Superionic conductors for sustainable energy applications

Recent reports (1,2) demonstrate the need for increasing the share of renewable energies, as well as of electrical transportation in the overall energy mix, in order to decarbonate the energy production and/or use and limit the temperature increase. Both aspects will need efficient and reliable electrical energy storage solutions. The issue is also that these energy storage solutions be sustainable and safe, which is far from being the case for the leading technology, namely the Li-ion battery.

By exploiting solid-state properties of some titanate-based perovskites systems we demonstrated the possibility of developing all-solid Li-free, Co-free energy storage systems. These solid-state materials demonstrate a remarkable ion conductivity of about $\sigma_{ion} \simeq 1mS.cm^{-1}$ with an extremely low electronic conductivity ($\sigma_{electr.} < 10^{-8}S.cm^{-1}$) at room temperature, which makes them interesting for a large variety of applications. In some experimental situations however, the electronic contribution is found to strongly increase and become dominant, which can also be advantageous.

The mIcroscopic mechanisms at play behind the observed behavior remain to be investigated. What makes that electrons are localized in a material while ions are delocalized is a subtle problem. What makes that under small structure variations, or peculiar stimulations, the situation is reversed is what we aim to investigate.

The aim of this PhD project is therefore to tackle by a variety of experimental and theoretical techniques the fundamental mechanisms at play in these (and related) materials.

The candidate will be trained to use a variety of experimental techniques: electrical measurements, Electron microscopy (HRTEM, XPS…), Infrared and Raman spectroscopy, XDR and neutron diffraction, benefitting from a rich collaborative network (ANR MIMETIX project). He (she) will also perform ab initio simulations such as DFT and molecular dynamics.

The project will expose the student to a rich domain at the frontier of fundamental physics and chemistry with a large variety of experimental and modelling techniques, adding up various techniques to the students skills portfolio. It will also expose the student to an environment spanning from fundamental physics and chemistry to applicative devices, and will open carrier possibilities both in the academia and private sectors.

We are looking for a highly-motivated candidate, with a Master degree in Solid-State Physics or Material Physics, able to interact within a dynamical research network, to work and think independently and to be a force of proposition.

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