Université Bourgogne Europe, Dijon, France

MASTER THESIS M2 CDM (5 months, Feb. - June)

2025-2026

Title of the project: Development and optimization of a continuous flow synthesis bench for ultra-thin 2D gold single crystals.

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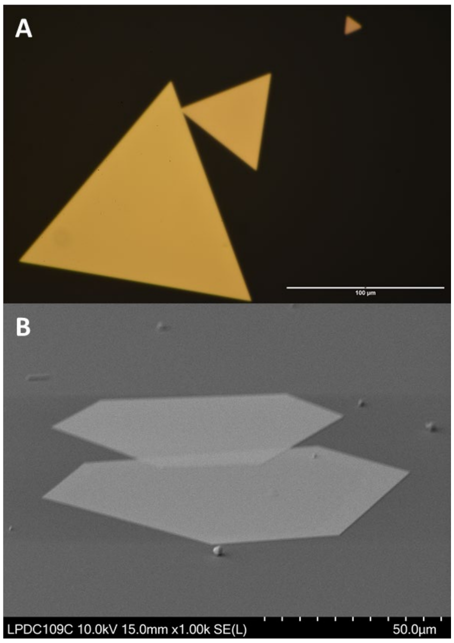
Laboratory : **ICB, U. Bourgogne Europe, CNRS UMR 6303 - Dijon**
Collaborations:

CONTEXT: While optical information transfer in fibers is a mature and relatively energy-efficient technology, the processing of this information remains essentially electronic, which has become significantly energy-intensive and requires inefficient opto-electronic conversion.[1] The miniaturization of optical components is a challenge that surface plasmon engineering proposes to address with sub-wavelength guides and, more recently at ICB, micrometric all-optical calculators.[2] These calculators are produced from ultra-thin gold single crystals (20-80 nm) with micrometric lateral dimensions.

To enable mass production of these calculators and thus optimize their performance, it is critical to increase this lateral size while preserving the structural quality of the crystalline gold. Our team has recently developed a method of growth directly on the surface that allows us to achieve ultra-thin crystals with a lateral size of at least 0.2 mm.[3]

OBJECTIVES: Develop a synthesis bench for maximum-size gold crystals using controlled-flow injection of reagents. Characterize the crystals using several methods: optical microscopy, electron microscopy, atomic force microscopy, ellipsometry. Implement a rapid, automated optical method for measuring the nanometric thickness of the crystals.

DESCRIPTION: Gold single crystals are obtained by solution chemistry but by nucleation on the surface of a submerged glass substrate (Figure). The slow continuous supply of reagents and the removal of by-products responsible for crystal thickening allow lateral growth to continue to macroscopic dimensions while maintaining a nanometric thickness. The adjustment, stability, and control of growth parameters require partial automation of the synthesis bench, which will be the main focus of the internship.



The success of the method will be evaluated by the structural and morphological quality of the wafers. To this end, characterization studies using optical microscopy, scanning electron microscopy (SEM), transmission electron microscopy (TEM), and atomic force microscopy (AFM) will be conducted by the intern. These will be supplemented by more specific measurements (XPS, EBSD, XRD, ellipsometry) in order to optimize the synthesis parameters and provide samples for the nanofabrication of calculators.

To speed up thickness measurements, an optical method may be implemented and calibrated by comparison with AFM measurements.

[1] "L'ordinateur optique", podcast. [2] F. Dell'Ova et al, ACS Photon., 2024, 11, 752. [3] L. P. Datta, F. Lebrun, et al., 2025, unpublished.

Type of project (theory / experiment): Experimental

Required skills: Knowledge in colloidal chemistry, taste for instrumentation and testing, interest in microscopy.

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