DURAMET
Methanol fuel Cells

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

Antonino S. Aricò

CONSIGLIO NAZIONALE DELLE RICERCHE

Institute for Advanced Energy Technologies "Nicola Giordano"

(CNR-ITAE)

Messina, Italy

arico@itae.cnr.it

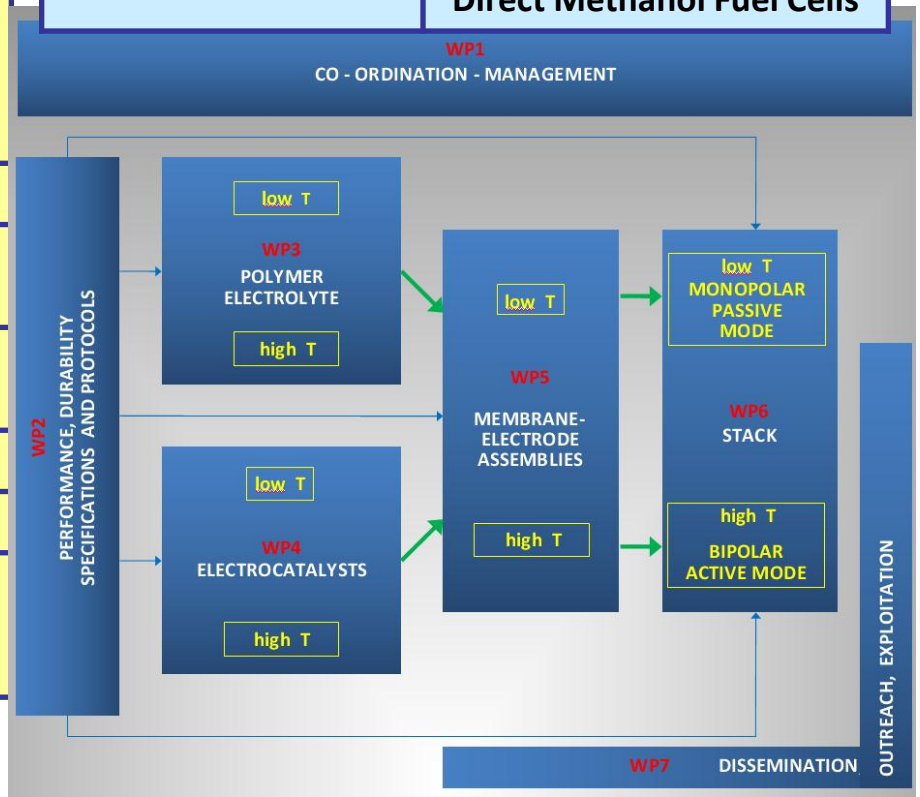
http://www.duramet.eu/

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	SME
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



http://www.duramet.eu/

Project objectives

Part 1

DURAMET objectives:

Duramet is addressing improved durability and cost-effective DMFC components for application in portable power and assisted power units.

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/ Sulfonated PEEK/ novel PFSA	Membranes	Polyphosphonic/ mixed functionalities/ doped PBI/ sPEEK/ZrP
Low-PtRu noble metal loading/ Pd-based (Pt/Ru free) Oxide catalysts & supports	Electrocatalysts	Low-PtRu noble metal loading/ Pd-based (Pt/Ru free)/ Non noble metal catalysts Oxide supports
Porosity & Hydrophobicity tailored	Membrane-electrode assemblies (MEAs)	Porosity & Hydrophilicity tailored
Monopolar configuration	Validation in short and mini stacks	Bipolar configuration

Durability

Performance

Cost-effectiveness

Project Milestones

Part 1

DURAMET Methanol fuel Cells

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 1-10 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

Project achievements

Part 1

DURAMET Methanol fuel Cells

Testing procedures

Four public deliverable reports have been produced and submitted. These regard characterization and assessment of membranes, catalysts, MEAs and stacks for DMFCs

http://www.duramet.eu/

Membrane development

FuMA-Tech:

-Long side chain (Fumion) PFSA blends (**F-1850**): 47 mS/cm at 60 ° C .

