Fuel cells and hydrogen
Joint undertaking

Programme Review Day 2011
Brussels, 22 November

New Energy World JU
fuel cells & hydrogen for sustainability

http://www.fch-ju.eu/

Fuel Cells and Hydrogen
Joint Undertaking

ROBANODE (245355)

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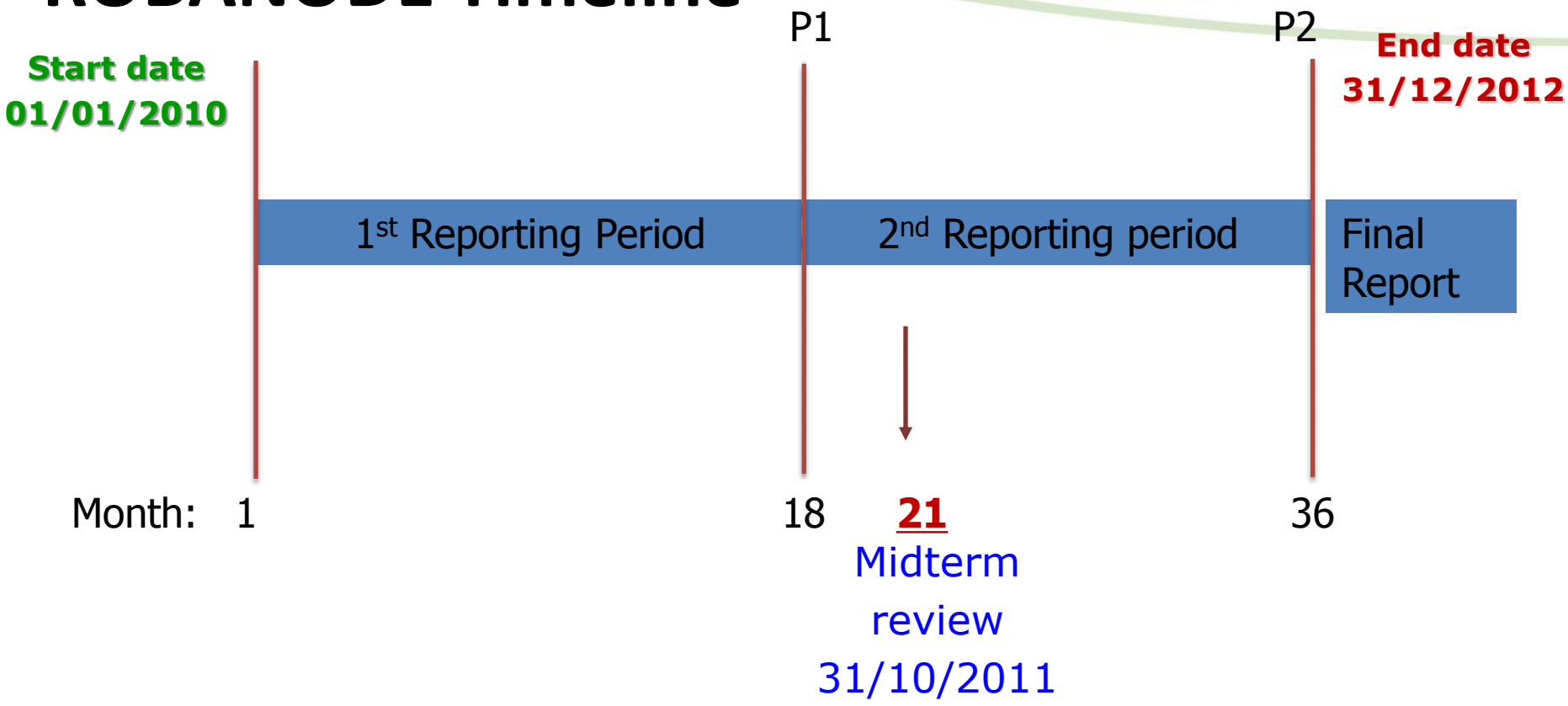
FCH-JU, Programme Review, 22 November 2011, Brussels-Belgium

