Communauté
UNIVERSITÉ Grenoble Alpes

PhD student OFFER

SECTOR **:** Higher Education Institution

LOCATION: France, Grenoble

RESEARCHER PROFILE:

□ *First stage researcher,*

INSTITUTION: Univ. Grenoble Alpes, University of Innovation/CNRS

One of the major research-intensive French universities, Univ. Grenoble Alpes enjoys an international reputation in many scientific fields, as confirmed by international rankings. It benefits from the implementation of major European instruments (ESRF, ILL, EMBL, IRAM, EMFL*). The vibring ecosystem, grounded on a close interaction between research, education and companies, has earned Grenoble to be ranked as the 5th most innovative city in the world. Surrounded by mountains, the campus benefits from a natural environment and a high quality of life and work environment. With 7000 foreign students and the annual visit of more than 8000 researchers from all over the world, Univ. Grenoble Alps is an internationally engaged university.

A personalized Welcome Center for international students, PhDs and researchers facilitates your arrival and installation.

In 2016, Univ. Grenoble Alpes was labeled «Initiative of Excellence ". This label aims at the emergence of around ten French world class research universities. By joining Univ. Grenoble Alpes, you have the opportunity to conduct world-class research, and to contribute to the social and economic challenges of the 21st century ("sustainable planet and society", "health, well-being and technology", "understanding and supporting innovation: culture, technology, organizations" "Digital technology").

* ESRF (European Synchrotron Radiation Facility), ILL (Institut Laue-Langevin), IRAM (International Institute for Radio Astronomy), EMBL (European Molecular Biology Laboratory), EMFL (European Magnetic Field Laboratory)

Key figures:

- + 50,000 students including 7,000 international students
- 3,700 PhD students, 45% international
- 5,500 faculty members
- 180 different nationalities
- 1st city in France where it feels good to study and 5th city where it feels good to work
- ISSO: International Students & Scholars Office affiliated to EURAXESS

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MANDATORY REFERENCES:

SUBJECT TITLE: *Performance and Durability of architecturally oxygen electrodes designed by ESD for SOEC*
RESEARCH FIELD: oxygen electrode, microstructure, solid oxide electrolysis cell, electrochemistry, durability
SCIENTIFIC DEPARTMENT (LABORATORY'S NAME): LEPMI, CEA-LITEN Grenoble
DOCTORAL SCHOOL'S: IMEP-2
SUPERVISOR'S NAME*:* Prof. Elisabeth DJURADO, Dr. Jérôme LAURENCIN

SUBJECT DESCRIPTION:

Context and state-of-the-art - Ceramic high-temperature fuel cell and electrolyser are efficient energy-conversion systems for electrical power generation and hydrogen production. This type of electrochemical device is constituted by a stack of elementary Solid Oxide Cells (SOCs), each one being composed of a dense electrolyte sandwiched between two porous electrodes. The industrial deployment of SOCs is still hindered by key issues related to durability and costs. For instance, the instability of the oxygen electrode made of Lanthanum Strontium Cobalt Ferrite (LSCF) is recognized as one of the prevalent mechanisms involved in the loss of SOCs performance, especially when operated in electrolysis mode [1]. The processes of the material deterioration being thermally activated, many studies have been recently undertaken to reduce the operating temperature with new oxygen electrode materials in order to improve the performances as well as to mitigate the degradation. However, the performances of SOCs are not only due to intrinsic properties of materials but they are also strongly related to the association of functionally structured electrodes and the properties of the electrode/electrolyte interface. In this frame, architecturally designed $La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_{3-\delta}$ (LSCF) and $La_{2-x}Pr_xNiO_{4+\delta}$ (x=1, LPNO) oxygen electrodes layered by Electrostatic Spray Deposition (ESD) and SP on $Ce_{0.9}Gd_{0.1}O_{2-\delta}$ (CGO) electrolyte are selected as innovative solutions for the next generation of SOCs. To date, optimum polarization resistances have been reported [2-4] thanks to the presence of a nanostructured ESD active porous functional layer facilitating the oxygen surface exchange and ions diffusion, fundamental in the oxygen electrode design.

