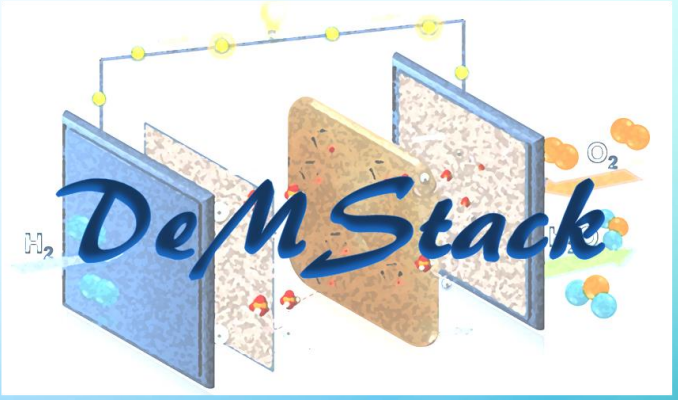
Understanding the Degradation Mechanisms of a High Temperature PEMFC Stack & Optimization of the Individual Components

DeMStack

GA No: 325368



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http://demstack.iceht.forth.gr/

PROJECT OVERVIEW

DeMStack 325368	
Call topic	SP1-JTI-FCH.2012.3.1_Cell and stack degradation mechanisms and methods to achieve cost reduction and lifetime enhancements
Application area	Stationary Power Generation & CHP
Start date	01/05/2013
End date	30/04/2016
Total Budget	2,576,615
FCH JU contribution	1,495,680
Stage of implementation	83% project duration passed

FORTH/ICE-HT

JRC EUROPEAN COMMISSION

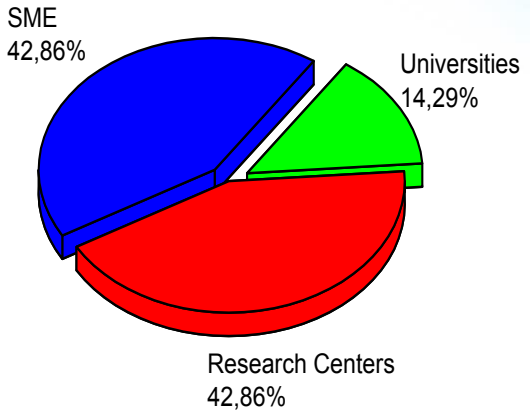
Advent

IK4 CIDETEC Research Alliance

cmr Prototech

INSTITUTE OF CHEMICAL TECHNOLOGY PRAGUE

helbio



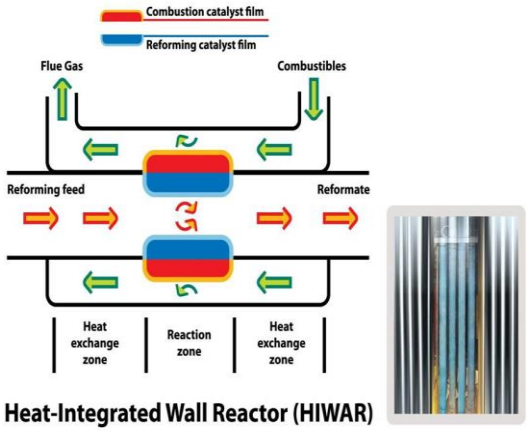
PROJECT TARGETS AND ACHIEVEMENTS

➢ DeMStack activities are on the stack optimization and construction based on the high temperature MEA technology of ADVENT S.A..

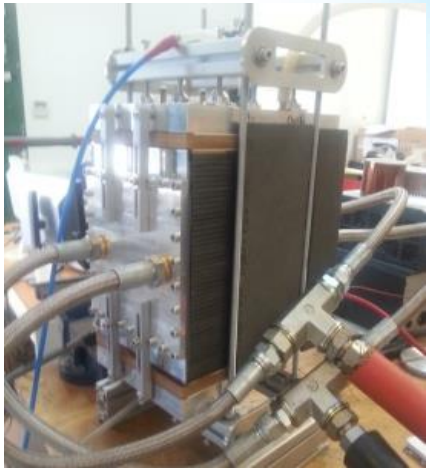
➢ This is the first attempt to combine optimized components and methodologies into an integrated system; a low-cost HT PEMFC 1 kW stack will be integrated with a fuel processor specifically built to suit the demands of the FC stack.

