Master 2 internship

ICB, *Univ. Bourgogne Europe, CNRS (Dijon)*

2025-2026

TITLE

Optimization of a continuous flow synthesis of ultra-thin 2D gold single crystals on surfaces and its implementation within a thermostated microfluidic cell.

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 growth method directly on the surface that allows us to achieve ultra-thin crystals with a lateral size exceeding 0.2 mm.[3]

OBJECTIVES

Develop a synthesis bench for maximum-sized 2D gold crystals using controlled-flow injection of reagents. **Design and build** a microfluidic cell compatible with (1) the controlled-flow reactant injection system, (2) optical monitoring in transmission and reflection, (3) thermal regulation at 80-90°C, (4) prolonged exposure to reagents. **Characterize** the crystals using several methods: optical microscopy, electron microscopy, atomic force microscopy, ellipsometry.

DESCRIPTION

Gold single crystals are obtained by nucleation on the surface of an immersed glass substrate (Figure B) from a precursor solution. 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. However, folding, overlapping, and creasing phenomena occur that are not understood and the final thicknesses, though thin, vary. The adjustment, stability, and control of growth parameters require partial automation of the synthesis bench. To understand and better control these phenomena, the internship will set up in-situ monitoring of this surface growth by designing, building, and testing a thermostatic microfluidic cell (see general principle in Figure A).
The success of the method will be evaluated by the structural and morphological quality of the 2D gold crystals. Characterization studies using optical microscopy, scanning electron microscopy (SEM), transmission electron microscopy (TEM), and atomic force microscopy (AFM) will be conducted. 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.

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 Video [3] L. P. Datta, F. Lebrun, et al., **2025**, unpublished.

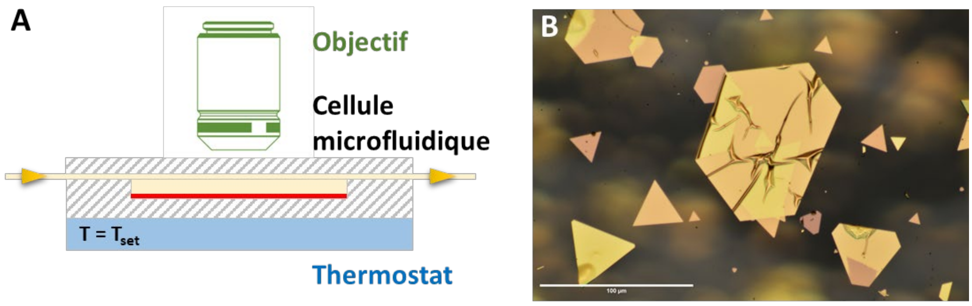

Figure: (A) General principle of the temperature-controlled microfluidic cell for optically monitoring the in-situ and on-surface growth of 2D gold crystals. **(B)** Optical image of 2D gold crystals obtained on glass. Red, orange and yellow color indicates the presence of several different thicknesses. Overlapping, avoidance, folding and creasing phenomena will be explored.

SUPERVISOR

Erik DUJARDIN
Laboratoire Interdisciplinaire Carnot de Bourgogne (ICB)
Département Photonique - Equipe PRISM - Bâtiment Mirande, Aile D, Bureau DR11B
9 avenue Alain Savary - BP 47870 - 21078 Dijon Cedex - FRANCE
Email : erik.dujardin@cnrs.fr

FACILITY ACCESS

Office with dedicated PC. **Lab space** with dedicated bench and all required equipement to develop the set-up. **Access and training** to characterization tools in the **ARCEN** platform (CAD on Inventor, mechanical workshop for fabricating the designed parts, optical microscopies, thermoplastic embossing and PDMS molding units for microfluidic cell fabrication). Collaboration with microfluidic experts in ICB (L. Markey)