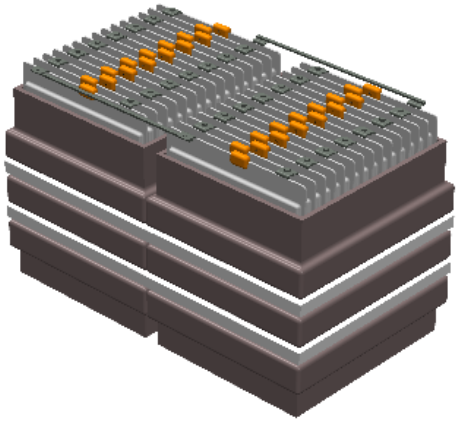
CHALMERS
UNIVERSITY OF TECHNOLOGY

Insplorion

Master Thesis (30/60 ECTS)

Unveiling Na-ion storage mechanism in Na-ion batteries by *operando* Surface Plasmon Resonance spectroscopy



Aim:

The aim of this project is to explore the storage mechanism of sodium ions (Na^+) in hard carbon (HC) of sodium ion batteries (SIBs). To aid in this investigation the primary tool will be the utilization of *operando* fibreoptic sensing with nanosized sensing elements to monitor internal processes in real time. Implementing complementary electrochemical cycling and spectroscopy techniques enables correlation of the results and a deeper understanding of the mechanisms at play.

Background:

Sodium ion batteries (SIBs) have recently attracted much attention as promising alternatives to lithium ion batteries (LIBs) due to the abundance of active material precursor, expected lower cost, and ability to be stored in fully discharged state. However, due to thermal dynamic issues graphite—commonly used as anode material in LIBs—the Na-ions do not intercalate well and thus using graphite in SIBs do not provide meaningful capacity. Instead, hard carbon (HC), sometimes also referred to as non-graphitizable carbon, has emerged as the leading candidate as carbonaceous anode material. While the effects of Na-ion insertion into HC are clear in the form of good electrochemical performance, a clear understanding of the actual insertion mechanisms at play is still lacking. Its disordered nature makes HC a complex system to study with traditional characterisation techniques.

Insplorion AB is a spin-off company from Chalmers University of Technology that is developing and marketing it proprietary NanoPlasmonic Sensing (NPS) technology. Insplorion has been selling scientific instruments based on this technology since 2010 and recently brought its NO2 sensors to the market. In this project optical fibre based NPS will be used for *operando* measurements on SIBs. By introducing optical fibres bearing Insplorion's NPS structures and embedding them inside batteries, we aim to study chemical changes taking place at the HC anode as a function of the battery's state of charge. Understanding involved mechanisms will be assisted by various electrochemical cycling techniques (CCCV, CV, LSV, GITT, etc..). Moreover, other characterisation techniques (Raman, IR, XRD, XPS, etc..) will be used to probe structural changes of HC electrodes after cycling.

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This project will be performed as a collaboration between Insplorion and Patrik Johansson's group and the Department of Physics at Chalmers. Johansson's research group focus their efforts on battery chemistries of the future, oftentimes with the aim of investigating cheaper and more abundant chemical components or bio-degradable materials.

Project description:

In this project you will first learn how to fabricate sodium ion battery (SIB) coin cells with integrated *in situ* sensors. An experimental measurement setup will then be arranged where electrochemical cycling is combined with the optical interrogation setup for the *operando* NPS sensor probe. Further complementing the measurement setup with characterization techniques such as Raman spectroscopy will also be explored. Finally, you will collect and correlate the acquired data with the goal of achieving deeper understanding of the processes at play.

The project includes the following activities:

1. Drawing up a project plan for the work to be done.
2. Conducting literature studies on SIBs, the processes, and constituents—primarily focusing on the anode—as well as on the characterization techniques available in the project.
3. Developing a fabrication protocol for SIB coin cells with fibreoptic sensors using the facilities at Chalmers and Insplorion, including learning how to work in a glovebox.
4. Setting up and carrying out measurements on the fabricated coin cells, followed by compiling and analysing the outputs.

Qualifications:

Suitable candidates should be well focused, motivated and self-going with some of the following master programs as background: Nanotechnology, Material Chemistry, Applied Physics, or similar. The student must be enrolled at a Swedish university.

Additional information:

The Master Thesis work will be performed at the Department of Physics at Chalmers University of Technology and at Insplorion AB, Biotech Center, Gothenburg.

Supervisors:

Academic supervisor: Patrik Johansson, Department of Physics, Chalmers University of Technology.
Industrial supervisor: Elin Langhammer, CTO, Insplorion AB.

Examiner: Patrik Johansson

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