Fuel Cells and Hydrogen
Joint Undertaking

No	1	2	3	4	5	6	7	8
Partner Short Name & Logo	FORTH/ ICE-HT	TUC	NTUA	EPFL	CSIC	CNRS	CERECO S.A.	Saint Gobain CREE
								
Country	Greece	Germany	Greece	Switzerland	Spain	France	Greece	France

- Four (4) EU members (France, Germany, Greece, Spain) and Switzerland
- Six (6) Research organizations (FORTH/ICE-HT, TUC, NTUA, EPFL, CSIC, CNRS)
- One (1) SME (CERECO S.A.)
- One (1) Industrial partner (Saint Gobain CREE)

ROBANODE Timeline



Aims of ROBANODE

A deeper insight with regards to the interference and the concerted action of the various factors that contribute to degradation of Ni - based cermet anodes in SOFCs.

- Agglomeration of Ni particles due either to thermal or electrochemical sintering.
- Degradation due to carbon deposition and improvement of tolerance under CH_4 Internal Steam Reforming (ISR) (S/C = 0.5 or less).
- Degradation due to sulfur contamination and tolerance improvement under CH_4 ISR conditions in the presence of H_2S (5 – 30ppm).
- RedOx tolerance of the cermet anodes.

Main Objectives

- **Understanding the interrelations between the aforementioned degradation factors so that *targeted modifications* in the structure and morphology of the Ni-based anodes can be made.**
- **Modeling of the degradation processes in correlation with experimental observations.**
- **Simulation of the chemical and physicochemical processes under SOFC operation.**

Strategy

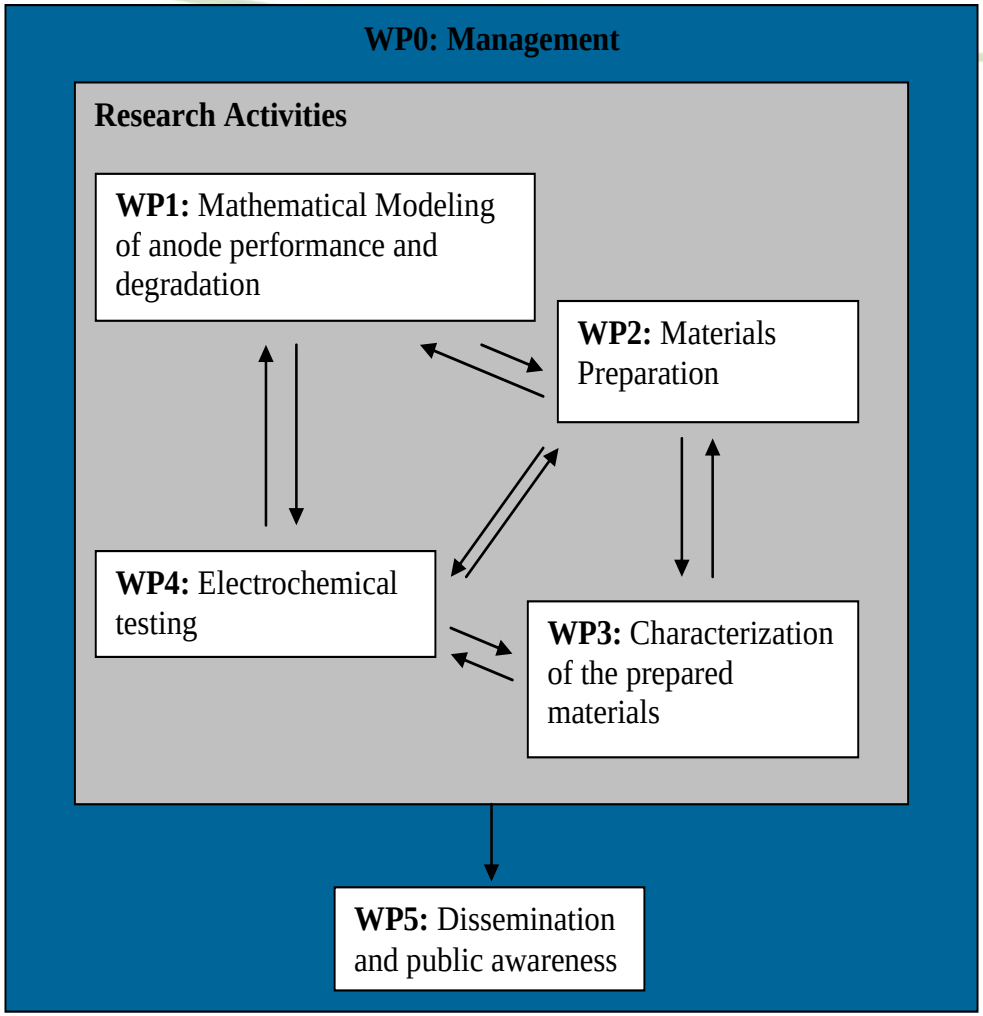
- ***State-of-the-art*** **Ni-based cermet anodes (e.g. NiO/GDC) will be modified with a second metal (e.g. Au, Mo and other) and their performance concerning *carbon and sulfur tolerance* will be studied.**
- **The degradation processes in the modified anodes will be investigated using various techniques (including XPS, UPS, SEM, TEM, XRD, TPR impedance spectroscopy and other…)**
- **The outcome of the aforementioned studies will be used as feedback to a mathematical model for prediction of the anode behavior.**

