Development of advanced catalyst for PEMFC automotive application

Nano-CAT (325239)

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PROJECT OVERVIEW

- Call topic:
  - SP1-JTI-FCH.2012.1.5), new catalyst structure
- Application Area: transportation
- Start/end dates: 01 May 13 / 30 April 16 (implementation: 75%)
- Budget:
  - Total: 4,394 k€
  - FCH JU contribution: 2,418 k€
- Project summary:
  - Development of new catalyst/support to reduce Pt loading and increase MEA life time
  - From catalyst synthesis up to MEA testing (single cell and stack)

PROJECT TARGETS AND ACHIEVEMENTS

Programme objective/target	Project objective/target	Project achievements to-date	Expected final achievement
MAIP			
Breakthrough approaches to decrease Pt loading	New catalyst concept (Pt-free, structured alloys) to decrease Pt content	Catalyst performance validated in *ex situ* characterization	60 %
AIP			
Pt loading: 0.1 g/kw; Power density: 1 W/cm^2 @ 1.5 A/cm^2	0.1 g/kW @ max power, 0.3 g/kW @ 55% yield; 1 W/cm2 @ 1.5 A/cm2 Under H_2/air	Max power: at 1,6 A/cm2; 750 mW/cm2 → 0.22gPt/kW At 55% yield: 460 W/cm^2 → 0.37 g_{Pt}/kW Low loaded MEA(A: 0.04 mg_{Pt}/cm^2; C: 0.115 mg_{Pt}/cm^2)	60%

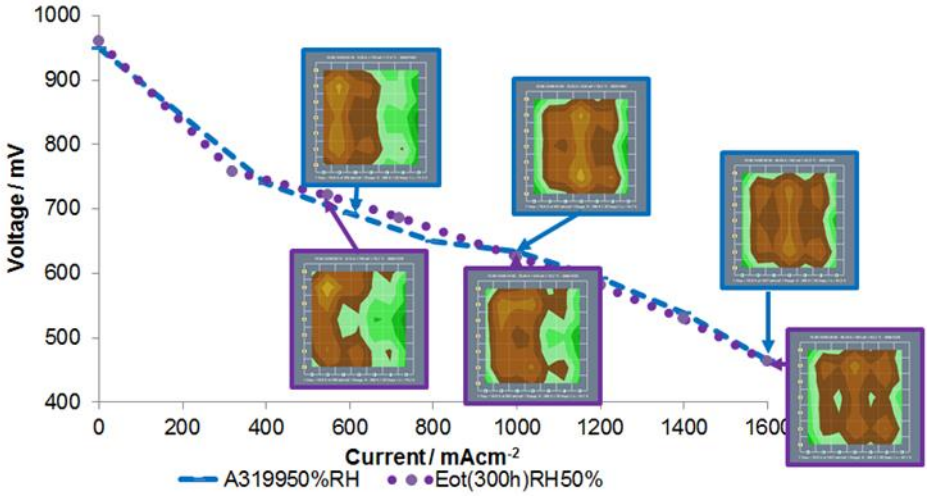
PROJECT TARGETS AND ACHIEVEMENTS

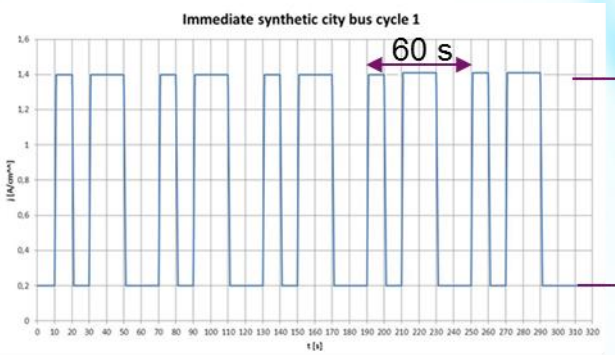
Programme objective/target	Project objective/target	Project achievements to-date	Expected final achievement
MAIP			
Breakthrough approaches to increase MEA life time	New support, carbon nanotube and metal oxide	Same BoT performance for carbon nanotube. Lower loss of ECSA (ex-situ characterization). Same performance when use at the anode in full MEA. New MOx support → conductivity + porosity close to Carbon black.	80 %
AIP			
Life time: 5 000 hrs	10% loss after hundred hrs of utilization	53 µ/h @ 1 A/cm^2 after 300hrs under synthetic bus cycle (MEA loading: A: 0.115, C: 0.45 mg$_{Pt}$/cm^2).	80 %

