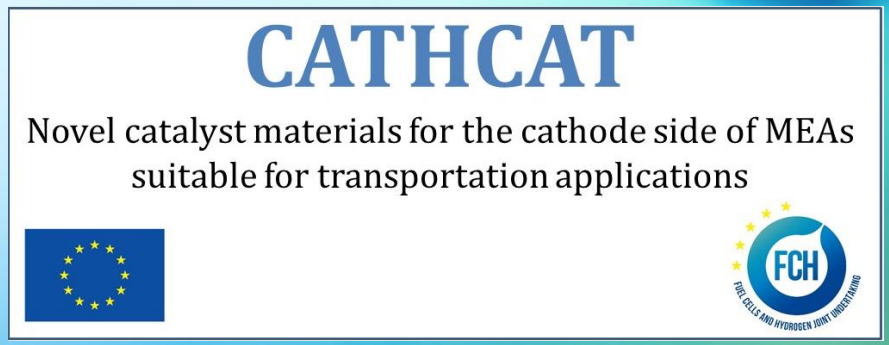
Novel catalyst materials for the cathode side of MEAs suitable for transportation applications CATHCAT
(303492)



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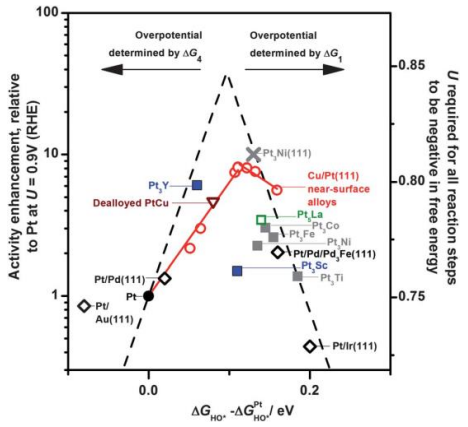
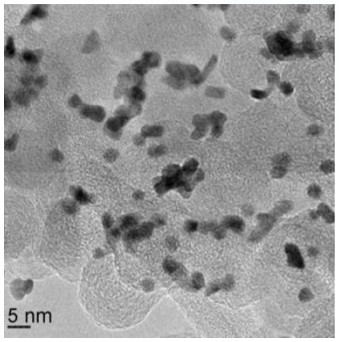
PROJECT OVERVIEW

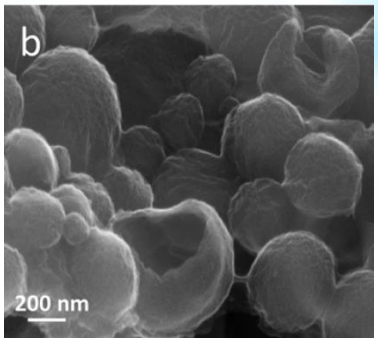
- SP1-JTI-FCH.2011.1.5: Next generation European MEAs for transportation applications
- Transportation & Refuelling Infrastructure
- 01.01.2013-31.12.2015
- Budget: 3,088,327.80 €,
  FCH JU contribution: 1,895,862.00 €
- Research on Pt/Pd-rare earth alloy catalysts and advanced support materials
- Stage of implementation: 94%

