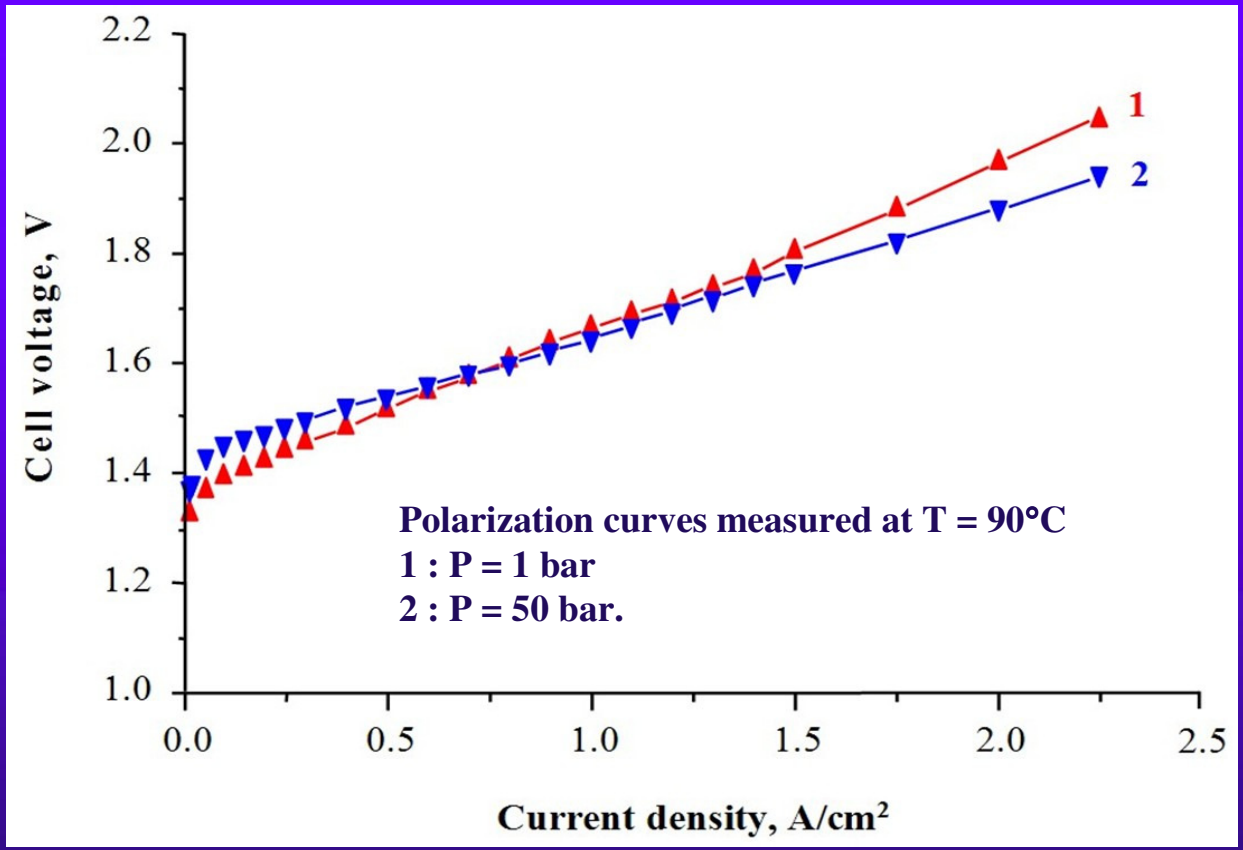


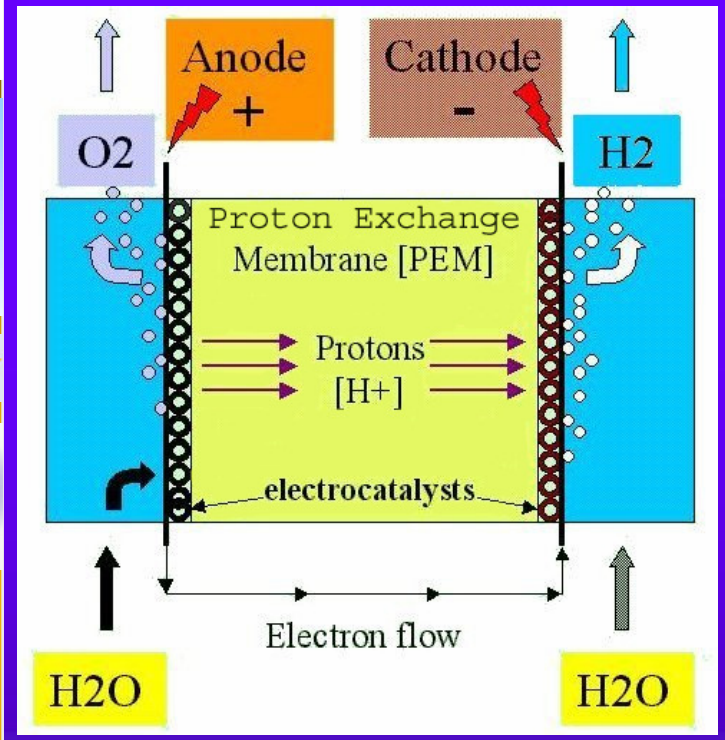
High pressure PEM water electrolysis

High pressure operation

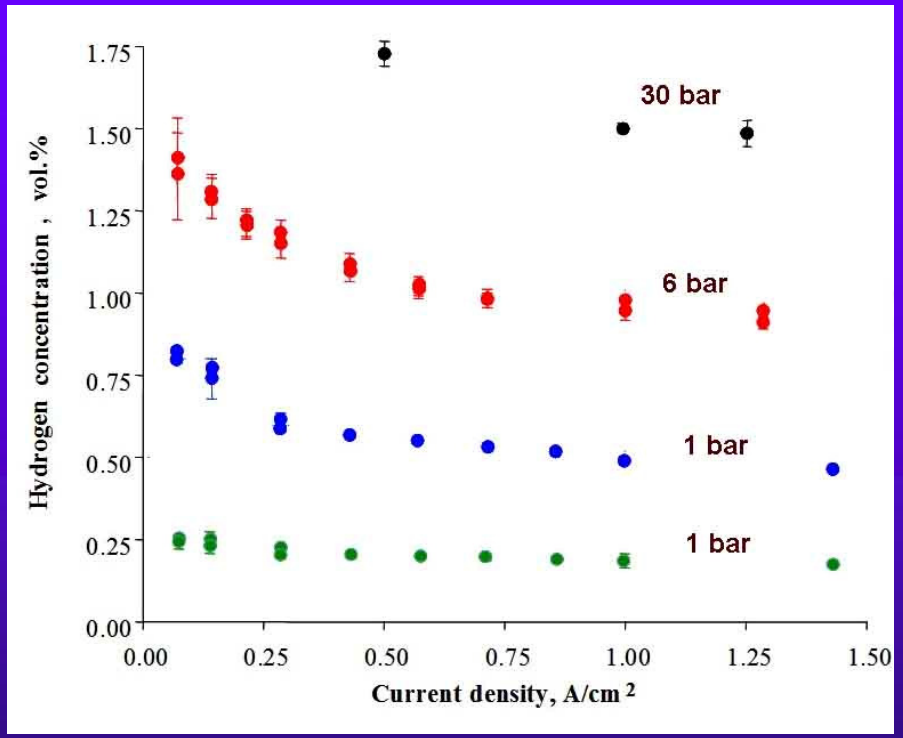


No significant impact of pressure on electrochemical performances

High pressure operation



PEM WE cell

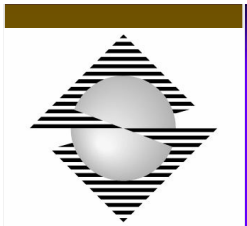


O_2 purity at anode

V.FATEEV, S.GRIGORIEV, P.MILLET, S.KOROBTSEV, V.POREMBSKY, M. PEPIC

High pressure PEM electrolyzer hydrogen safety problems

2nd International Conference on Hydrogen Safety, San Sebastian, Spain, 11-13 september 2007



