Sujet de thèse :
Epitaxial p-type thermoelectric perovskite oxides for integrated thermal energy harvesting

Durée / Duration : 36 mois
lieux / Places : INL (site ECL, Ecully) à 80%, et **ILM** (site UCBL, Villeurbanne) à 20%.
INL : équipe « *Matériaux Fonctionnels et Nanostructures* » (Co-Resp. Romain Bachelet)
ILM : équipe « *Nanomatériaux pour l'énergie* » (Co-Resp. Stéphane Pailhès)

Domaine et contexte scientifique / Scientific domaine and context

Thermal management has become of major importance on microelectronic platforms. Either device temperature has to be reduced or waste thermal energy could be harvested and converted into electricity to build autonomous devices. Thermoelectric (TE) materials allow reaching both objectives, by Peltier effect or by Seebeck effect, respectively [1]. TE materials are heavily doped semiconductors, and standard TE materials are based on Te (*e.g.* Bi_2Te_3) [2], which are toxic, chemically unstable and expensive because of scarcity [3-4]. Oxides of perovskite structure (ABO_3) are good alternative TE materials overcoming these issues since its chemical flexibility allows a wide range of doping and thus TE property optimization by cationic substitution [3-6]. Furthermore, they can contain low toxic and abundant elements [3,7], and allow proper advanced integration on Si-based microelectronic platforms by molecular beam epitaxy (MBE) for which the leading team has a long-term international recognized expertise [8].

Objectifs de la thèse / Job description

In order to overcome the current issues of this thematic, we propose to:

i) Develop promising *p*-type TE oxides of perovskite-structured solid-solutions by MBE at INL (partly based on *ab-initio* calculations from a collaboration with C. Adessi, ILM)
ii) Study and optimize the global TE properties by doping, strain, defects, couplings, and interface strategies (physical properties partly measured in collaboration with S. Pailhès and V. Giordano, ILM)
iii) Develop a sustainable technological process for the fabrication of a functional integrated TE micromodule (at INL, with the support of the Nanolyon technological platform).

Profil du candidat / Skills and qualifications

The candidate should have **very good marks** (average >12) and a strong background in **solid-state physics** and **materials science**. Knowledges/skills in solid-state chemistry, crystalline growth process, structural characterizations by diffraction and spectroscopy means, (thermo)electrical characterizations, as well as microfabrication tasks would be appreciated in addition. He/she should enjoy **collaborative and experimental works**, partly in cleanroom environment, within the group and with external collaborators. He/she should have summary skills with good communication abilities.

Références bibliographiques / References (*in blue from the supervising team*)

[1] F.J. DiSalvo, Science **285**, 703 (1999); https://www.science.org/doi/10.1126/science.285.5428.703
[2] G.J. Snyder and E.S. Toberer, Nature Mater. **7**, 105 (2008); https://doi.org/10.1038/nmat2090
[3] J. He *et al*., J. Mater. Res. **26**, 1762 (2011); https://doi.org/10.1557/jmr.2011.108
[4] G. Bouzerar *et al*., EPL **118**, 67004 (2017) ; https://iopscience.iop.org/article/10.1209/0295-5075/118/67004
[5] M. Apreutesei *et al*., Sci. Tech. Adv. Mater. **18**, 430 (2017) ; https://doi.org/10.1080/14686996.2017.1336055
[6] D. Han *et al*., ACS Appl. Electron. Mater. **3**, 3461 (2021) ; https://doi.org/10.1021/acsaelm.1c00425
[7] O. Caballero-Calero *et al*., Adv. Sustain. Syst. **5**, 2100095 (2021) ; https://doi.org/10.1002/adsu.202100095
[8] G. Saint-Girons *et al*., Chem. Mater. **28**, 5347 (2016) ; https://doi.org/10.1021/acs.chemmater.6b01260

A propos de l'INL / About INL

The Institute of Nanotechnology of Lyon (INL) is a Joint Research Unit (UMR 5270) whose supervision is the CNRS, the ECL, the INSA, the University Lyon 1 and CPE Lyon. INL's mission is to develop multidisciplinary technological research in the field of micro and nanotechnologies and their applications. Research activities extends from materials to systems, and laboratory relies on the technological platform Lyon NanoLyon. Areas of application cover major economic sectors: the semiconductor industry, information technology, life and health technologies, energy and the environment. The laboratory is multi-sites with locations on the campuses of Ecully and Lyon-Tech La Doua. It includes around 200 people including 121 permanent staff. INL is a major player in the Research and Teaching Pole.
https://inl.cnrs.fr/

A propos de l'ILM / About ILM

The Institute for Light and Matter (Institut Lumière Matière - iLM) is a joint **CNRS-University of Lyon 1** research unit located on the Lyon Tech La Doua campus. With approximately **300 employees**, including a hundred doctoral students and post-docs, the iLM is a **major player in physics and chemistry research** in the Auvergne Rhône Alpes region, internationally recognized for the excellence of its research. **The continuum between fundamental research, responses to major societal challenges and innovation** is at the heart of the unit's approach. The entire staff is committed to promoting **excellence** and **ethical and responsible research**.
https://ilm.univ-lyon1.fr/

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ILM supervision (30%) : Stéphane Pailhès <stephane.pailhes@univ-lyon1.fr>

How to apply:

To apply : send a **CV** (including date of birth), Bachelor and Master **marks**, and a motivation **letter**
Dead line of applications: before **May 10th**, 2024

Other infos :

Salary : ~2300 euros (gross/brut), ~1800 euros (net) per month
French Ministry grant
Dates : 01/10/2024 – 30/09/2027
ED : EEA, https://edeea.universite-lyon.fr/
Requirements: average of the overall scholar marks (BSc and Masters): >12