



Joint Technology Initiatives-CP

Project: **ROBANODE-245355**

“Understanding and minimizing anode degradation in H_2 and natural gas fuelled SOFCs”

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FCH – JU 3rd SGA, 10 November 2010, Brussels, Belgium

Outline

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Partners of ROBANODE project

No	1	2	3	4	5	6	7	8
Partner Short Name	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)

Aims of ROBANODE project

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*.

- Study of the **agglomeration** of the Ni particles due either to **thermal** or **electrochemical** sintering
- Study of anode degradation due to **carbon deposition**
- Study of the anode degradation due to **sulfur contamination**
- Study of the **redox kinetics** 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.
- **Sulfur and carbon contamination** as well as **thermally and electrochemically driven agglomeration** of the Ni particles will be treated in a **holistic manner**.
- The degradation processes **in the modified anodes** will be investigated using **various techniques** (including XPS, UPS, SEM, TEM, impedance spectroscopy e.t.c.)

Strategy

- The outcome of the aforementioned studies will be used as **feedback of a mathematical model for prediction of the anode behavior.**
- **Mathematical modeling** will be also used to simulate **the thermal and electrochemical sintering** of the Ni particles in the modified anodes.
- The **kinetics of oxidation** during **redox cycles** will be studied.
- **Half-cells, full cells and stacks** will be produced for **electrochemical testing** of the modified anodes and for investigation of the **long-term performance concerning degradation.**

Brief description of the WPs

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- **WP0: Project Management**