Strategy

- Mathematical modeling will be also used to simulate the thermal and electrochemical sintering of Ni particles in the modified anodes.
- The kinetics of Ni oxidation during redox cycles.
- Half-cells, full cells and stacks will be fabricated for electrochemical testing of the modified anodes and for investigation of the long-term performance.

Milestones

- Implementation of management
- Model describing the degradation processes
- Preparation of modified anode powders
- Preparation of cells
- Comparison of the model predictions with the observed electrochemical behavior of the anode.
- Establishment of communication with scientific community, other projects and wide public.



Alignment to MAIP/AIP & Innovation

- **According to MAIP/AIP:** ***"Fuel cell stacks for stationary power applications require an operational lifetime up to 40,000 hours"***
- **This target has not been achieved yet and anode degradation is one of the main reasons.**

- ***The ultimate goal of ROBANODE is the study, understanding and modeling of the degradation mechanisms of state-of-the-art (SoA) Ni based cermet anodes.***
- ***Thus ROBANODE fits exactly to the objectives of: "Degradation and lifetime fundamentals of SOFCs".***

Alignment to MAIP/AIP & Innovation

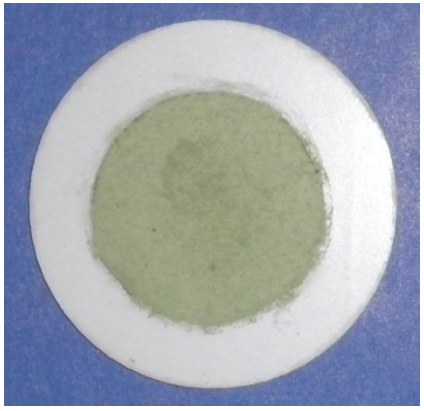
- ***Principal output of ROBANODE***

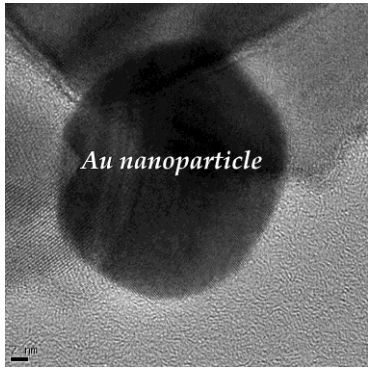
- **Development of a model for prediction of the (SoA) Ni-based anode performance and degradation.**
- **Development and improvement/optimization of (SoA) Ni-based anodes, easily commercialized, for CH_4 fuelled SOFCs (under Internal Reforming or Direct Oxidation conditions).**
- **Study of degradation mechanism due to thermal and electrochemical sintering.**
- **Study of degradation mechanism due to carbon deposition and sulfur poisoning.**

Alignment to MAIP/AIP & Innovation

- ***Modified (SoA) anodes and cells preparation/characterization***

- **Au-NiO/GDC, Mo-NiO/GDC and Au-Mo-NiO/GDC**
- **Degradation studies due to carbon deposition and sulphur poisoning.**