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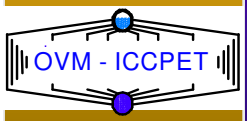
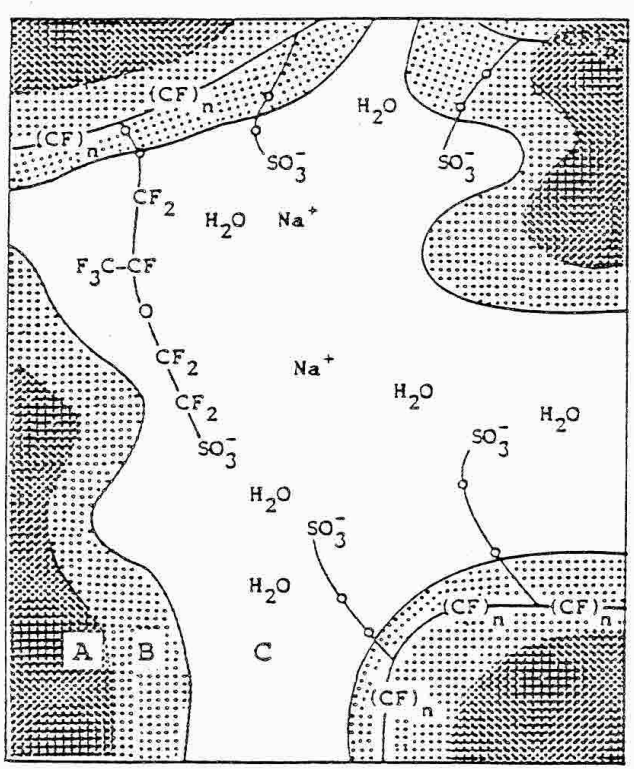
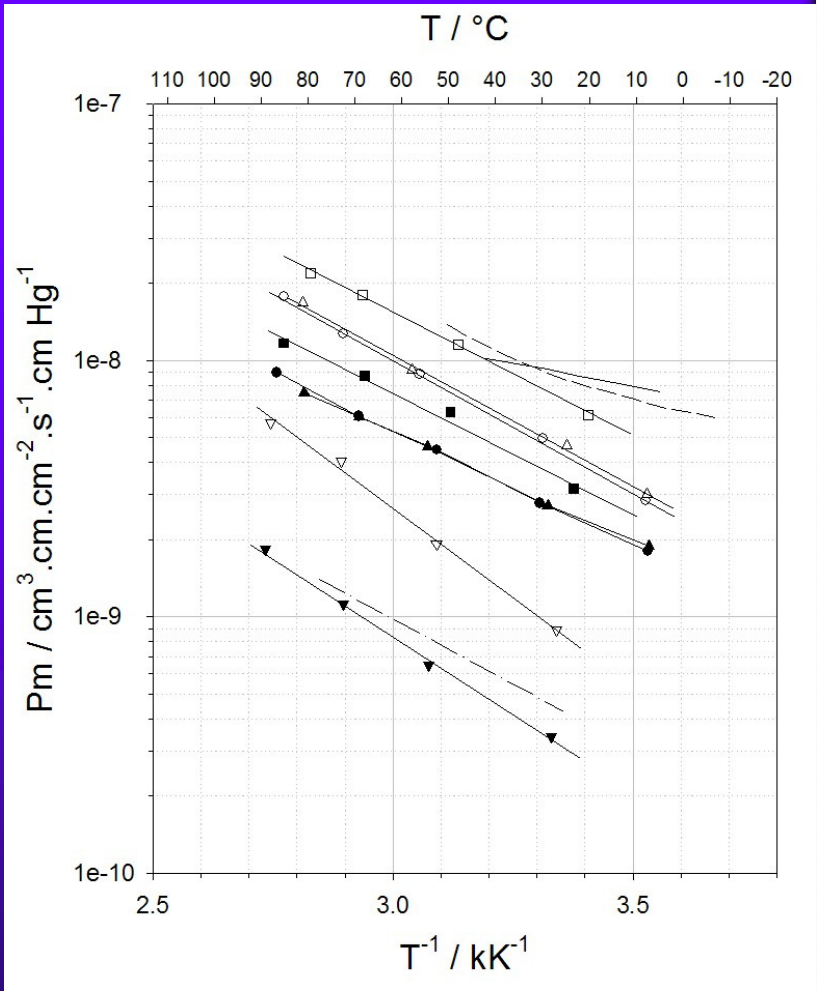


Gas cross-permeation phenomena

High pressure operation



Nafion microstructure
(Yeager 1981)