-mixed functionality sulfonic-phosphonic acid (~30-40 mS/cm at 120 ° C, 50% RH)

- sulfonated polyetheretherketone (**E-730**); MeOH cross-over 6-26 mA/cm2 at 30° /60 ° C

CNRS:

- **sPEEK-ZrP** and PFSA-ZrP (50 mS/cm at 120 ° C, 95%RH)

-phosphoric acid doped PBI >150 mS/cm at 140 ° C (dry conductivity cell)

CNR-ITAE:

- Composite sulfonated polysulfone sPSf and silica **sPSf- SiO_2–S:**

50 mS/cm is 60 ° C ; Methanol cross over 6-20 mA/cm^2 at 30 and 60 ° C

Cross-over ~5 times lower than Nafion membrane of similar thickness at comparable proton conductivities; high conductivity achieved at high temperature and low RH

DURAMET Methanol fuel Cells

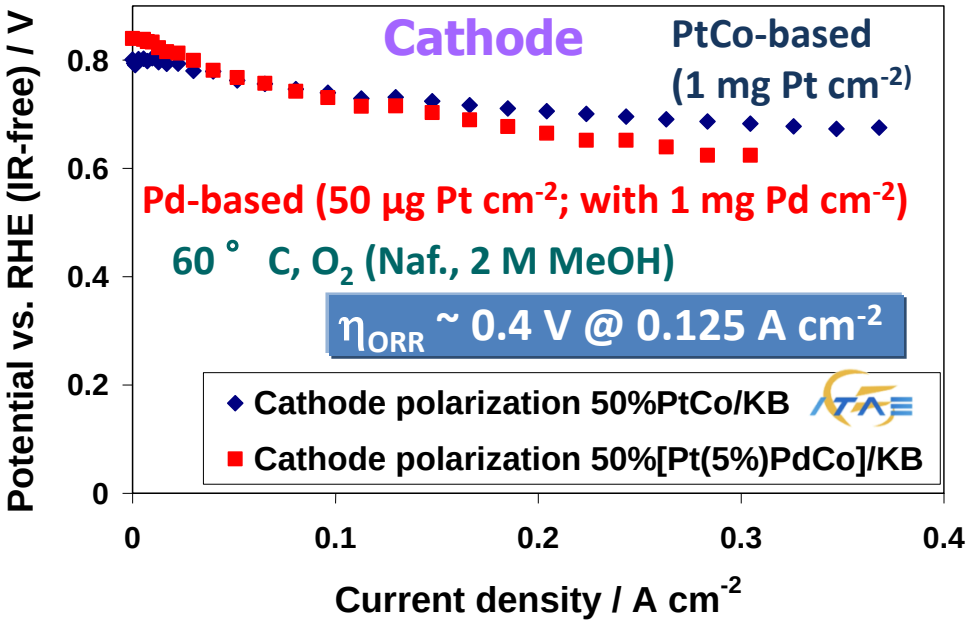
Technical Achievements and Progress

Part 1

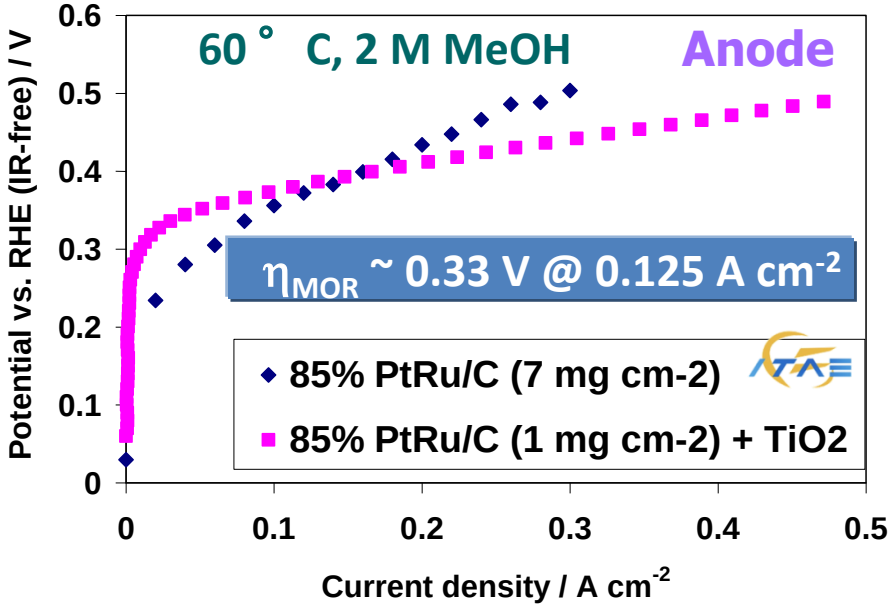
Electrocatalyst development

Half-cell reactions

Oxygen reduction & tolerance to methanol



Methanol oxidation



Reduction of reaction overpotential at practical current densities and low Pt loading with respect to conventional electrocatalysts