Objectives of the thesis and work plan -The main goals of the thesis are focused on the preparation and the optimisation of both LSCF and LPNO oxygen electrodes with a precise controlled composition and microstructure. For this purpose, the architecture of the electrode/electrolyte will be tuned using the ESD manufacturing technique. The new electrodes will be applied in SOCs in order to investigate the performances and the durability when operated in electrolysis modes at intermediate temperatures.
An coupled experimental and modelling approach will be considered in order to understand the underlying mechanisms of the electrodes aging (in terms of delamination and chemical stability) of both LSCF and LPNO oxygen under- and over-stoichiometric compounds in symmetric and complete cell configurations as a function of temperature, oxygen partial pressure, and polarization. Experimental and modelling approaches will be combined. Simulations at the microscopic length scale will be conducted as a guide to analyse the role of microstructure and the relationship between electrode reaction mechanisms and the degradation phenomena. In addition, LSCF or/and LPNO infiltrated by ESD in CGO backbone will be tested in order to be compared with the infiltrated ones by impregnation of a solution (in parallel, done in the consortium). More precisely, this project resides on the fabrication (low-cost ESD, SP), characterization (XRD, FIB-SEM tomography, electrochemical impedance spectroscopy) and modelling (microstructure, electrochemistry, and mechanic) triptych.

To conclude, this Ph.D. thesis aims at improving our knowledge of the degradation mechanisms which are to blame for the performance losses upon SOCs operation. Still, it will enable to propose recommendations for in-use conditions to ensure the integrity of cells while guarantying acceptable performances. This facet of the project will thus aim at proposing practical solutions for SOEC technology.

[1] Ph.D. thesis Federico Monaca, Université Grenoble Alpes, in progress.
[2] Ph.D. thesis Ozden Celikbilek, Université Grenoble Alpes 2016.
[3] Ph.D. thesis Rakesh K. Sharma, Université Grenoble Alpes 2016.
[4] Ph.D. thesis Nur I. Khamidy, Université Grenoble Alpes, in progress.

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Role of the candidate:
The PhD candidate will split his/her time between the two partner teams at UGA/CNRS/LEPMI and at CEA-Grenoble/LITEN to realize the following tasks:
- Preparation of different microstructures/architectures of oxygen electrodes based on $La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_{3-\delta}$ (LSCF) and $La_{2-x}Pr_xNiO_{4+\delta}$ (x=1, LPNO) and/or CGO using ESD and screen-printing.
=> The microstructure/architecture of the oxygen electrode will be selected versus the best electrochemical properties using symmetrical cells for the use in solid oxide electrolysis cells. The candidate will carry out the structural, microstructural and electrical characterization of the obtained materials by X-ray diffraction, FEG-SEM, FIB-SEM tomography, impedance spectroscopy. The 3D information obtained on electrode microstructures will feed an electrochemical analysis.
- Study and understanding of the electrodes aging (in terms of delamination and chemical stability)
=> Both LSCF and LPNO oxygen under- and over-stoichiometric compounds will be studied in symmetric and complete SOEC configurations as a function of temperature, oxygen partial pressure, polarization and time. This study aims to record the I-V and P-V curves on these complete cells, under SOEC operation, for 500 < T (°C) < 700. Experimental and modelling approaches will be combined. Simulations at the microscopic length scale will be conducted as a guide to analyse the role of microstructure and the relationship between electrode reaction mechanisms and the degradation phenomena.

ELIGIBILITY CRITERIA
Applicants:
- must hold a Master's degree (or be about to earn one) or have a university degree equivalent to a European Master's (5-year duration),

Applicants will have to send an application letter in English and attach:
- Their last diploma, transcripts at least of the Master degree
- Their CV
- A letter of motivation (1 page max)
- Letters of recommendation are welcome.

Address to send their application: elisabeth.djurado@lepmi.grenoble-inp.fr & jerome.laurencin@cea.fr

SELECTION PROCESS
Application deadline: **September 07 2018** at 17:00 (CET)
Applications will be evaluated through a three-step process:

1. Eligibility check of applications by September 07, 2018
2. 1st round of selection: the applications will be evaluated by a Review Board at the end of September 2018. Results will be given at the beginning of October 2018.

TYPE of CONTRACT: temporary-3 years of doctoral contract
JOB STATUS: Full time
HOURS PER WEEK: 35
OFFER STARTING DATE: December 3rd, 2018
APPLICATION DEADLINE: September 07, 2018
Salary: 1768.55 € brut per month