LMGP/LEPMI **PHD THESIS OFFER 2020-2023**

Design, optimization and advanced characterization of new electrode microstructures for micro-Solid Oxide Fuel Cells

Doctoral school / Starting date

IMEP2 / Starting date: 01/10/2020

Subject

CONTEXT

A breakthrough in micro-energy harvesting and storage technologies is required to cover the increasing demand of autonomous wireless sensor nodes (WSN) for the future Internet of Things (IoT), which is considered one of the five technologies that will change the world by connecting 27 billion devices and generating €2 trillion market by 2025. The FeTOpen European HARVESTORE project (http://www.harvestore.eu/) aims to power these IoT nodes from ubiquitous heat and light sources by using nano-enabled micro-energy systems with a footprint below 1cm^3. A radically new family of all-solid state micro-energy sources able to harvest and store energy at the same time will be developed, the so-called "µ-harvestorers" (µHS), which will be integrated in silicon technology. This will allow reaching the highly dense features and scalability required for a real miniaturization and massive deployment that will show their viability as a new technological paradigm of embedded energy.

LMGP is directly involved in the design and development of reversible solid oxide cells (SOCs) that operate at intermediate temperatures. Their integration in silicon proposed is based on the concept of self-standing micro-Solid Oxide Fuel Cells (µ-SOFC)[1], which allows reducing operating temperatures fairly to the 300-500°C range (by using thin films and grain-boundary enhanced mass transport properties[2,3]) and store up to 100J/cm^3. In particular, for the electrodes new perovskites of the $(La,Sr)(Mn,Cr,Fe,Co)O_3$[4] family and Ruddlesden-Popper phases (such as La_2NiO_4[5]) will be studied.

THESIS PROJECT

In order to be able to reach the very ambitious performance requirements for the micro-Solid Oxide Fuel Cells at low operation temperatures, this thesis proposes **the design, optimization and advanced characterization of new electrode microstructures**. For this we propose **new deposition methodologies** using 2 chemical deposition techniques, i.e. Metal Organic Chemical Vapour deposition (MOCVD) and Atomic Layer Deposition (ALD), both individually and combined (at LMGP laboratory). In addition to the standard structural, chemical, morphological and electrochemical characterization, we will also develop **new *in-situ* advanced characterization techniques** to relate the structure and functionality of these thin film oxide materials (in collaboration with the LEPMI laboratory).

OBJECTIVES

The main goals of the PhD thesis are:

1. **To develop novel electrode architectures with improved performance (low Area Specific Resistance).**
   For this hierarchical microstructures will be designed with large catalytically active areas. By combining dense and porous regions the functionality of the electrodes (oxygen reduction reaction, ionic and electronic transport and current collection) will be locally optimized "per region" of the electrode.
2. **To characterize the designed electrodes by *in situ* measurements under operation conditions (temperature, current flow, atmosphere, etc.).**
   For this we will develop specific time-resolved spectroscopic techniques, in particular imaging, *in-situ* and *operando* Raman spectroscopy.

Scientific Environment

This project will be a collaboration between LMGP and LEPMI laboratories. The complementary experience will be combined in this project leading to a unique set of complementary competences for the student.

Within the **LMGP, Materials and Physical Engineering Laboratory**, the candidate will work in the NanoMat team. Located in the heart of an exceptional scientific environment, the LMGP offers the applicant a rewarding place to work. Within the **LEPMI, Laboratory of Electrochemistry and Physical-Chemistry of Materials and Interfaces,** the candidate will work in the MIEL group, in particular in its Raman platform.

LMGP Web Site: http://www.lmgp.grenoble-inp.fr/

LEPMI Web Site: http://lepmi.grenoble-inp.fr/

Profile & requested skills

The candidate must be graduated from an engineering school and/or with a Master 2R degree whose training focuses primarily on materials science, physics, chemistry or related field.

We are looking for a highly-motivated student with a strong interest in experimental physics and materials science. Interpersonal skills, dynamism, rigor and teamwork abilities will be appreciated. Candidates should be fluent in English and/or in French. In addition, well-written English will be highly appreciated.

Salary

According to French regulations for a PhD

Supervisors

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Further information and Application

For further information don't hesitate to contact us.

To apply please send both supervisors by email **ASAP** and before **the 23rd May 2020** your:

- Detailed Curriculum Vitae
- Cover letter explaining the motivation for the PhD work
- Transcript of marks obtained in Masters
- Contact details of two referees

Bibliography

(1) Evans, A.; Bieberle-Hütter, A.; Rupp, J. L. M.; Gauckler, L. J. Review on Microfabricated Micro-Solid Oxide Fuel Cell Membranes. *Journal of Power Sources*. 2009.

(2) Saranya, A. M.; Pla, D.; Morata, A.; Cavallaro, A.; Canales-Vázquez, J.; Kilner, J. A.; Burriel, M.; Tarancón, A. Engineering Mixed Ionic Electronic Conduction in La0.8Sr0.2MnO3+δ Nanostructures through Fast Grain Boundary Oxygen Diffusivity. *Adv. Energy Mater.* **2015**, *5* (11), 1500377.

(3) Tarancon, A.; Morata, A.; Pla, D.; Saranya, A. M.; Chiabrera, F.; Garbayo, I.; Cavallaro, A.; Canales-Vazquez, J.; Kilner, J. A.; Burriel, M. Grain Boundary Engineering to Improve Ionic Conduction in Thin Films for Micro-SOFCs. *ECS Trans.* **2015**, *69* (16), 11–16.

(4) Saranya, A. M.; Morata, A.; Pla, D.; Burriel, M.; Chiabrera, F.; Garbayo, I.; Hornés, A.; Kilner, J. A.; Tarancón, A. Unveiling the Outstanding Oxygen Mass Transport Properties of Mn-Rich Perovskites in Grain Boundary-Dominated La0.8Sr0.2(Mn1- XCox)0.85O3±δ Nanostructures. *Chem. Mater.* **2018**, *30* (16), 5621–5629.

(5) Burriel, M.; Garcia, G.; Santiso, J.; Kilner, J. A.; Chater, R. J.; Skinner, S. J. Anisotropic Oxygen Diffusion Properties in Epitaxial Thin Films of La 2 NiO 4+δ. *J. Mater. Chem.* **2008**, *18* (4), 416–422.