DURAMET
Methanol fuel Cells

Improved Durability and Cost-effective Components for New Generation Solid Polymer Electrolyte Direct Methanol Fuel Cells (Contract number 278054)

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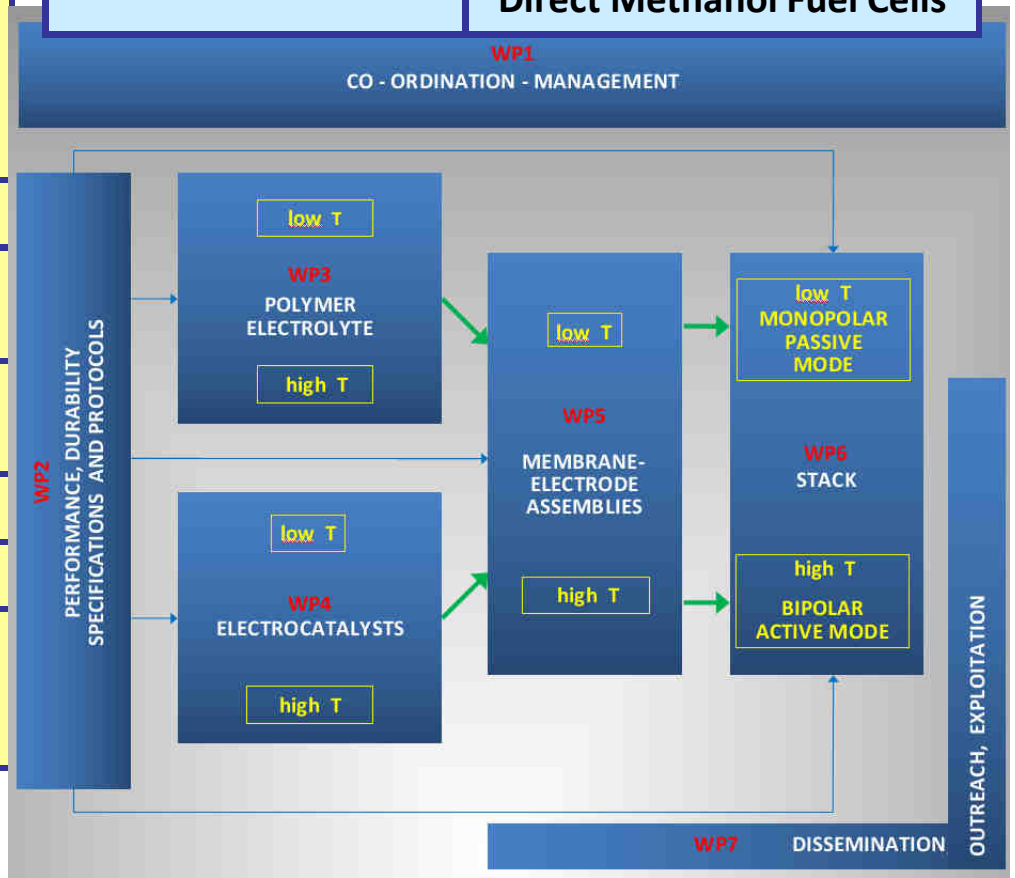
http://www.duramet.eu/

Project information

0. Project & Partnership description

Start date: 1st December 2011	**Duration:** 36 months
Total Cost: € 2,956,874	**Requested EU contribution:** € 1,496,617
Collaborative project	**Theme: SP1-JTI-FCH.2010.4.4 Components with advanced durability for Direct Methanol Fuel Cells**

Beneficiary name	Country	Partner type
CONSIGLIO NAZIONALE DELLE RICERCHE (CNR-ITAE)	Italy	Research
CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE (CNRS)	France	Research
FUMA-TECH GESELLSCHAFT FUER FUNKTIONELLE MEMBRANEN UND ANLAGENTECHNOLOGIE MBH (FUMA-TECH)	Germany	Industry
CENTRO RICERCHE FIAT SCPA (CRF)	Italy	Industry
TECHNISCHE UNIVERSITAET MUENCHEN (TUM)	Germany	Research
IRD FUEL CELLS A/S (INDUSTRIAL RESEARCH & DEVELOPMENT A/S) (IRD)	Denmark	Industry
POLITECNICO DI TORINO (POLITO)	Italy	Research
PRETEXO (PXO)	France	SME
European Commission, Directorate-General Joint Research Centre, Institute for Energy, Petten (JRC-IE)	Belgium	Research



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Project objectives

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DURAMET objectives:

The main objective of Duramet is to develop

improved durability and cost-effective components for direct methanol fuel cells for application in portable power and assisted power units as well as for remote generation.

