Master Thesis Topic
(February – August, 2024)

Title of the research topic	Lithium ionic conductors from the binary thio-LISICON system Li_3PS_4-Li_4SiS_4
Laboratories	**Laboratoire de Réactivité et Chimie des Solides (LRCS)** **Laboratoire de Physico-Chimie de l'Atmosphère (LPCA)**
Addresses, Country	**15 rue Baudelocque, 80039 Amiens Cedex, France** **189A, Avenue Maurice Schumann 59140 Dunkerque, France**
www Links	**https://www.lrcs.u-picardie.fr/, https://lpca.univ-littoral.fr/**
Master thesis Advisors	**Dr. Pierre GIBOT, MCF Mohammad KASSEM**
E-mails	**p.gibot@u-picardie.fr, mohamad.kassem@univ-littoral.fr**

Scientific Project:

The ever-increasing demand for electrochemical energy storage means that current systems are constantly evolving. Li-ion batteries (LIBs) are a suitable and competitive technology in particular for the development of electric vehicles[1]. However, this technology requires the use of highly flammable non-aqueous liquid electrolytes that can lead to safety issues. As a result, most of the current research about these electrochemical devices is focused on the development of all-solid-state batteries (ASSBs), in which solid electrolytes (SE) replace liquid electrolytes (LE), making these batteries safer[1].

Among the different types of solid electrolytes expected in ASSBs, sulphides are attracting a lot of attention because of their superior ionic conductivity and good mechanical properties compared with other SEs such as oxides. Thio-LISICON materials with the general formula $Li_xM_xS_4$ (M=P, Si, Sn, Ge) are particularly interesting with a conductivity of around 10^{-4} S/cm (Li_3PS_4)[2]. By combining two of these materials, solid solutions with improved conductivity can be synthesized as demonstrated with the Li_3PS_4-Li_4GeS_4 binary system[3] with a conductivity of 2.2×10^{-3} S/cm.

The aim of this internship will be to study other solid solutions from this family of materials, and in particular those based on the chemical element silicon (Si), since Si has a lower criticality index (more abundant, less toxic and inexpensive) than germanium (Ge). The lithium-based solid electrolyte family Li_3PS_4-Li_4SiS_4 will be targeted[4,5]. Various compositions will be synthesized by a melt/quenching approach, characterized and electrochemically tested.

Techniques used:

. Melting/quenching synthesis, TG and DSC analyses, Raman spectroscopy, Scanning electron microscopy, Impedance spectroscopy, X-Ray diffraction, Electrochemical cycling.

Recent publications related to the topic:

1. Fraunhofer Institute for Systems and Innovation, Research ISI, Karlsruhe, April 2022.
2. Liu et al., J. Am. Chem. Soc. 135 (2013) 975−978.
3. Kanno et al., J. Electrochem. Soc. (2001), 148, A742.
4. Hayashi et al., Electro. Solid State Lett. 6 (2003) A47-A49.
5. Murayama et al. J. Solid State Chem. 168 (2002) 140-148.

Documents to provide: We wish to hire a highly motivated Master student with skills in inorganic chemistry and interest in synthesis. Please provide Curriculum vitae and motivation letter.