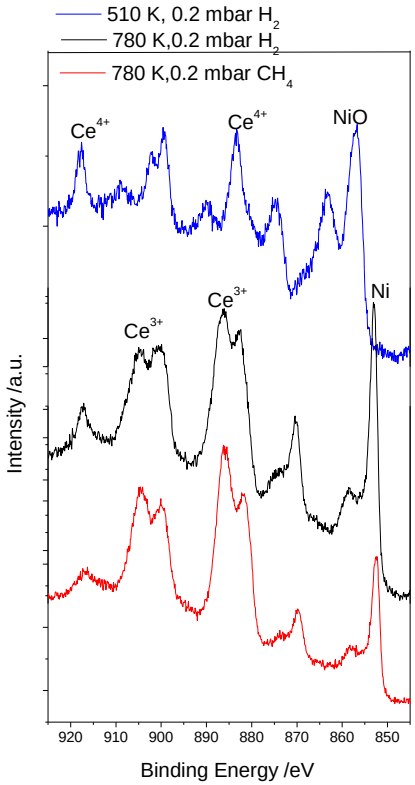


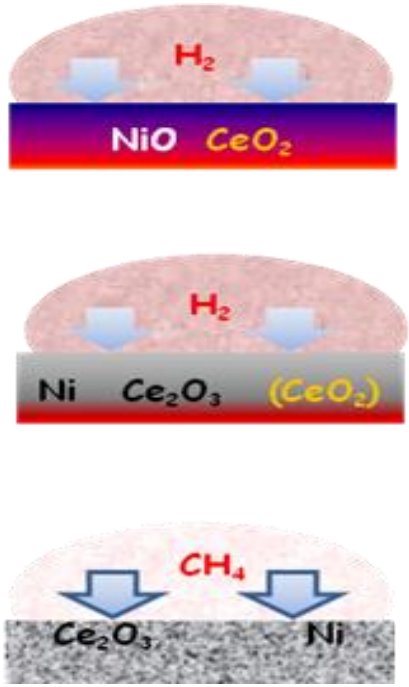


- **Electrolyte-Supported Cells**
- **Anode-Supported Cells**

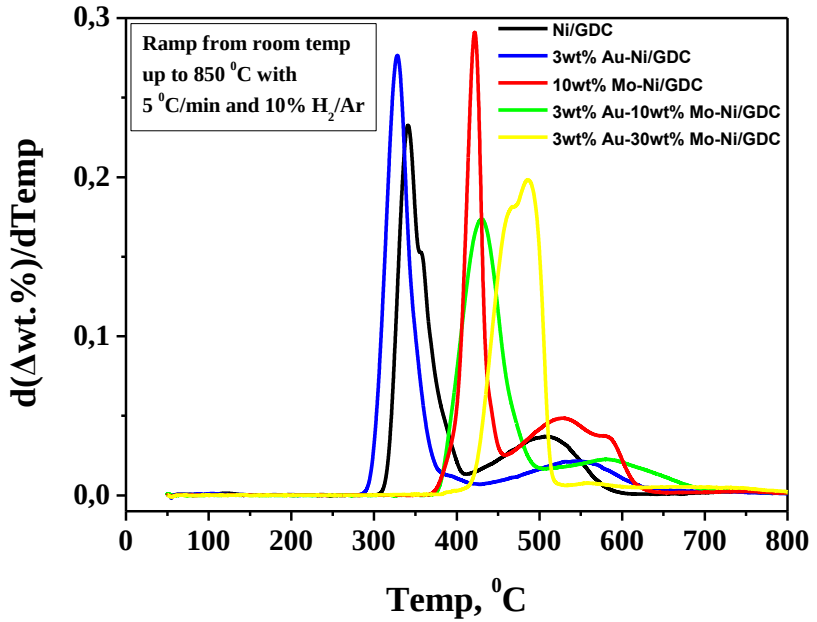
Alignment to MAIP/AIP & Innovation

- ***Modified (SoA) anodes and cells preparation/characterization***





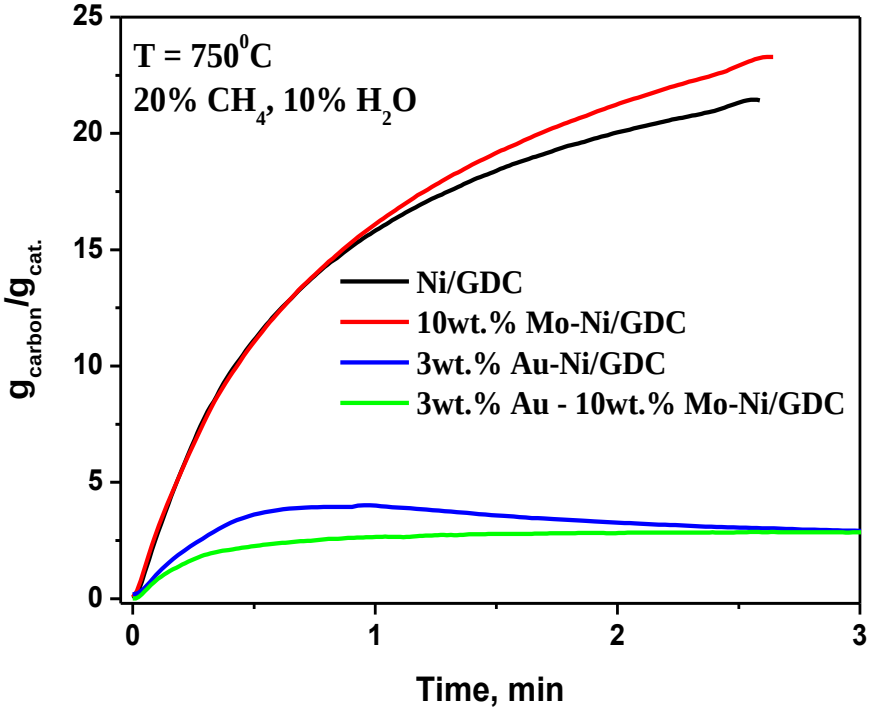
- **Several ex-situ techniques…**
- **In Situ XPS, NEXAFS XRD, e.t.c.**