The final target of the project is to demonstrate the newly developed or optimized DMFC components, i.e. catalysts, membranes and MEAs, in single cells and in short stacks.

Approach in performing the activities:

Portable	← DMFC Applications →	APU / remote & micro-distributed
Ambient to 60-80 ° C (rapid start-up)	Target operating temperatures	120 ° C (rapid start-up)
Sulfonated polysulfone/ novel PFSA	Membranes	Polyphosphonic/ mixed functionalities/ Sulfonated PBI
Low-noble metal loading/ Pd-based (Pt/Ru free) Oxide supports	Electrocatalysts	Pd-based (Pt/Ru free)/ non noble metal catalysts Oxide supports
Hydrophobicity tailored	Membrane-electrode assemblies (MEAs)	Hydrophilicity tailored
Monopolar configuration	Validation in short and mini stacks	Bipolar configuration

Durability
Performance
Cost-effectiveness

Project milestones

DURAMET targets:

M12-24 — Membrane

Conductivity better than 50 mS/cm
& MeOH cross-over lower than $5x10^{-7}$ $mol \cdot cm^{-2} \cdot min^{-1}$
at 5-10 M conc. at the targeted temperatures

M18-24 — Catalysts

PGM loading <0.5-1 mg cm^{-2}; ORR overpotential< 0.4 V;
MOR overpotential < 0.3 V at 0.125-0.5 A cm^{-2}
for LT and HT operation

M32 — MEAs

Performance > 250 mW cm^{-2} for HT operation;
> 50 mW cm^{-2} for LT & passive mode operation;
degradation a factor of 2 smaller than benchmark MEAs

M36 — Stacks

Validation in short stacks
(150 W active, and 1 W passive mode);
500 hrs durability test

Testing procedures

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Three public deliverable reports already submitted regarding characterization and assessment of membranes, catalysts and MEAs specifilly addressing DMFC applications

These deliverables define a set of testing protocols for characterisation of baseline and novel DMFC components to allow to allow for a homogeneous screening and evaluation of the newly developed materials.

The deriverables identify benchmark materials against which progress is assessed in terms of properties.

The protocols are used as means of verification to assess the achievement of project milestones.

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fumatech
Funktionelle Membranen und Anlagentechnologie