PROJECT TARGETS AND ACHIEVEMENTS

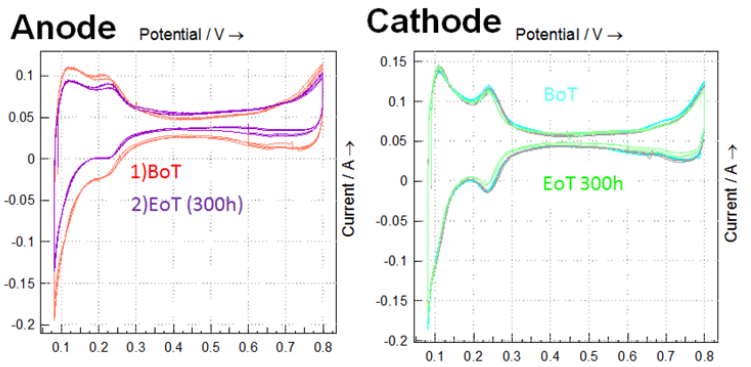
- Evidence of degradation using harsh cycle:

- Cathode: 10 nm Pt particles on graphitized carbon
No loss of ECSA
- Anode: 3 nm Pt particles on vulcan
Loss of ECSA





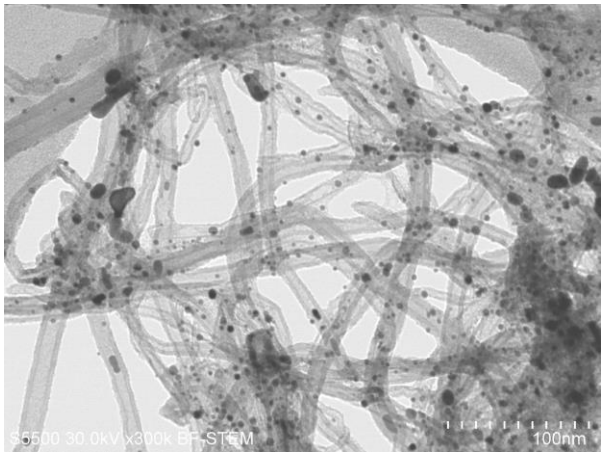
80°C, 100%RH, 1,5 bar, flow Imax $St_{H2/Air}$ 1.2/2