➢ The robustness of the stack, the simplicity of BoP and the operational stability into a commercially reliable product will be demonstrated.

- Fuel Cell Stack Power output of 1 kW at 0.2 A/cm^2 at 180^{o}C (electrical efficiency > 45%)
- Operation over a wide range of reformates: (H_2≥50%, CO = 0-4%, steam = 0-30%)
- Overall cost reduction by a factor of 2 (reduction of the MEA's cost)

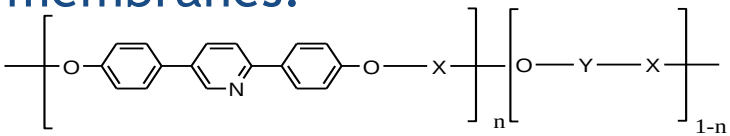


Heat-Integrated Wall Reactor (HIWAR)

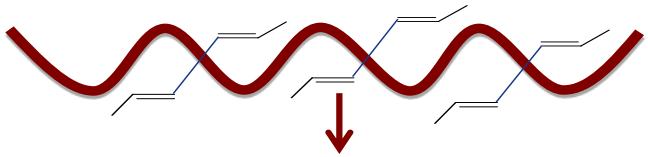


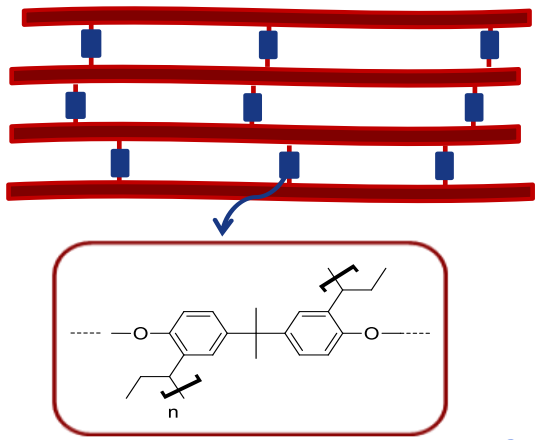
PROJECT TARGETS AND ACHIEVEMENTS

- Low cost stable HT Membrane Electrode Assemblies.
- Catalytic layers of alternative architectures and low Pt loadings.
- Overall cost reduction by a factor of 2 resulting by the significant reduction of the MEA's cost due to the lower Pt loading and the cheaper membranes.