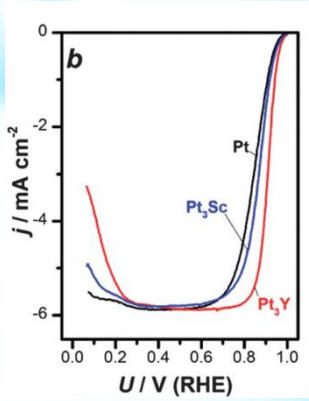
PROJECT TARGETS



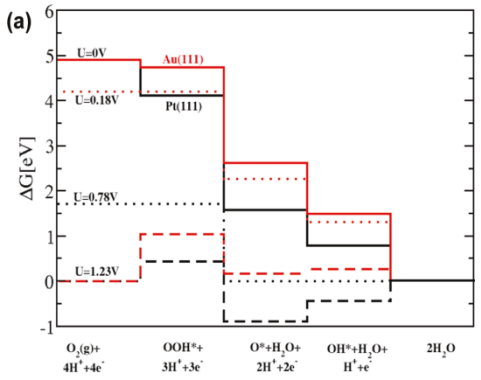
DTU Research



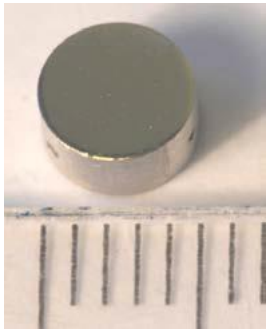




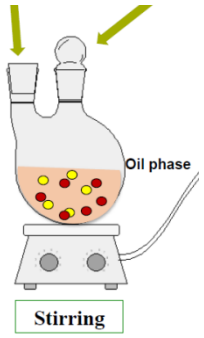
New ORR Catalysts and Supports



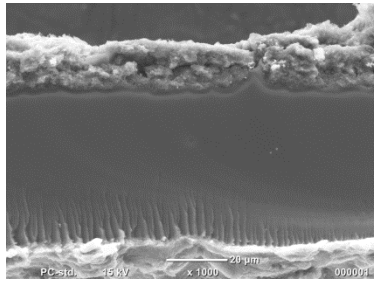
Theory (Pt-RE, Pd-RE)



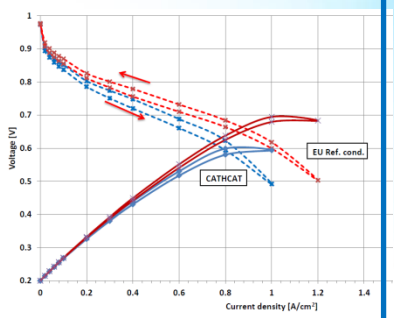
Model Alloys



Synthesis



MEA preparation



MEA testing

Stephens et al., Energy Environ. Sci., 2012, 5, 6744–6762; Luo et al., ChemPhysChem 2014, 15, 2136 – 2144; Perini et al. , ACS Appl. Mater. Interfaces 2015, 7, 1170−1179; C. H. Kjaergaard et al; Inorg. Chem. 49 (2010) 3567-3572.

PROJECT TARGETS AND ACHIEVEMENTS

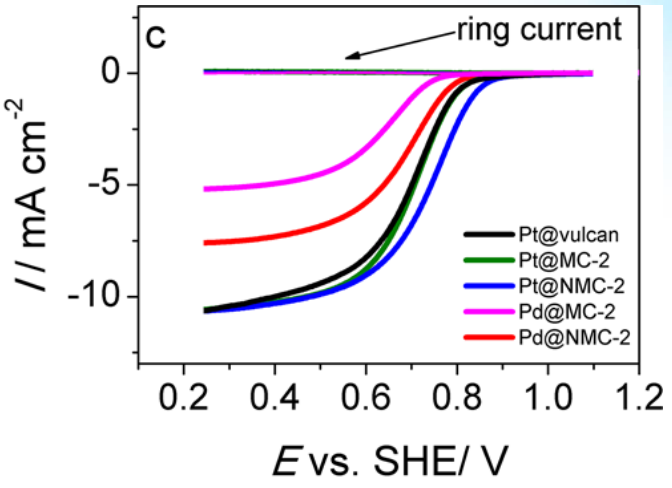
Programme objective/target	Project objective/target	Project achievements to-date	Expected final achievement
MAIP			
Electrochemically stable and low-cost catalysts for MEAs	Stable ORR catalysts with reduced Pt loading, advanced carbon- and oxide-based support materials	• Improved catalyst support materials developed and up-scaled for MEA testing • Pt-Y alloy catalyst produced outside a vacuum chamber showed good performance and is upscaled for MEA testing	• Three improved catalyst / support systems characterized in MEA • Scalable routes for Pt-RE catalyst preparation developed

PROJECT TARGETS AND ACHIEVEMENTS

Programme objective/target	Project objective/target	Project achievements to-date	Expected final achievement
AIP			
• Pt < 0.15 g/kW • BOL: > 55% efficiency • BOL > 1 W/cm^2 at 1.5 A/cm^2 • Lifetime (EOL) > 5,000h • EOL degradation < 10% • EOL > 0.9 W/cm^2 at 1.4 A/cm^2 • Temperature: up to 130 °C	• < 0.15 g/kW Pt loading (preferentially < 0.1 g/kW) • Increase in activity by a factor of 10 or more • BOL efficiency and power as specified in the call • Minimum of five improved catalyst systems	• Model catalyst RDE (3.6 A mg^{-1} @ 0.9 V): 0.3 g/kW @0.9 V • benchmark MEA: 0.4 g/kW • BOL efficiency: 56% at 1 A cm^{-2}; 50% @ 1.5 A cm^{-2} • BOL power density: > 0.9 W @ 1.5 A cm^{-2} • EOL not yet tested.	• < 0.25 g/kW Pt loading • BOL > 55% efficiency • BOL > 1 W/cm^2 at 1.5 A/cm^2