Gas permeability

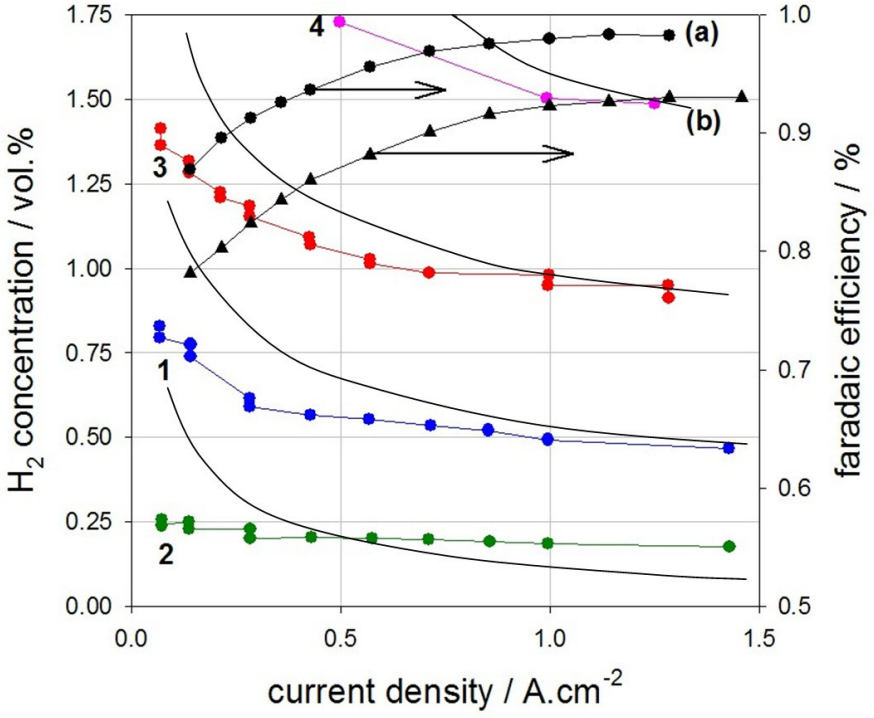
Modelling

- Thermodynamics : Henry's law
- Kinetics : Fick's law of diffusion

T / °C	10	20	40	60	85
P^m_{O2}/cm^2.Pa^{-1}.s^{-1}	2.1×10^{-12}	2.3×10^{-12}	3.7×10^{-12}	5.3×10^{-12}	8.4×10^{-12}
D_{O2} / cm^2.s^{-1}	2.1×10^{-7}	2.5×10^{-7}	4.2×10^{-7}	6.5×10^{-7}	1.1×10^{-6}
P^m_{H2}/cm^2.Pa^{-1}.s^{-1}	3.8×10^{-12}	4.6×10^{-12}	7.6×10^{-12}	1.2×10^{-11}	2.0×10^{-11}
D_{H2} / cm^2.s^{-1}	3.9×10^{-7}	4.9×10^{-7}	8.7×10^{-7}	1.5×10^{-6}	2.6×10^{-6}
D_{H2}/D_{O2}	1.9	2.0	2.1	2.3	2.4

H_2 and O_2 permeability and diffusion coefficient in fully hydrated Nafion 117 at different temperatures.

the H_2 content in O_2 (at constant temperature and pressure) is inversely proportional to current density



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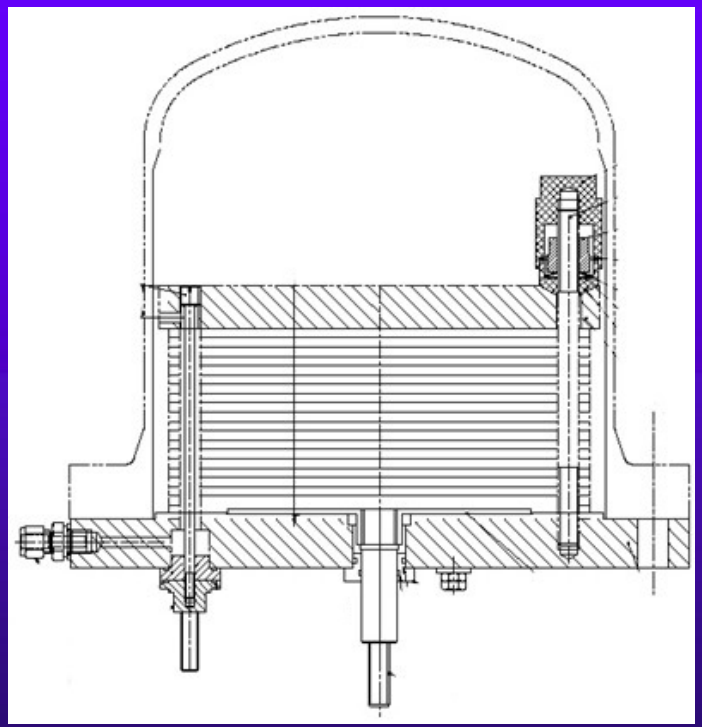
OVM - ICCPET