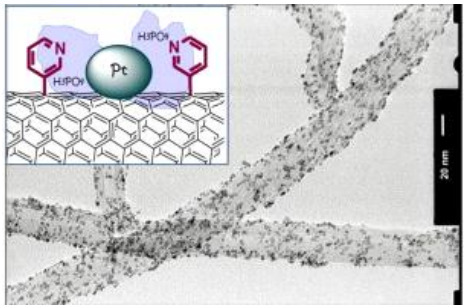


Cross-linking through side double bonds





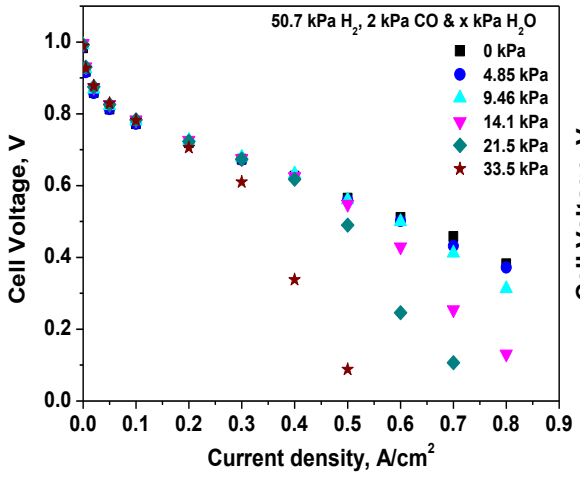
Effective, simplified and low cost pro



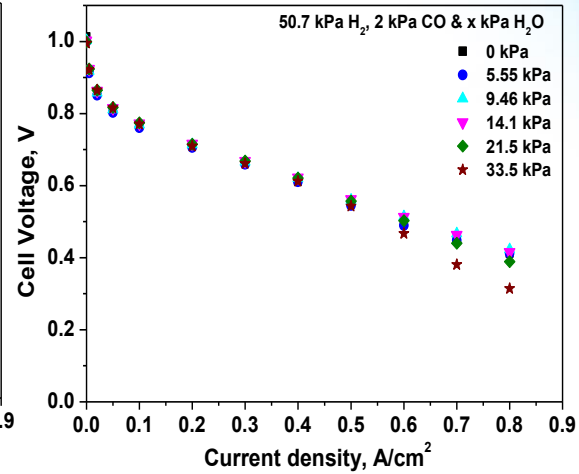
Pt loading≈ 0.7 mgPt/cm²

0.5gPA/gPt

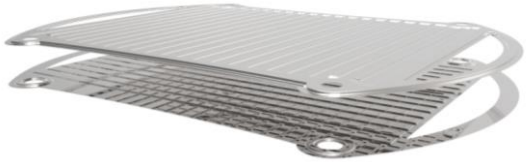
30wt% Pt/C

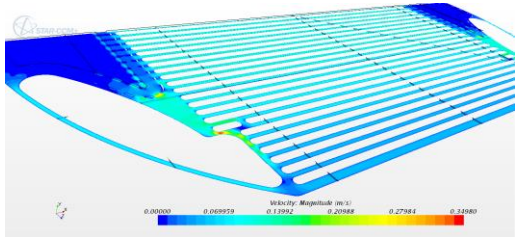


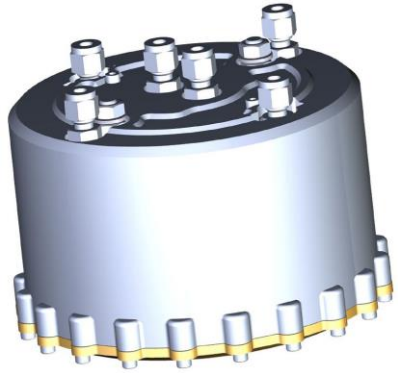
30wt% Pt/ox.MWCNT-Py



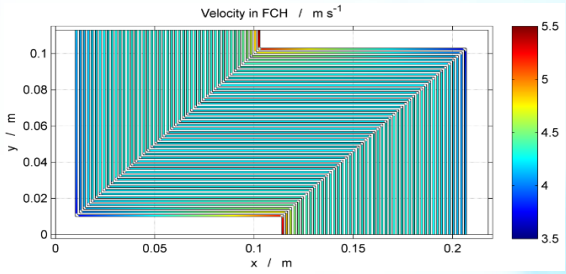
PROJECT TARGETS AND ACHIEVEMENTS

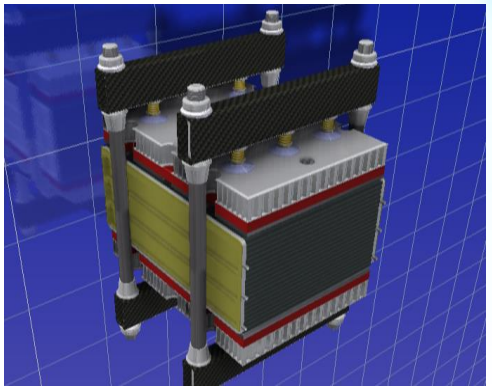


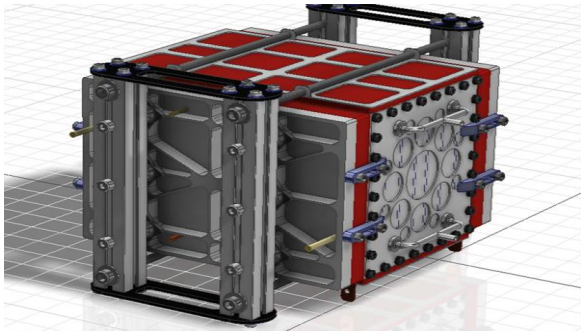




Hydroformed thin metal plates. New challenging concept
CFD calculations, completion of designs.
Selection and testing of materials.







Graphitic Bipolar Plates. Already validated concept.
Increase of bending stiffness of the end plates
Decrease of the weight of the peripheral structure.