- **WP1: Mathematical Modeling**

Integrated anode performance and degradation modeling

- **WP2: Materials Preparation**

Preparation of the materials needed for the project

Brief Description of WPs

- **WP3: Characterization of the prepared materials**

Provision of input data for the mathematical modeling

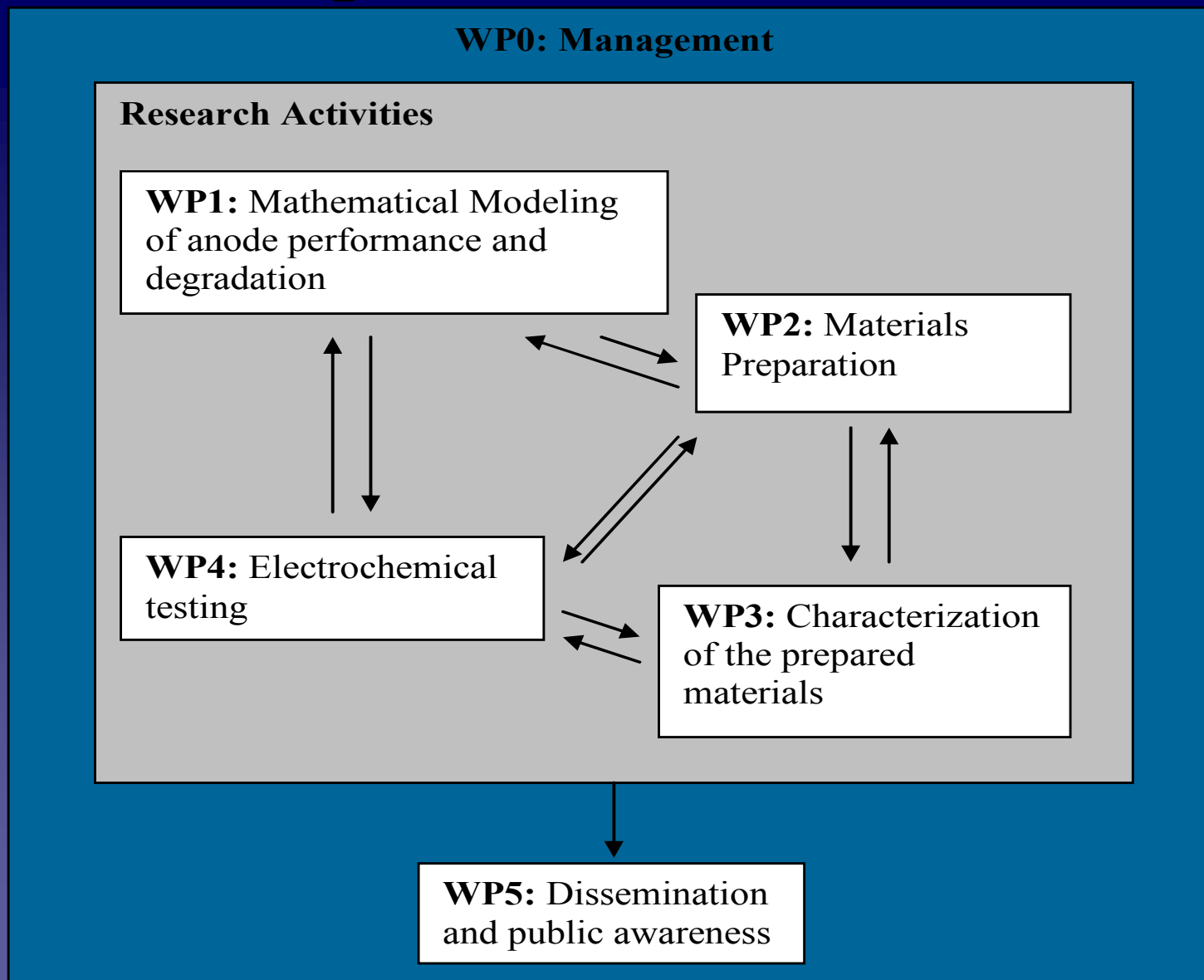
- **WP4: Electrochemical testing**

Half cells, Cells, Stacks

- **WP5: Dissemination and Public Awareness**

Publications, Participation in Congresses, Web page

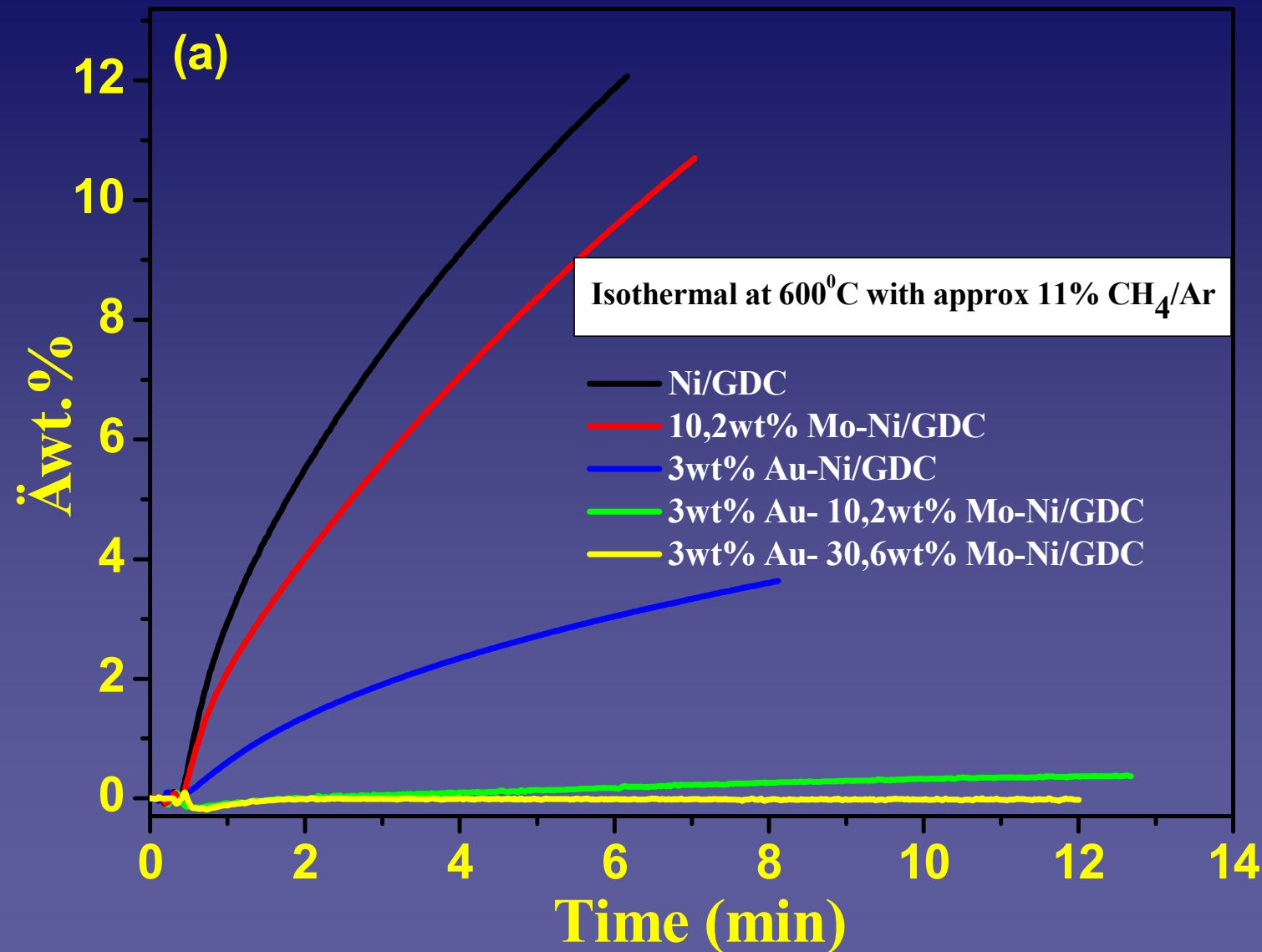
Brief Description of WPs



Some first results

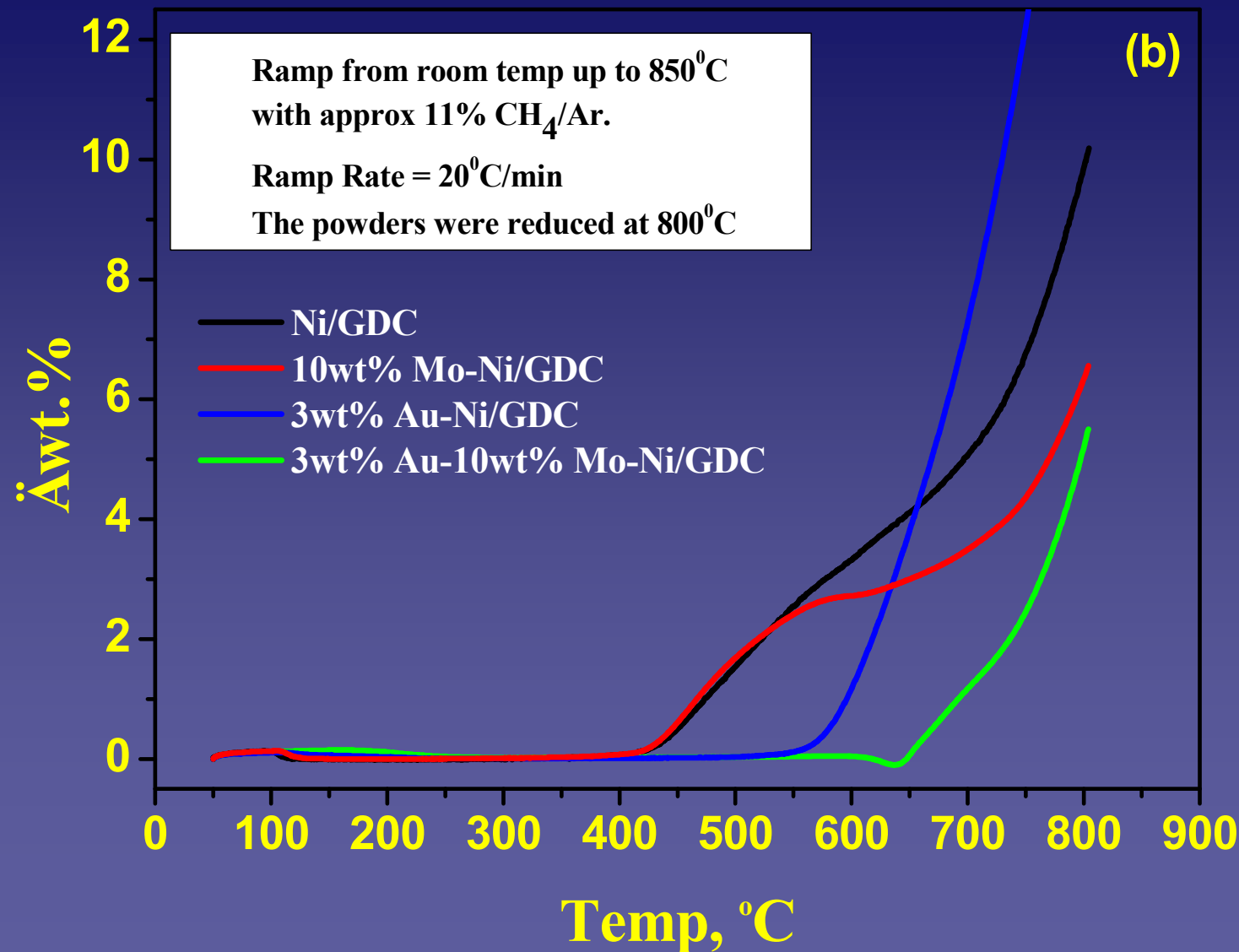
Some first results

❖ TGA on **Au – Mo – Ni/GDC** samples



Some first results

❖ TGA on **Au – Mo – Ni/GDC** samples



Conclusions

- Possible formation of **Ni-Au-Mo alloy** during reduction, under further investigation...
- Indication of **synergy effect** between **Au** and **Mo** for the reaction of CH_4 dissociation.
- Primary experiments under **Steam Reforming conditions** show **catalytic activity** for the **Au-Mo-Ni/GDC** powders.
- **Electrocatalytic** and **catalytic** experiments (in the process...) will provide **data for the modeling**.

Summary

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- *The ultimate goal of ROBANODE is the study, understanding and modeling of the degradation mechanisms of state-of-the-art Ni based cermet anodes.*
- *ROBANODE will offer an effective methodology for predicting anode performance, degradation and lifetime of SOFCs, under various operating conditions.*

Summary

➤ *ROBANODE aims to play a key role and to **contribute** in the efforts for robust operation, sufficient lifetime, competitive cost and overall in **SOFC commercialization**.*

➤ *ROBANODE is **financially supported** by the European Commission and Fuel Cells and Hydrogen Joint Undertaking (**EU – FCH – JU**)*

Future research agenda

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- ❑ *ROBANODE is not enough...*
- ❑ *Persistence in research on **modified state** – of – the art **Ni - based** and/or **new Ni – free** anode materials.*
- ❑ *Further **study of anode degradation mechanisms** for Solid Oxide Fuel Cells, under H/C and/or natural fuel gas.*
- ❑ *Further **improvement in the relationship** between IG and RG...*
- ❑ ***Market needs** and **Research** can and should “**find a common ground**” and this is a task for FCH-JU and EC!*

Thank you for your attention!!