## PhD Opportunity — Multiscale Optical Imaging of Electrochemical Interfaces

**Title:** *Exploring Electrochemical Interfaces with QLSI Interferometry: From Battery Electrodes to Emerging Systems*

**Project Summary:** Electrochemical technologies underpin the global shift to sustainable energy—whether in batteries, electrolyzers, or sensors. Yet, critical processes at electrochemical interfaces remain poorly understood, notably in terms of phase formation, active species transport, and interfacial degradation. Existing in situ tools struggle to resolve these dynamic, multiscale phenomena in real time.

This PhD project pioneers the use of *Quadriwave Lateral Shearing Interferometry* (QLSI)—a quantitative phase imaging technique originally developed for bioimaging—to address this challenge. QLSI provides highly sensitive, label-free mapping of nanoscale optical phase shifts, allowing access to volume changes, concentration gradients, and structural reorganizations under polarization. Although QLSI is well-established in optics and nanophotonics, it has never been applied to electrochemical systems—making this project a first of its kind.

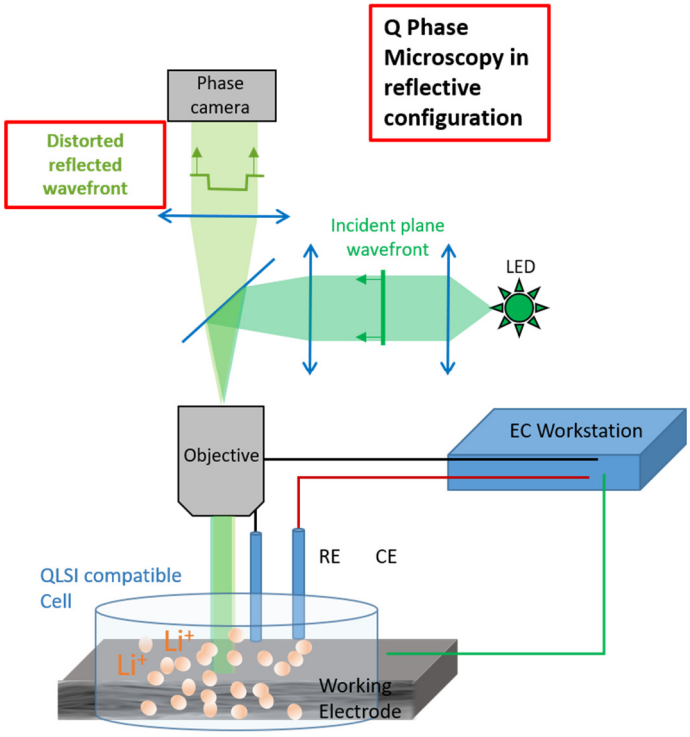



*Figure 1. Sketch of a setup being developed in the project*

Focusing initially on battery negative electrodes, particularly MXene-based architectures, the PhD will also explore broader electrochemical contexts such as electrodeposition or SEI formation across different platforms. Coupling QLSI with surface plasmon resonance (SPR)—an interface-sensitive technique—will enable correlative insights into both volumetric and interfacial phenomena.

**Objectives:**

- Adapt QLSI microscopy for operando studies of electrochemical interfaces.
- Investigate (de)lithiation and SEI formation in MXene-based battery electrodes.

- Develop a dual QLSI-SPR platform to map dynamic interfacial and bulk processes.
- Extend this approach to other electrochemical systems beyond batteries.

**Expected Impact:**
This project introduces a new toolbox for operando, multiscale characterization of electrochemical processes. By accessing both surface and bulk dynamics optically and in real-time, it will shed new light on fundamental mechanisms limiting device performance and stability. This innovative approach has the potential to influence a wide range of technologies—from next-gen batteries to advanced electrochemical sensors.

**Candidate Profile:**
- MSc or equivalent in physics, chemistry, materials science or nanotechnology.
- Skills in electrochemistry, microscopy, or materials characterization are a plus.
- Scientific curiosity, analytical rigor, and a strong interest in interdisciplinary research.

**Research Environment:**
The work will be conducted at the *Light, Nanomaterials and Nanotechnologies Laboratory (L2n, CNRS UMR 7076)* at the Université de technologie de Troyes (UTT). The candidate will receive training in nanomaterial synthesis, optical microscopy, operando electrochemistry, and spectroscopy. The project benefits from expert supervision and an interdisciplinary team.

**Supervisors:**

- Dr. Jeremy Mallet – jeremy.mallet@utt.fr
- Dr. Benoît Rogez – benoit.rogez@utt.fr


**Start date:** October 1, 2025 — **Duration:** 3 years
**Application deadline:** June 6, 2025
**Location:** L2n Laboratory, UTT, 12 rue Marie Curie, 10004 Troyes Cedex, France