PROJECT TARGETS AND ACHIEVEMENTS

Programme objective/target	Project objective/target	Project achievements (to-date & expected)
MAIP		
Small Scale - Domestic 1 - 5 kW	1 kW HT PEMFC operating on reformates	Optimization and selection of components of the stack and fuel processor. Completion of designs. Currently the stacks are being constructed.
2015 target: 4,000 €/kW industrial/commercial units	< 3000€/kW	Cost analysis for mass production (5,000units/year) estimates close to 2,000€/kW)
AIP		
Electrical efficiencies 35-45% for power units	Electrical efficiency 38-44% at 180°C (0.14 W/cm^2 @ 0.2 A/cm^2)	Already validated efficiency using preliminary designs
Operational lifetime > 20,000	Stack will be tested on an accelerated basis aiming at 5,000 h operation	The stability test is programmed for the last 6 months of the project

RISKS AND MITIGATION

- Operational lifetime
  - Concept successfully approached with already existing materials. Successful implementation of these materials and their combination, as well as the long term operation of the integrated system is still an open question.

- The metallic BP stack and internal liquid cooling system not performing well
  - This is an initial attempt, additional to the work proposed in the DoW. Target is the proof-of-concept.

SYNERGIES WITH OTHER PROJECTS AND INITIATIVES

Previous FCH-JU/EU funded projects	
DEMMEA_245156	The present project is built on technology, techniques and methodologies from the DEMMEA project.
IRAFC_245202	DeMStack used knowledge gained under the IRAFC on polymer electrolytes.
IRMFC_325358	There is interface-exchange of knowledge with IRMFC. Moreover, DeMStack exploited polymer electrolytes optimized under IRMFC.
CathCat_303492	Interaction in terms of knowledge exchange.
Interactions with any international-level projects or initiatives	
European Space Agency	Development of a Closed Loop Regenerative HT PEM Fuel Cell System

HORIZONTAL ACTIVITIES

- Involvement of several Ph.D. students and young postdocs in the research.
- Public Website.
- Organization of 3degis conference (3rd International Workshop on Degradation Issues of Fuel Cells and Electrolysers)
- Efforts are underway to formulate testing protocols for high temperature PEMFCs.
- Participation in the discussion on “Harmonization of Testing Protocols”. The application area (automotive) is different, but can constitute a starting point.

DISSEMINATION ACTIVITIES

- SMEs ensure fast dissemination of the results through technology improvement
- 23 participations in Conferences and Workshops
- 4 Publications

1. "The interaction of H_3PO_4 and steam with PBI and TPS polymeric membranes. A TGA and Raman study" M.K. Daletou, M. Geormezi, E. Vogli, G.A. Voyiatzis, S.G. Neophytides, Journal of Materials Chemistry A, 2(4) 1117-1127 (2014).
2. "Improved Polymer Electrolytes and Carbon Nanotubes Based Electrodes for High Temperature PEM Fuel Cells" M.K. Daletou, A.K. Andreopoulou, K. Papadimitriou, A. Orfanidi, M. Geormezi, J.K. Kallitsis, S.G. Neophytides, 10th ESA Conference Proceeding ESA 2014, SP-719.
3. "The structure and stability of the anodic electrochemical interface in a high temperature Polymer Electrolyte Membrane Fuel Cell under reformate feed", M. Geormezi, F. Paloukis, A. Orfanidi, M.K. Daletou and SG. Neophytides, Journal of Power Sources, 285, 499-509 (2015).
4. "Electrochemistry of Phosphorous and Hypophosphorous Acid on a Pt electrode", M. Prokop, T. Bystron, K. Bouzek, Electrochimica Acta 160 (2015) 214–218.

EXPLOITATION PLAN/EXPECTED IMPACT

- Possible applications in
  - Auxiliary power units (3-10kW),
  - CHP units, Battery chargers with LPG (300 W),
  - Power supply in remote/off grid areas (2kW),
  - Regenerative fuel cells for space (3kW satellites),
  - Stationary back up power systems.

- The three SMEs involved ensure fast exploitation of the results through the improvement of their technology.

- Advent and Prototech are advancing their level and experience into HT PEMFC stack manufacturing, which broadens their cooperation with industrial end-users.

- More intense joint activities between involved SMEs.

- A new proposal has been submitted (APU init for TRU applications) as the continuation.