cnrs

ATAE

TECHNISCHE UNIVERSITÄT MÜNCHEN

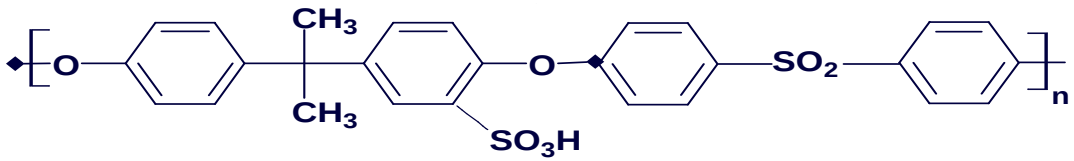
POLITECNICO DI TORINO

European Commission

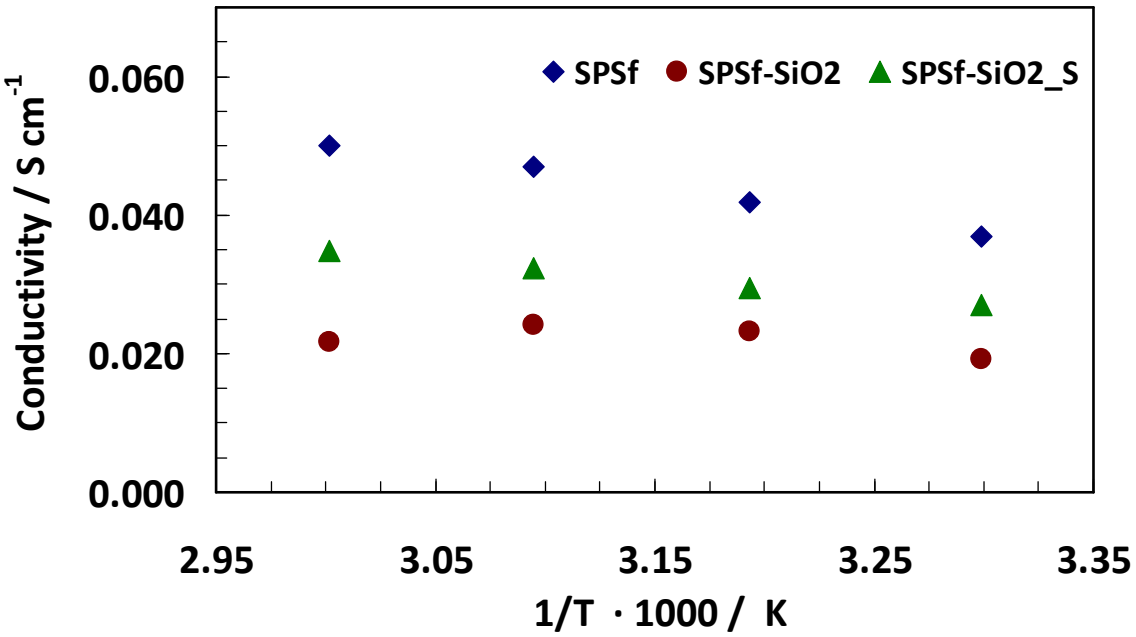
Technical Achievements and Progress

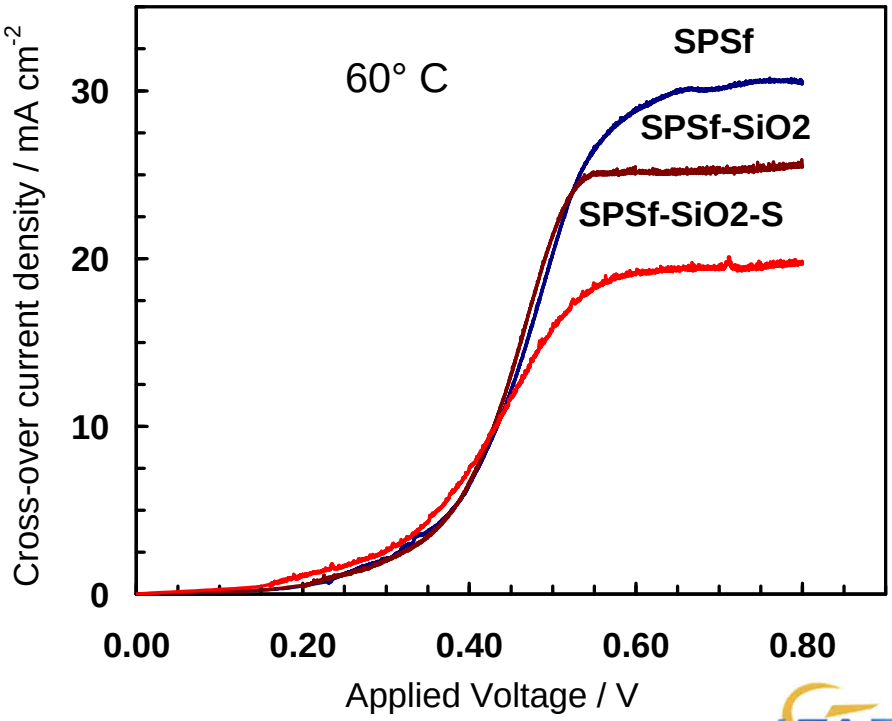
Membrane development:

Sulfonated polysulfone (bare and composite with SiO_2)



Low cost; Low H_2O / MeOH uptake and swelling; Low MeOH cross-over; good conductivity; durability