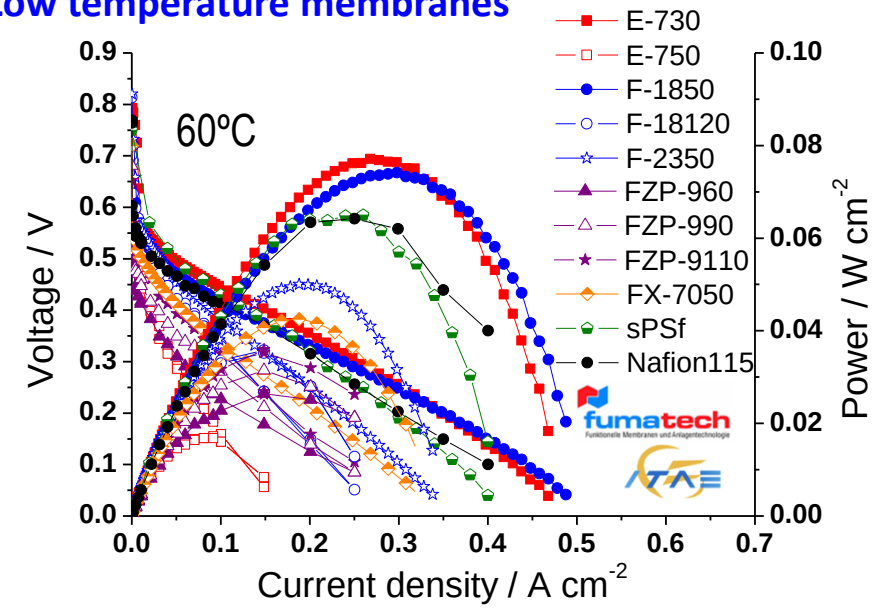
Technical Achievements and Progress

Part 1

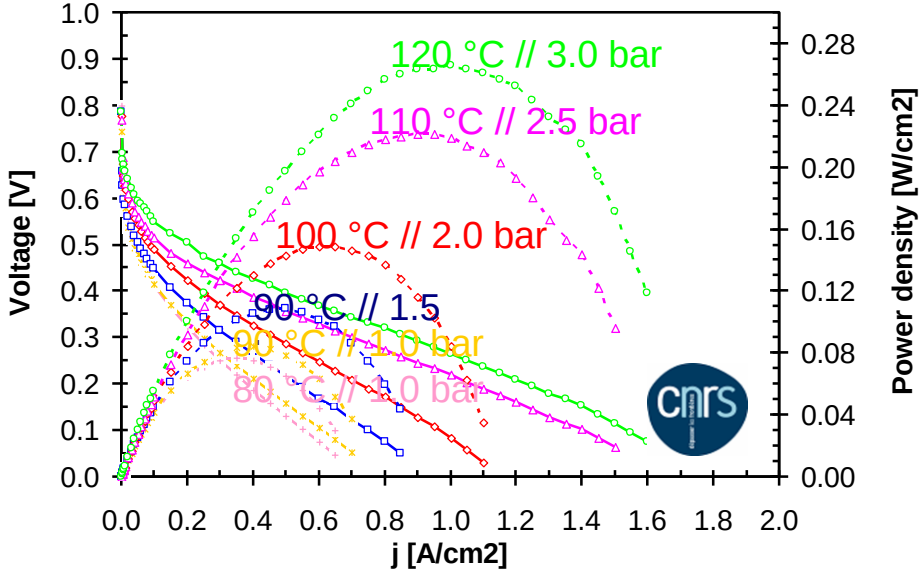
MEA performance assessment

Parameter	Units	E-730	E-750	F-1850	F-18120	F-2350	FZP-960*	FZP-990	FZP-9110	FX-7050	sPSf**	Nafion 115	
Max. Power density	$mWcm^{-2}$ @60°C	77	17	74	36	50	41	32	35	42	65	64	**Performance**
R_s (EIS)	Ωcm^2 @ 60°C	0.2	0.62	0.2	0.50	0.31	0.07	0.29	0.33	0.13	0.18	0.20	
Cross-over current	$mAcm^{-2}$ @ 60°C	47.6	185	47	100	88	128	135	208	186	30	120	**Cross-over**