Anode ECSA losses (300h): 25%
Cathode ECSA losses (300h) <10%

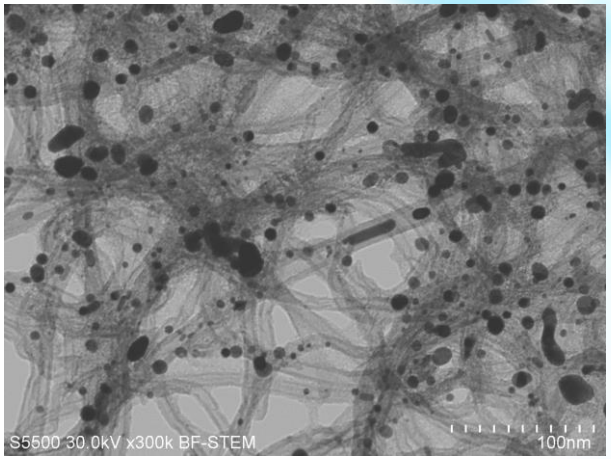
PROJECT TARGETS AND ACHIEVEMENTS

Stability of the catalyst validated in single cell



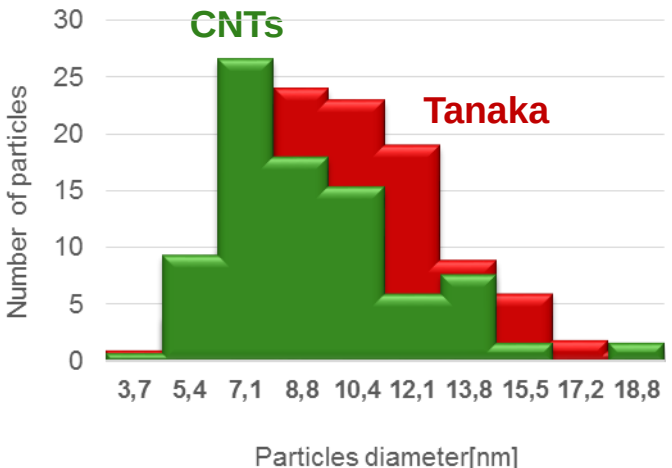
30 Kcy

AST,
0.6-1.0 V



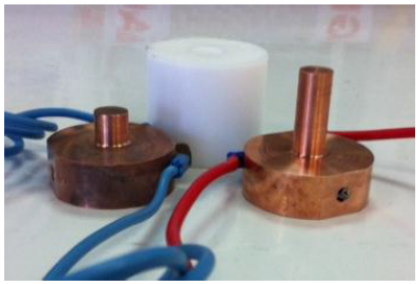
- Catalyst supported on N-NTC is more stable than TEC10V50E
- Support production: industrial scale
- Catalyst production: up scale in progress

Catalyst size after ageing

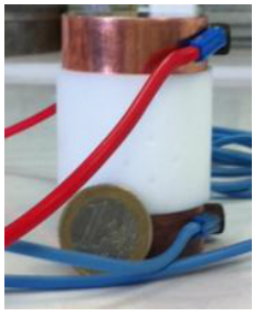


PROJECT TARGETS AND ACHIEVEMENTS

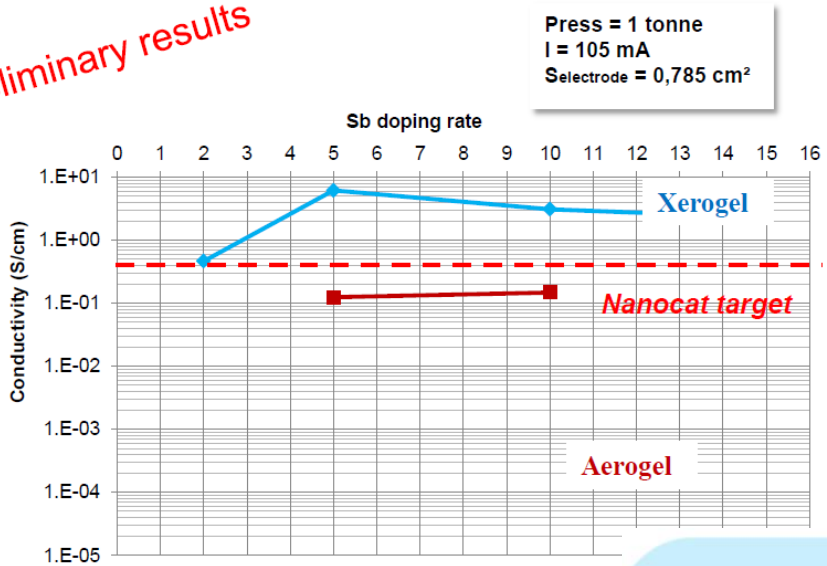
Synthesis of porous and conductive SnO_2:Sb



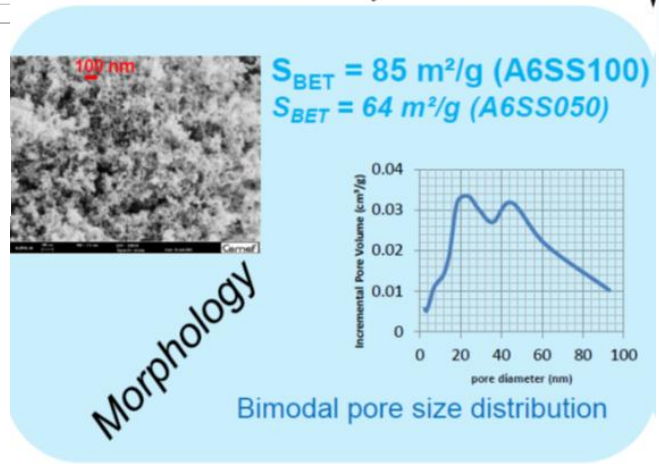
New cell



Preliminary results



- Lower conductivies for aerogels but still acceptable (σ = 0,12 S/cm)
- Higher conductivities values than for xerogels



