22nd March 2024

PhD contract offer

Development of thermoelectric generators based on sulfur compounds

General information

Workplace: Institut Jean Lamour, Nancy, France
Type of contract: PhD contract
Contract period: 36 months
Expected date of employment: October 2024
Proportion of work: Full time
Remuneration: 2044 € (gross salary)
Desired level of education: Master's degree in solid-state physics, solid-state chemistry or material science
Experience required: /

Missions / Activities

General context

Thermoelectric (TE) materials can convert a temperature difference into an electrical current (Seebeck effect) and vice versa (Peltier effect). This solid-state energy conversion offers many advantages such as the absence of moving parts and vibrations, and the absence of emission of greenhouse gases. The main obstacle to a wider deployment of this technology is the low conversion efficiency of TE devices, which remains lower than that obtained by other green-energy technologies. The efficiency is directly related to the transport properties of the TE materials that make up the active part of these devices. A good TE material must have, at a given temperature T (K), a high Seebeck coefficient S (or thermoelectric power, V/K), a low thermal conductivity C (W/mK) so as to maintain the temperature gradient and low electrical resistivity E (Ω.m) to minimize the Joule effect. These desirable properties are expressed through the dimensionless thermoelectric figure of merit $ZT = (S^2T)/(C.E)$. This factor is used to assess the quality of a material for TE applications. The manufacture of high-performance TE devices necessarily involves obtaining materials with ZT greater than 1.

The integration of optimized materials into TE generators faces numerous scientific obstacles. If reducing the height of the thermoelectric legs allows a significant increase in the power density generated, it also induces a significant increase in the thermomechanical constraints exerted on TE materials which are generally fragile. We recently demonstrated how this problem can be circumvented by inserting metal layers that act as a buffer layer from a mechanical point of view, leading to record power densities with optimized skutterudite compounds.

Objectives and work program

The objective of this thesis is to manufacture TE devices based on sulfur compounds and to monitor the evolution of the TE performance of the devices as a function of temperature and time. The activities of the successful candidate will focus on the manufacturing of these devices with possible metallic buffer layers whose nature will be modified in order to determine the impact of their composition on TE performance. Finite element modeling will guide this research by predicting the expected output performances depending on the nature of the materials constituting the TE legs. Analyses by scanning electron microscopy will make it possible to follow the evolution of the interfaces between the different materials after high-temperature annealing. This thesis is part of the ANR Biscottes project (which begins in April 2024), which includes two academic partners (IJL in Nancy and CRISMAT in Caen). It aims to manufacture thermoelectric modules based on sulfur compounds at low cost and high-power density by optimizing the module assembly stage.

Work context

The thesis will take place at the Institut Jean Lamour in Nancy, under the supervision of Christophe Candolfi (director) and Bertrand Lenoir (co-director).
At the end of the thesis, the student will have learned to master the techniques for manufacturing thermoelectric modules, to measure their thermoelectric performance as a function of temperature and to model the latter by the finite element method using commercial software (Comsol Multiphysics).

Skills required

- Holder of an engineering degree or a Master 2 in the field of materials science.
- Knowledge of solid-state physics or chemistry and characterization of materials.
- Fluent in English.

About Institut Jean Lamour

The Institute Jean Lamour (IJL) is a joint research unit of CNRS and Université de Lorraine.
Focused on materials and processes science and engineering, it covers: materials, metallurgy, plasmas, surfaces, nanomaterials and electronics.
It regroups 183 researchers/lecturers, 91 engineers/technicians/administrative staff, 150 doctoral students and 25 post-doctoral fellows.
Partnerships exist with 150 companies and our research groups collaborate with more than 30 countries throughout the world.
Its exceptional instrumental platforms are spread over 4 sites; the main one is located on Artem campus in Nancy.

Constraints and risks

The position you are applying for is located in a sector relating to the protection of scientific and technical potential. It therefore requires, in accordance with the regulations, that your arrival be authorized by the competent authority of the Ministry of Higher Education, Research and Innovation.
Risks of exposure to electromagnetic and ionizing radiations, risks associated with high temperatures.

Application

Applicants are invited to send a CV, two names of recommending people together with diploma copies and grades to:
Dr. Christophe Candolfi: christophe.candolfi@univ-lorraine.fr
Pr. Bertrand Lenoir: bertrand.lenoir@univ-lorraine.fr