Low temperature membranes



High temperature s-PEEK-ZrP membrane



Technical Achievements and Progress

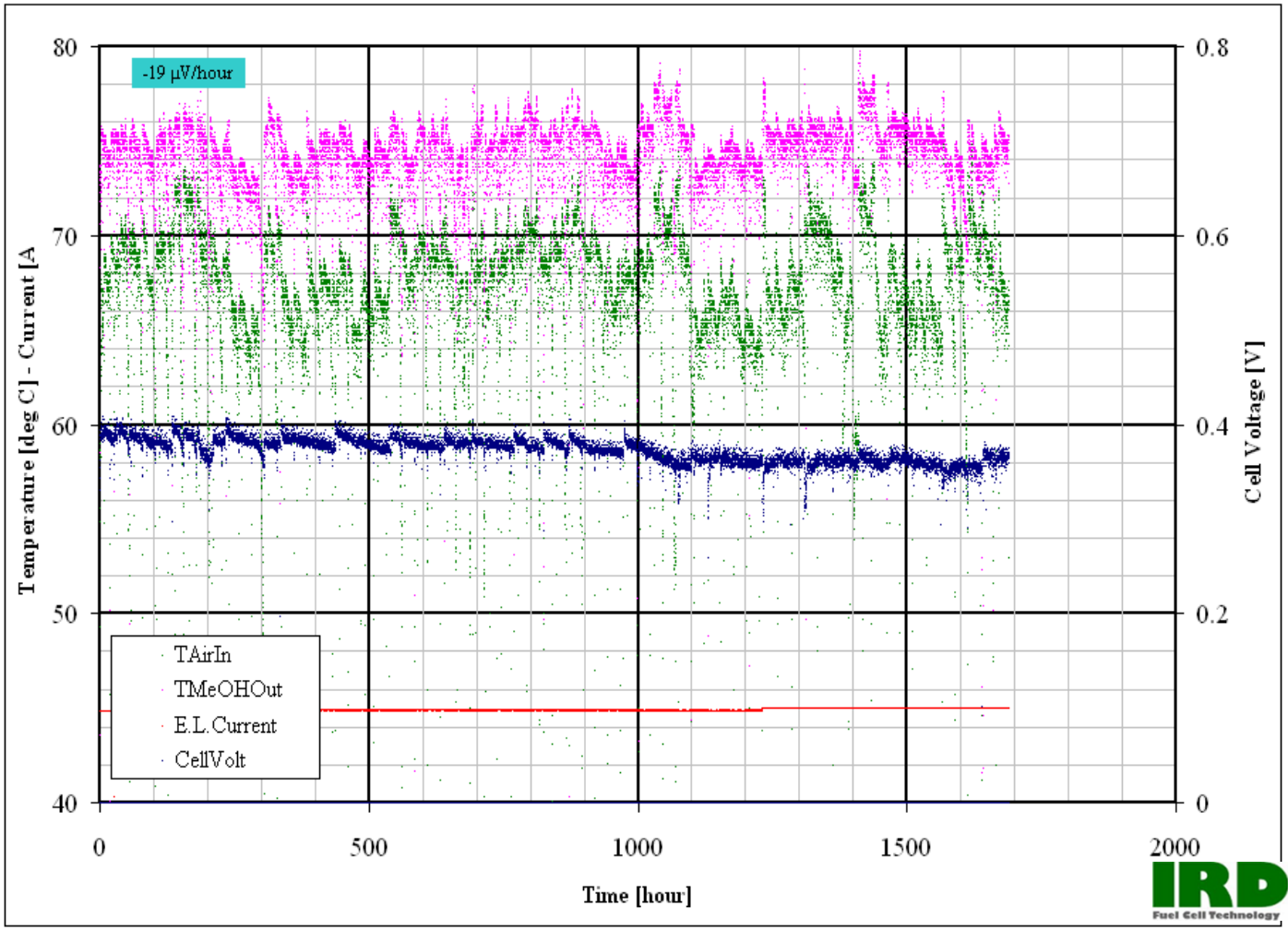
Part 1

DURAMET Methanol fuel Cells

MEAs durability testing

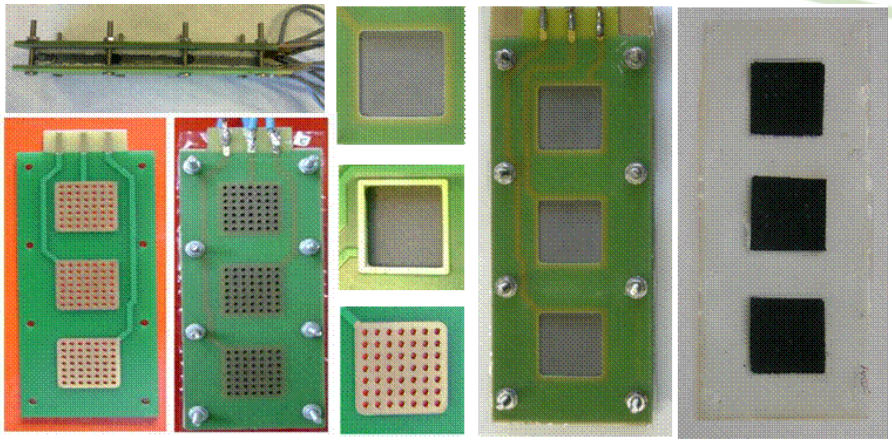
MEA tests :
-Refresh cycle every 20 minutes.
-5 days operation 2 days of stop.