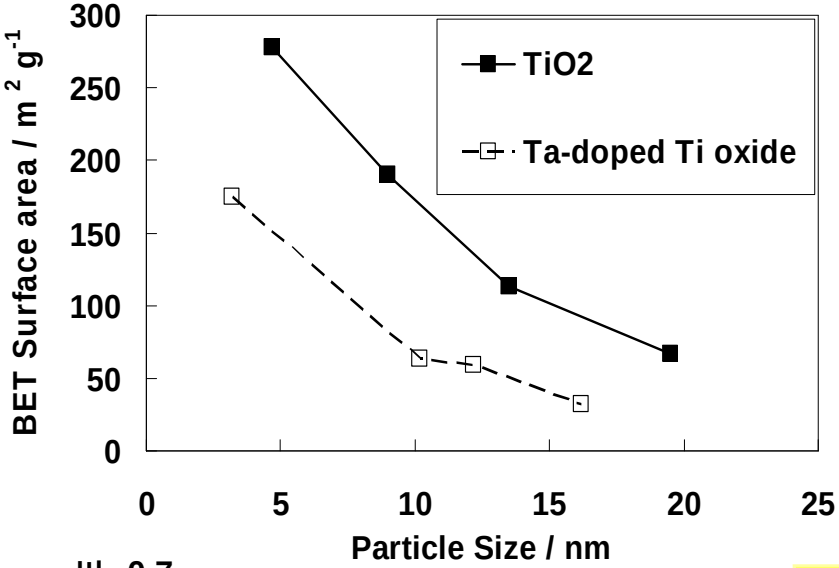
Target of conductivity for hydrocarbon membranes of 50 mS cm^{-1} achieved

Cross-over 5 times lower than Nafion membrane of similar thickness

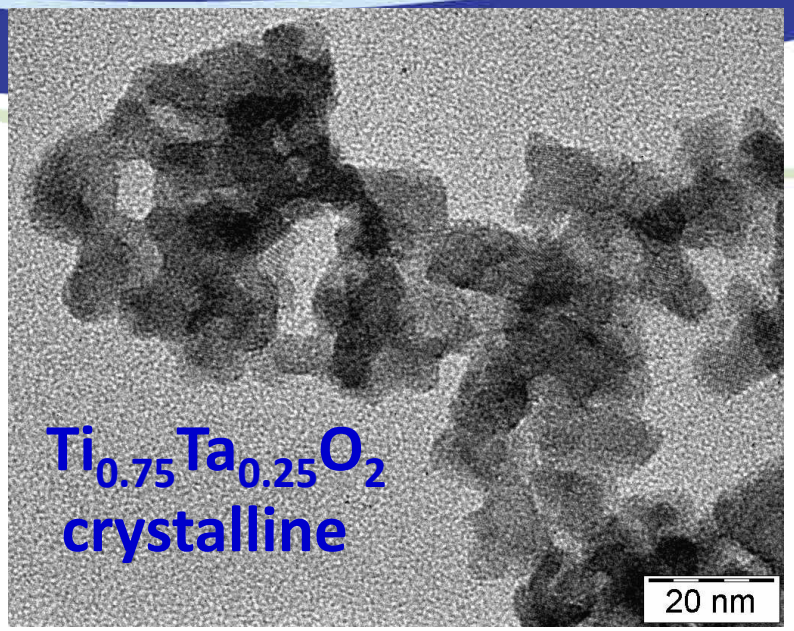
Technical Achievements and Progress

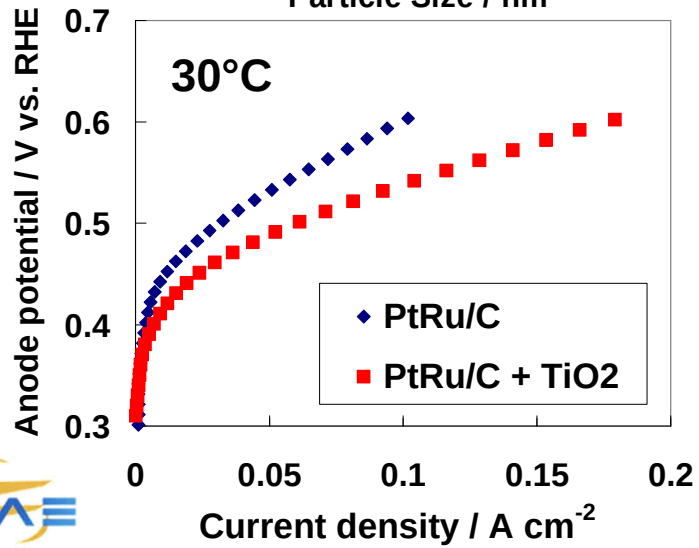
Electrocatalyst development:

Novel Ti oxide-based supports and composite electrodes with reduced noble metal loading 0.5 mg cm^{-2}

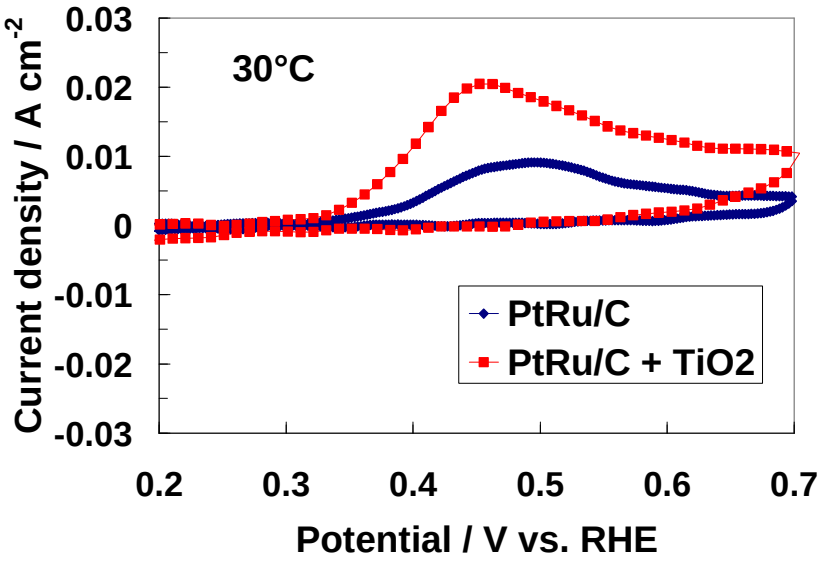


High BET Surface area





Reduced anodic overpotential vs. conventional catalyst



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Non-noble metal catalysts

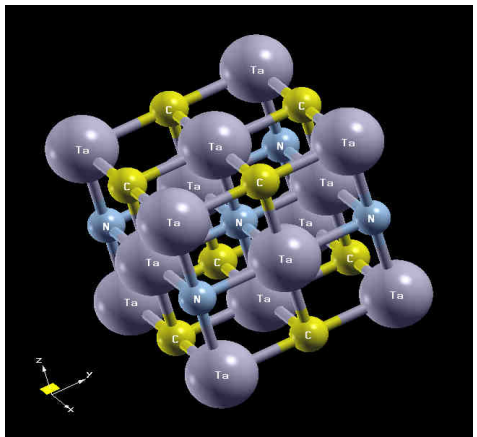
Modeling of structure and properties of partially oxidized tantalum carbonitride for ORR

Study the of the TaCN structure

- Find the optimized unit cell and bulk energy
- Identify the different surfaces and compute the surface energies

QUANTUM ESPRESSO code

Study of the Ta_2O_5 structure



- Find the optimized unit cell
- identify the different surfaces of Ta_2O_5 and compute the surface energies
- study the defective Ta_2O_5 surface : O vacancies, C and/or N doping
- study the interface behavior between TaCN and Ta_2O_5
- In the defective structure, are the electronic properties of Ta similar to the ones of Pt behaving as a catalyst?