PROJECT TARGETS AND ACHIEVEMENTS

- Superior catalytic performance and stability of polycrystalline Pt_5RE alloys (up 5x compared to Pt)
- Mass selected Pt_xY and Pt_xGd nanoparticles show improved mass activity (x3.6) and peak activity at 7-9 nm diameter
- Improved activity of Pt/N-doped mesoporous carbon compared to Pt/Vulcan and Pt / conducting Titania-based substrates demonstrated in half cell measurements
- Several different routes for up-scaled NP preparation explored. Sputtering, reduction at elevated temperatures and electrochemical methods gave promising results
- Pt-Y alloy catalyst up-scaled for MEA preparation
- MEA testing of Pt/advanced support and Pt-Y alloy/mesoporous carbon underway

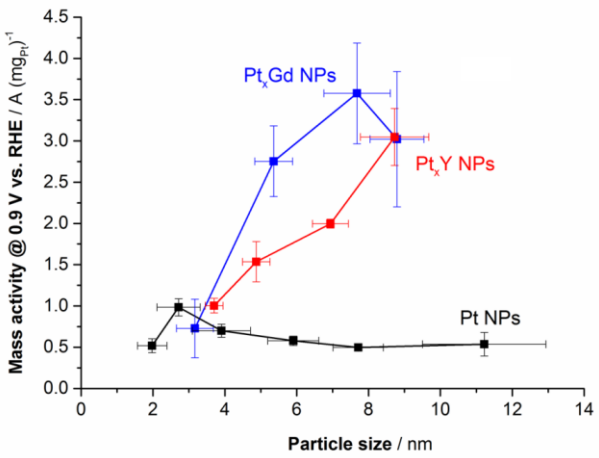


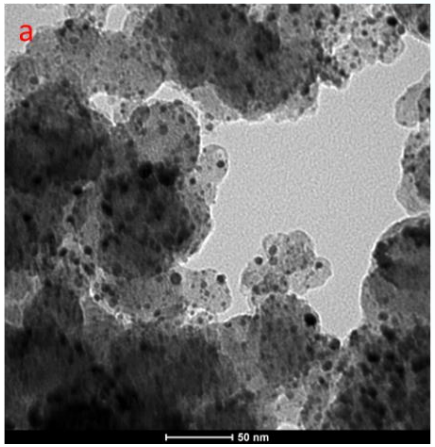
RISKS AND MITIGATION

- Targets of five improved catalyst systems and full characterization of MEAs based on those might not be reached:
  - Several different catalyst/support systems upscaled for MEA fabrication
  - Other catalysts may be tested in future work
- Difficulties in upscaling of Pt-RE catalyst NP:
  - Preparation of Pt-Y alloy catalyst NP with one of the tested methods was successful
  - Electrochemical preparation made significant progress
  - Direct sputtering of catalysts on suitable substrate for MEA testing carried out
  - New strategy implemented to make MEA with less catalyst

RISKS AND MITIGATION

- Performance targets might not be fully reached:
  - For Pt-RE nanoparticles, an improvement by 3.6 has been found in RDE tests at 0.9 V at RT, which represents a leap forward, once confirmed in MEA





  - The adjustment of the actual particle size to the value required for optimum stability might require further optimization
  - Advanced support materials expected to create additional benefit

SYNERGIES WITH OTHER PROJECTS AND INITIATIVES

- Use of knowledge generated in FC Anode and FCTESQA
- Participation in the JRC efforts on harmonization of testing with several other FCH JU projects
- Participation in the CATAPULT workshop in La Grande Motte
- Discussion with members of several FCH JU projects

HORIZONTAL ACTIVITIES

- Involvment of several Ph.D. students and young postdocs in the research
- Use of results for teaching
- Collaboration in the „Harmonisation of Testing Efforts“
- Discussions and partner contributions regarding RDE testing protocols
- Public Website

DISSEMINATION ACTIVITIES

- Organisation of a Dissemination Session at the 3degis Workshop in Santorini
- More than 30 Presentations of Project Results at conferences and workshops
- More than 20 publications

EXPLOITATION PLAN/EXPECTED IMPACT

- Novel catalyst materials will lead to a reduction in catalyst loading and thus reduced cost at good durability.
- New knowledge generated serving as knowledge base for future fuel cell and other research.
- Results exploited by patents and publications from partners, and possibly in subsequent projects and by industrial partners.
  - Catalysts with up to 5 times better activity than Pt identified and characterised
  - Significant Progress in Preparation of these catalysts
  - Improved Support Materials identified
  - Further RTD activities required for industrial commercialisation