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



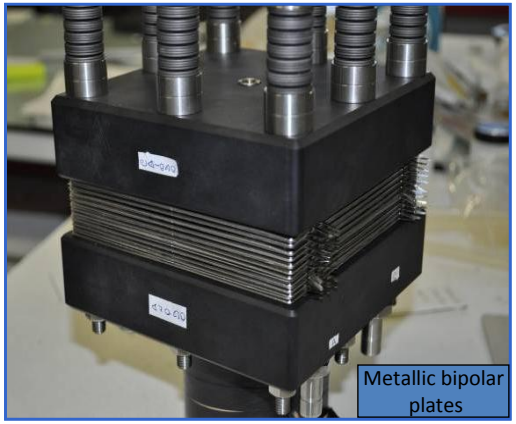
IRD Fuel Cell Technology

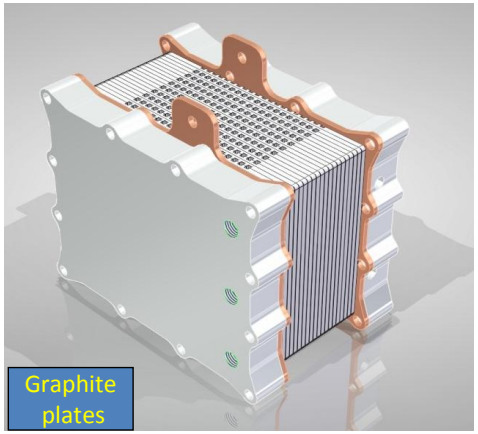
MEA validation in short stacks



Passive mode operation monopolar ministack for portable applications

Specifications :
Power density: 20-50 mW/cm²
Nominal Power ~ 1 W
Single cell active area: 4 cm²





Bipolar short stack for APU applications

Specifications :
Power density: 100-250 mW/cm²
Nominal Power: 100-150 W
Single cell active area: 100 cm²
Operation temperature: 90-130 ° C

Project achievements in relation to the AIP/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 for sPSf, F-1850 and >50 mS cm^{-1} at 120° C for mix.funct. and composite membranes -MeOH cross-over < 6-20x10^{-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 > 70 mW cm^{-2} at LT (low PGM); ~250 mW cm^{-2} at HT (high PGM); Stability over 1500 hrs;
	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	Promising results 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; cheap catal.	PGM loading <0.5-1 mg cm^{-2}; Hydrocarbon membranes; Non noble metal catalysts

DURAMET
Methanol fuel Cells

- **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, CNR Italy-NRC Canada, CNR Italy-NRC Egypt 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**

DURAMET addresses and contributes to:

- **Training/education** of 2 Ph.D. student (POLITO, TUM), 4 post-doctoral researchers in materials science processing and assessment (CNR, POLITO, TUM);

- **Dissemination** of project results through publication in international peer-reviewed journals, conference presentations and via the project web site:http://www.duramet.eu/
  - ✓ 5 Articles published on peer reviewed journals
  - ✓ 10 Conference presentations;
  - ✓ Workshop planned for 2014; → **CIMTEC 2014 Symposium FA (Fuel cells)**
  - ✓ Edition of a brochure

- **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.

DURAMET
Methanol fuel Cells

Exploitation and Post-Project Activities

- The market segments for DMFC devices developed in the project concern with portable generators, UPS, back-up power systems and portable micro-fuel cells
- The consortium covers the manufacturers of DMFC basic materials, MEA, stack, system as well as an end-user.
- Exploitation of the project results is thus mainly carried out inside the consortium
- The industrial partners will seek to inform potential customers of results arising from the project in accordance to the IPR considerations.

Recommendations towards the Programme

- Identify quantitative targets for DMFCs in the AIP/MAIP; increase the support on focused research programs
- More support should be addressed to research efforts for breakthrough materials for alcohol fuel cells.