FIAT CRF CENTRO RICERCHE FIAT

Technical Achievements and Progress

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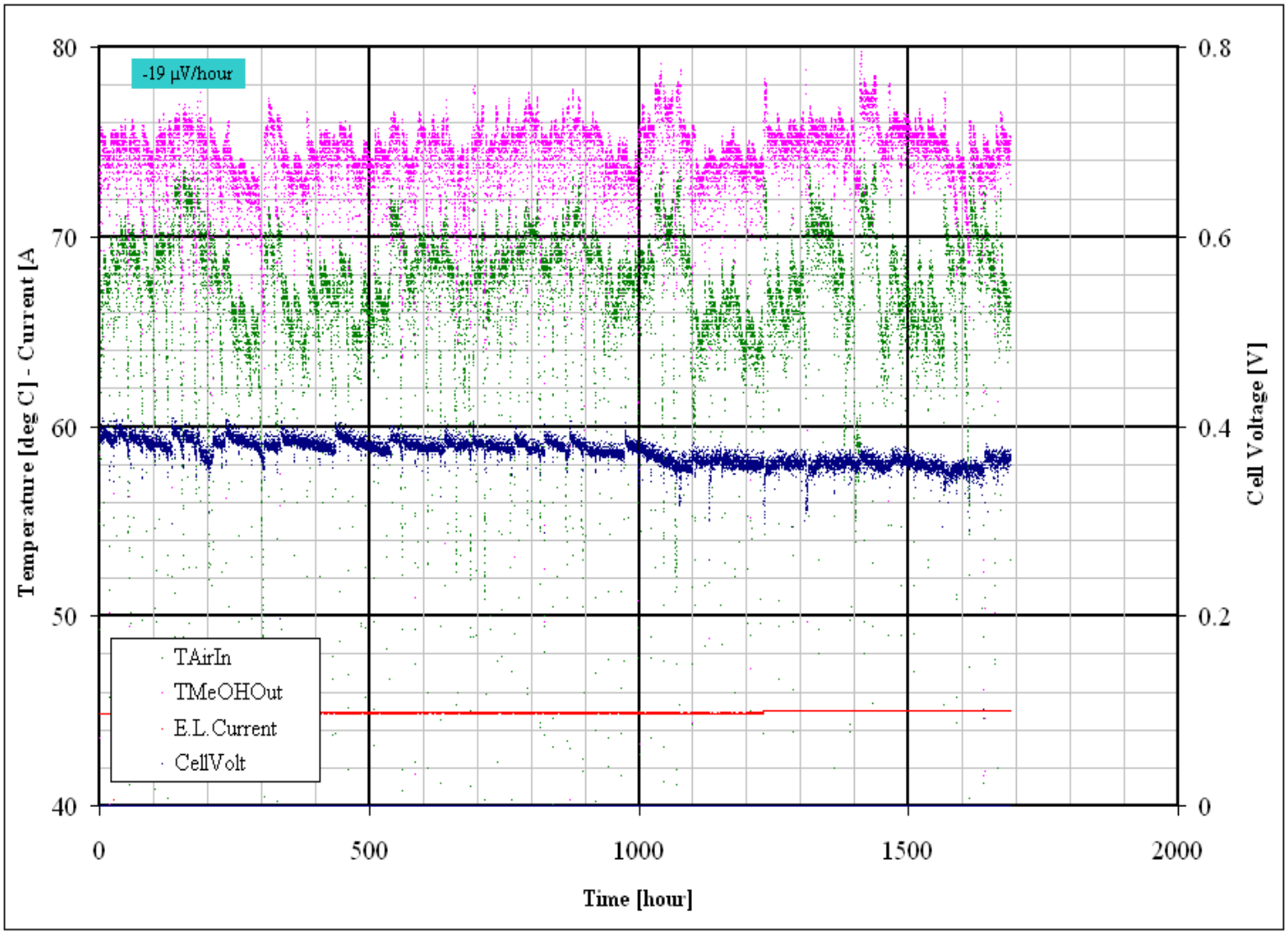
MEAs testing with baseline materials:

MEA tests :
-Refresh cycle every 20 minutes.
-5 days operation 2 days of stop.

Degradation
- Overall 19 µV/h
- Initial 9 µV/h
- Gasket blown@ 1000 hours



IRD Fuel Cell Technology

Alignment with AIP 2010/MAIP

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Duramet:

The clear focus of the project is on the demonstration of the enhanced performance and durability of newly developed or optimized DMFC components, i.e. catalysts, membranes and MEAs, in single cells and in appropriate short stacks with realistic cell area and under practical operation for the different applications.

All these aspects were addressed specifically by the JTI call, Area SP1-JTI-FCH.4: Early Markets SP1-JTI-FCH.2010.4.4 Components with advanced durability for Direct Methanol Fuel Cells.

The scope of this topic was regarding "*Research and development to develop improved components demonstrating superior durability vis-a-vis state-of-the-art while at the same time lowering the cost/kW for Direct Methanol Fuel Cells*".

Alignment with AIP 2010/MAIP

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Duramet is relevant to the FCH-JU MAIP, Application area: Early Markets

This application area aims to develop and deploy a range of fuel cell-based products capable of entering the market in the near term. The main goal is to show the technology readiness of portable and micro fuel cells for various applications; portable generators, back-up power and UPS-systems etc.