RISKS AND MITIGATION

- **Power density: 1W cm^2 @ A/cm^2**
  - Bottleneck: integration of new catalyst in MEA and validation in single cell test
  - risks to project: no test validation of the expected added value of the developed catalysts
  - Remedial action taken: test with commercial catalyst and best available material for MEA fabrication and validation

- **0.1 g/kW @ max power, 0.3 g/kW @ 55% yield**
  - Bottleneck: reduction of Pt loading without performance degradation
  - risks to project: no improvement towards state of the art (commercial MEA)
  - Remedial action taken: focus on life time improvement, modification of operating conditions thanks to progresses on system integration

SYNERGIES WITH OTHER PROJECTS AND INITIATIVES

FCH and FP projects	Interaction and/or joint activities
DECODE	Discussion about degradation processes and mechanisms; Use of DECODE GDLs in Nano-CAT
Autostack CORE	Discussion on low loaded MEAs under automotive conditions (conditions, cost)
PremiumAct	Discussion on degradation
Second Act	Discussion on degradation
IMPALA	Exchange about improved GDLs
IMPACT	Discussion related to low loaded MEAs
PEMICAN	Discussion related to low loaded MEAs
Immediate	Provides stack

HORIZONTAL ACTIVITIES

- Training and education:
  - A PhD student is working in the project
- Safety, regulations, codes, standards:
  - Contribution to harmonization activities lead by JRC at EU level (test protocols for automotive applications)

DISSEMINATION ACTIVITIES

- Presentation of the results in conf./workshop:

- ACS national meeting 2014, Dallas: “Implementing bio-inspired nickel-based nanocatalysts for hydrogen uptake in a PEMFC” V. Artero

- Workshop on catalyst for PEMFC application, Karlsruhe: “PtCo and PtNi alloys deposition by DC Magnetron Sputtering”, F. Fernandez

- FDFC 2015, Toulouse: “Sb or Nb doped tin dioxide aerogels as catalyst support for PEMFC cathode”C. Beauger

- EERA Workshop 2015,DTU: “Metal Oxides Aerogels as promising catalyst supports for Fuel Cells and Electrolysers", C. Beauger

- EFCD 2015, La Grande Motte: “Nanocat : overview of nanoCAT” Pa Jacques

- EFCD 2015, La Grande Motte: “development of low PtCo and PtNi loading alloys by magnetron sputtering” F. Fernandez

- ECS fall meeting 2015, Phoenix : “Sn02 aerogels: towards performant and stable PEMFC catalyst support”, G. Ozouf

- 66th ISE meeting, Tapei (Poster): “Comparison of the Degradation process during the bus application loading cycling in PEMFC” D. G. Sanchez

- International Conference Molecular Electronics 2014, Strasbourg (Poster), S. Le Vot

- Publication:

- Chem. Sci., 2015,6, 2050-2053, V. Artero

EXPLOITATION PLAN/EXPECTED IMPACT

- Impact of in the panorama of FCH technology:
  - Validation of degradation mechanism in harsh cycle (anode loss of ECSA, ionomer degradation)
  - Validation of the use of harsh cycle for bus application
  - Development of new support to stabilized catalyst (industrial synthesis for N-CNT)→ enhance durability
- Project exploitation: Use of developed method to modified CNT / promotion of placyl grade by Nanocyl.
- RTD projects:
  - Conductive porous Sno_2
  - Synthesis of homogeneous dispersed Pt/N-CNT + AST in single cell.
  - synthesis of resistant catalyst to increase life time and reduce catalyst loading → effort on AL formulation with that new catalyst
  - Link with catalyst manufacturer to be build

Acknowledgements

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