ÎledeFrance

Design of a high pressure stack
High pressure test bench

High pressure PEM water electrolyzer

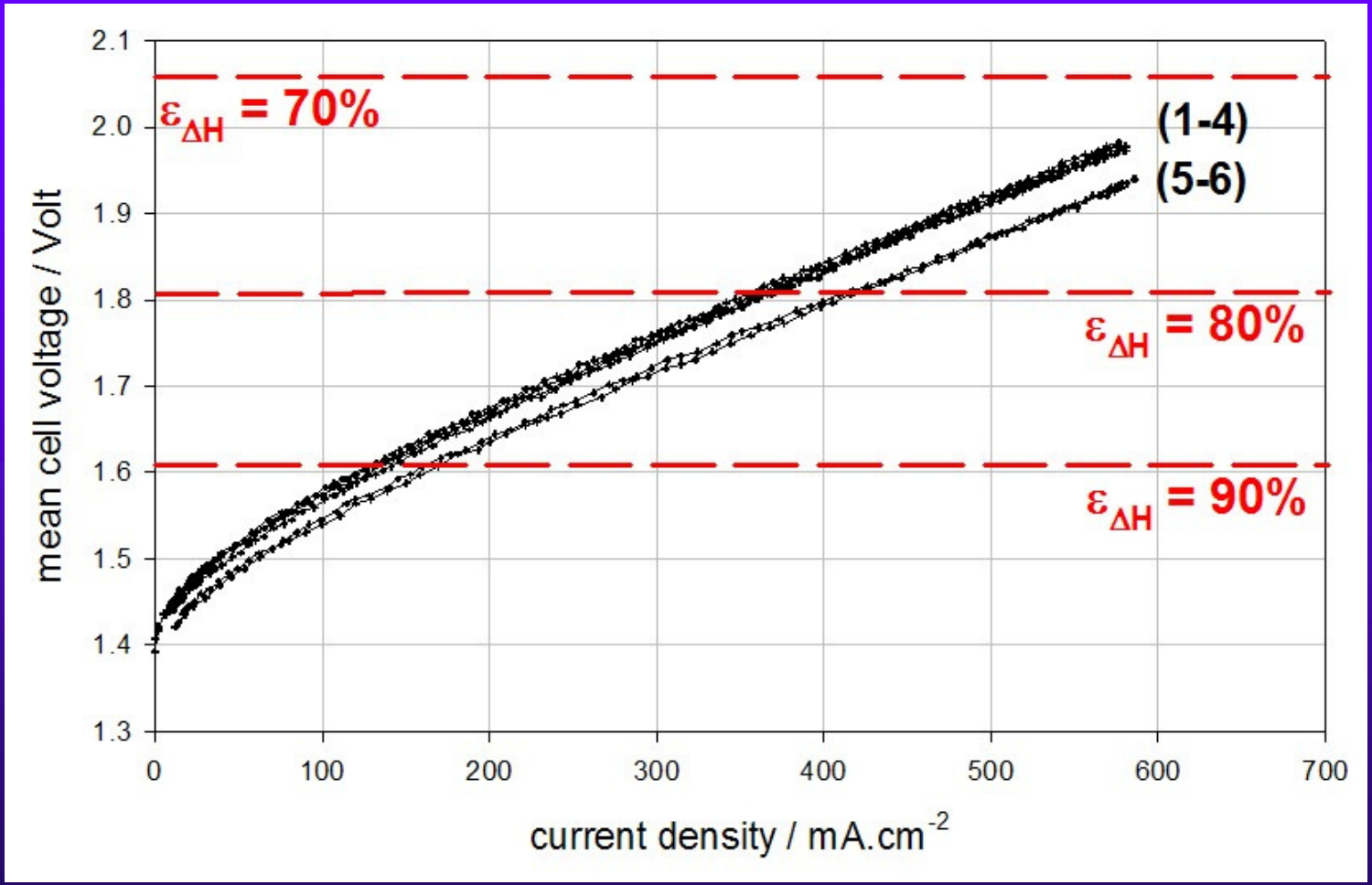
GenHy1000 PEM stack

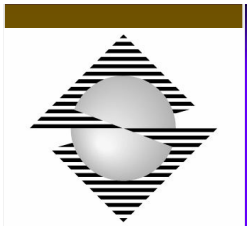


Pressurization vessel

High pressure test bench

Polarization curces measured on the stack





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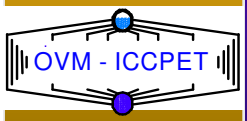

Technological developments

GenHy® PEM water electrolysers

GenHy® 1000 Nl H_2/hour
max input = 5 kW
1-10 bars

GenHy® 3000 Nl H_2/hour
max input = 5 kW
1-50 bars

GenHy® 5000 Nl H_2/hour
max input = 30 kW
1-10 bars

automated, EC certified

Conclusions & perspectives

Achievements

- GenHy®100 to GenHy®5000 (5 m^3 H_2/hour)
- operating pressure : up to 100 bars
- different technologies for different applications

Short-term perspectives

- non-noble electro-catalysts
- catalyst deposition techniques to be improved
- reversible systems