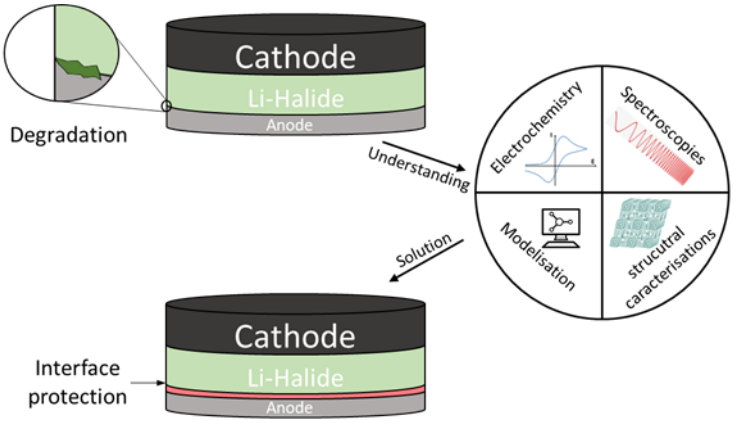
SAINT-GOBAIN

PhD Proposal

Fundamental understanding and stabilization strategies of the halide-electrolyte/anode interface in all-solid halide lithium batteries

Context



The challenges associated with climate change now oblige the electrification of transport which has led to an explosion in the development of batteries in recent years. However, the need for energy density, power and safety is continuously increasing and is pushing Li-ion technology to its limit, calling for a new technological leap. The replacement of the liquid electrolyte by a non-flammable solid electrolyte capable pairing with lithium metal is viewed as a crucial advance towards safer Li batteries. Among the different electrolyte materials considered, lithium halides seem to be promising among the battery community and beyond fully justifying that actor such as Saint-Gobain consider their industrial production. Nevertheless, prior taking this step, technical challenges remain, namely, to understand and solve the electrochemical instability of halides at the lithium anode.

Objectives

Until recently, oxides and sulfides are the two most studied families of materials as solid electrolytes for future all-solid-state batteries. However, these materials suffer from several major drawbacks limiting their industrialization: low conductivity and processability for oxides and toxicity of sulfides when exposed to humidity. Halides, recently described as potential solid electrolytes, have good conductivity, good processability owing to their favorable mechanical properties and are stable at high potential. In contrast, their weakness remains their instability toward the negative electrode. Preliminary studies on model materials have laid the first foundations of the halide degradation mechanism at the anode. However, a great deal of work remains necessary to establish the science beyond this reactivity, and then to develop a strategy to cure this instability. Within the framework of the proposed thesis, an intense characterization work will be carried out, on the one hand via advanced electrochemical techniques first to monitor and follow the kinetics of parasitic interfacial reactions, but also by an arsenal of structural characterizations (XRD, NMR, EPR, XPS, TEM, SEM, X-ray tomography etc...) with all be supported by theoretical calculations (DFT, MD...). These studies will use the tools available both at Saint-Gobain Research Paris and via the network of Jean-Marie Tarascon's laboratory with possible recourse to large scale facilities. Beyond the fundamental understanding, protection methods of the halide/anode interface will be studied via the deposition of inorganic coatings as chemical buffers or the creation of heterostructures, keeping in mind the importance of the industriability of the proposed solution. This will be done

by combining CdF surface engineering facilities and Saint-Gobain's large scale deposition expertise. The expected outcome of this thesis is the feasibility to demonstrate workable and long-life solid-state batteries based on halides as the only source of inorganic conducting electrolyte. To do so we believe that establishing a sounds scientific platform for studying the dynamic of interfaces is crucial, hence the need to hire a student capable of combining both fundamental and practical aspects.

Preferred profile

Student in engineering school in physical chemistry or master in material chemistry/physical chemistry with knowledge in electrochemistry. Previous experience in the field of lithium batteries would be a plus.

Host laboratory

Chaire de Chimie du solide et de l'Energie – Collège de France – Paris
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