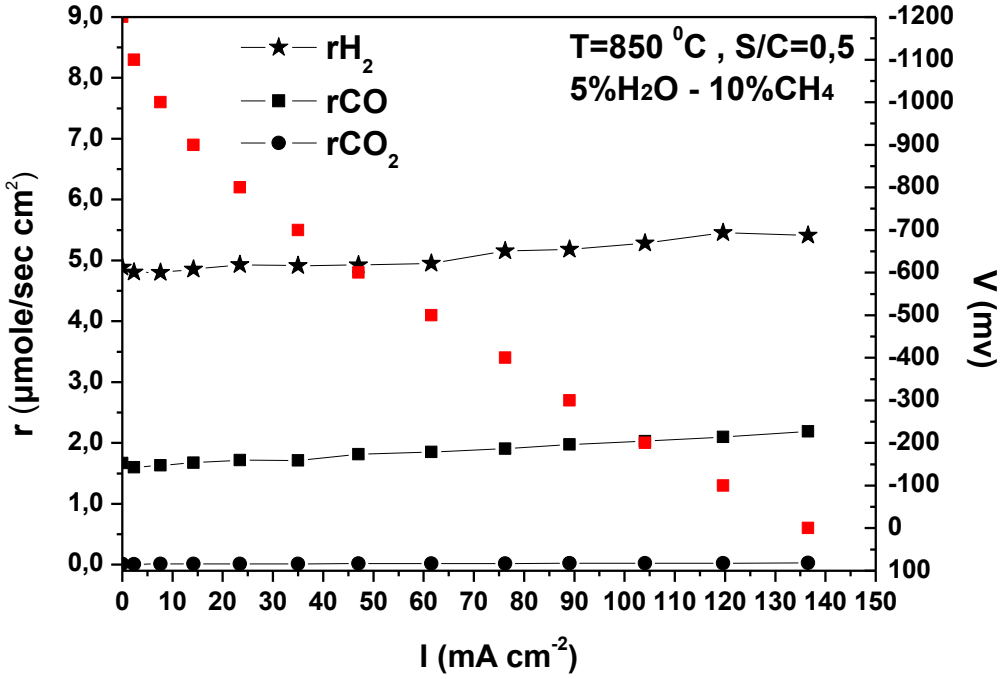


Alignment to MAIP/AIP & Innovation

- ***ESC and ASC performance and stability/stability testing***

➢ **Catalytic-Kinetic experiments**



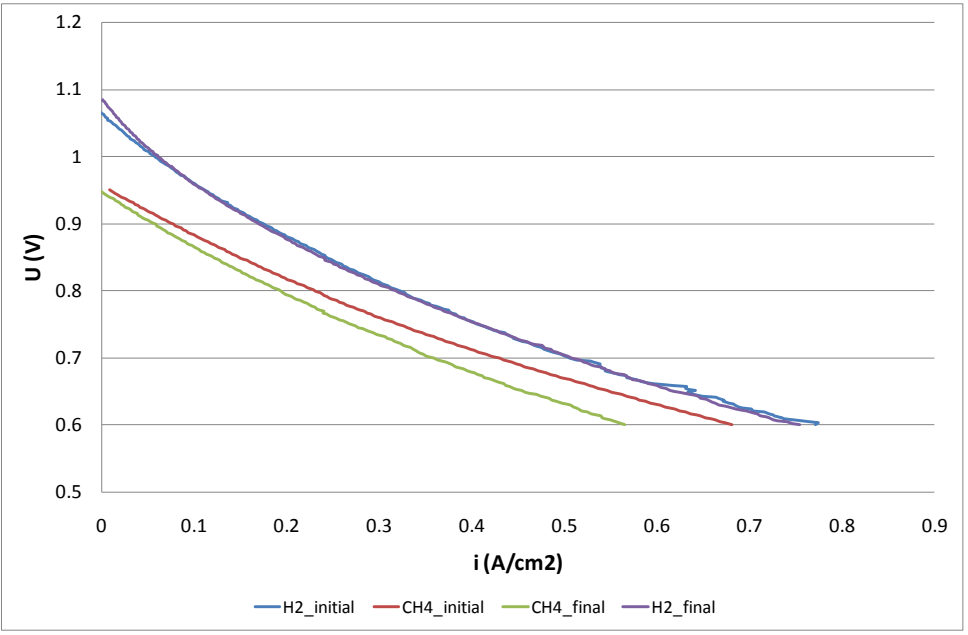


➢ **Electrocatalytic experiments**

Alignment to MAIP/AIP & Innovation

- ***ESC and ASC performance and stability/stability testing***

- **Cell & Stack testing – RedOx stability**



- **All tests provide feedback data for the Model Development**

2D model for description of fuel cell performance (power) under CH_4 steam reforming conditions and concomitant production of H_2

Alignment to MAIP/AIP & Innovation

❑ *Medium and long-term impact of ROBANODE*

- ❖ **Improvement and optimization of the properties and design of (SoA) Ni-based anodes.**
- ❖ **Minimization of degradation due to carbon deposition and sulfur poisoning in CH_4 fuelled SOFCs operating at 700-900°C under H_2O / CH_4 < 1 in the presence of H_2S (up to 30ppm).**
- ❖ **Long-term stability and reliability (degradation rate less than 0.5% /1000 h and operational lifetime of 40000 h) of natural gas fuelled SOFCs operating at 700- 900°C.**

Cross-cutting issues-dissemination-cooperation

- Proper dissemination activities through Peer Reviewed Publications, Participation in Conferences and several events.
- The established contact between academia and high technology industry through ROBANODE is capable to stimulate scientific career opportunities.
- Results coming out of the project are being shared not only among the project partners but also with all SOFC stakeholders, coming both from the scientific community and the related industry, as well as with the wider public.
- ROBANODE web site: http://robanode.iceht.forth.gr

Cross-cutting issues-dissemination-cooperation

- ROBANODE has the potentiality to contribute to the rapid penetration of the (SoA) Ni-based SOFCs into market.
- ROBANODE partners have high experience in the exploitation of the research results.
- CERECO S.A. and Saint Gobain CREE can ensure fast dissemination of the expected ROBANODE technology improvement, to more industrial end-users.
- The up to now results have triggered the interest of other organizations.

Thank you all for your Attention!

- ***Long term stability test of 3wt.% Au-Ni/GDC vs. Ni/GDC***