Research and technological development are carried out in parallel with the demonstration areas in order to prepare technologies needed for commercial use.

The project deals specifically with cost effective and enhanced durability components for high temperature direct methanol fuel cells amenable to be integrated in auxiliary power units, for portable powers sources and in general for applications related to energy supply systems for microdistributed and remote generation.

The overall objective is to significantly decrease the cost, enhance durability and offer a wide range of operating conditions by addressing the materials development for specific applications

Alignment with AIP 2011/MAIP

Expected output AIP Area: Early Markets Topic: 4.4 Components with advanced durability for Direct Methanol Fuel Cells. Call: 2010		**Objectives of the project**	**Results to date**
Expected Outcomes	**Proof-of-concept on the component level**	Conductivity better than 50 mS/cm & MeOH cross-over lower than $5x10^{-7}$ $mol.cm^{-2}.min^{-1}$	-Proton Conductivity ~ 50 $mScm^{-1}$ at 60 ° C (sPSf) and 35 $mScm^{-1}$ at 120 ° C (comp.); -MeOH cross-over < $20x10^{-7}$ $mol.cm^{-2}.min^{-1}$ (permeation)
	New components for DMFCs with improved durability, efficiency	Performance > 50-250 mW cm^{-2} for LT, HT operation; Degradation: two times less than benchmark MEAs	Performance > 20 mW cm^{-2} for LT (low PGM), *65-120 mW cm^{-2} at 150-200 ° C with PA-PBI for HT operation (high PGM)*
	Integration in at least one DMFC stack solution and proof of durability under simulated real operating conditions	Validation in short stacks (150 W active, and 1 W passive mode); 500 hrs durability test	Preliminary studies in short stacks under passive mode operation using the novel components.
	New components for DMFCs with superior cost efficiency	PGM loading <0.5-1 mg cm^{-2}; Novel hydrocarbon membranes	PGM loading <0.5-1 mg cm^{-2}; Sulfonated polysulfone;

Alignment with AIP 2010/MAIP

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Priorities and topics possibly under/over-estimated in the AIPs in terms of technical challenge

- Development of membrane electro-catalysts and MEAs for direct methanol fuel cells, satisfying the required targets of proper performance and durability by using cost effective materials such as novel hydrocarbon membranes and low PGM loading electrodes for portable as well as APU applications is quite challenging.
- It requires more support to be addressed to research efforts for breakthrough materials capable of operation in a wide range of temperature and methanol concentration, advanced MEAs characterised by a novel design and optimised architectures for the specific applications.
- Identify quantitative targets for DMFCs in the AIP/MAIP; increase the support on focused research programs

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DURAMET addresses and contributes to:

- **Training/education** of 1 Ph.D. student (POLITO), 3 post-doctoral researchers in materials science processing and assessment (CNR, POLITO).
- **Dissemination** of project results through publication in international peer-reviewed journals, conference presentations and via the project web site:
  - ✓ To date: 3 public deliverables on characterisation protocols of membranes, electrocatalysts and MEAs for direct methanol fuel cells available through project web-site;
  - 1 public deliverable report concerning with: State of the art on high temperature DMFCs and portable applications DMFCs.
  - ✓2 oral presentations (one invited)/ 2 posters at conferences;
  - ✓1 publication submitted, 2 in preparation.
- **Public awareness:** information activities to increase public awareness of alcohol-fed fuel cells including direct ethanol fuel cells during dissemination activities addressed to university and high school students with the visit to the research laboratories, etc.

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- **Technology Transfer / Collaborations**
  - ***link to previous work concerning with DMFC characterization carried out within the framework of Dreamcar (FP5) and Morepower (FP6) projects.***
  - ***Collaboration between CNR Italy-CNPQ Brazil and CNR Italy- CSIC Spain bilateral project on alcohol oxidation.***
  - ***Collaboration between POLITO and NRC Canada.***

- **Project Future Perspectives**
  - **Collaboration with other projects, institutes, and other entities are expected during the prosecution of the project**
  - **Need/opportunities for international collaboration**
  - **Possible contribution to the future FCH JU Programme**