OFFRE DE THESE EN CO-TUTELLE

Institut Jean Lamour
Laboratoire Nanotechnologies et Nanosystèmes

CAPTEURS ACOUSTIQUES PLASMONIQUES MULTIMODALES (MULTIPAS)
MULTIMODAL PLASMONIC ACOUSTIC SENSORS (MULTIPAS)

Keywords

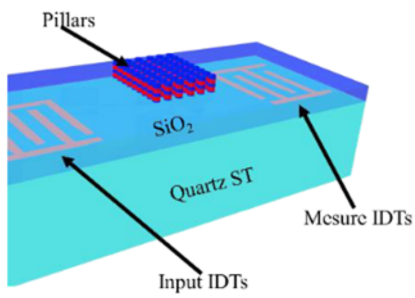
Acousto-plasmonics, Surface waves (SAW) & phonons, Multimodal biosensor, Multiphysics simulation (COMSOL/Lumerical), Nanofabrication, Light-matter interaction, Elasto-optic effect.

Introduction

Acousto-plasmonics exploits the interaction between piezoelectric-induced surface acoustic waves (SAWs) and metallic nanostructures to achieve high-speed and active control of optical signals. Acoustic modulation leverages coherent phonon propagation to mechanically and electronically reconfigure plasmonic resonances offering new opportunities in the field of sensing [1]. This interaction creates a unique spatiotemporal control over the plasmonic near-field, allowing for tunable optical responses via mechanisms ranging from macroscopic lattice deformation to microscopic energy relaxation control. Consequently, acousto-plasmonics offers a promising pathway for developing next-generation active optical components that are both compact and highly efficient.

Research Objectives

Current limitations in plasmonic biosensing are often defined not by the lack of optical response, but by the difficulty of distinguishing minute spectral shifts from environmental noise and thermal drift. To overcome this fundamental barrier, this research proposes a shift from static observation to active interrogation through the development of a grating-coupled acousto-plasmonic sensor. By integrating periodic metallic nanostructures with piezoelectric transducers, the system generates Surface Acoustic Waves (SAWs) that act as a high-frequency clock, rhythmically modulating the plasmonic resonance through simultaneous geometric deformation and dielectric perturbation. This dynamic coupling effectively converts the sensing signal from a static DC value into an oscillating AC waveform, enabling the use of lock-in detection techniques to isolate the plasmonic response from background interference. Consequently, this approach aims to drastically enhance the Limit of Detection (LOD), demonstrating that the coherent mechanical modulation of light—rather than passive reflection—is the key to achieving unprecedented sensitivity in next-generation optical sensors.



The aim of this doctoral thesis is the design and optimization of an integrated acousto plasmonic system (a typical one is shown in the illustration) to create a multimodal biosensor having a highly sensitive with wide dynamic range through usage of the elasto-optic effect. The idea is to explore the interaction between surface acoustic waves (SAWs) and localized surface plasmons in a multilayer structure containing spatially-localized functionalization on nanostructured surfaces [2,3]. The study may identify specific acoustic modes that strongly couple with plasmons, leading to significant modulation of physical parameters of plasmon frequency modulation. This will inevitably require a good understanding of the physics involved, so as to be able to carry out simulation stages before manufacturing and characterization.

Laboratories :	The thesis will be conducted between the following laboratories: • Laboratoire Nanotechnologies et Nanosystèmes (LN2 – IRL 3463 CNRS), University of Sherbrooke, Quebec, Canada. • Institut Jean Lamour (IJL - UMR 7198 CNRS), University of Lorraine, France The thesis will be jointly supervised by the two universities. Both laboratories are equipped with clean rooms and the technology necessary for the successful completion of the thesis. These two laboratories have already worked together on two theses and an ANR project and publish jointly. Collaborations with partners in Université Paris-Saclay will be possible during the thesis.
Candidate profile	This position requires a versatile and curious candidate. Student with a Master's degree or engineering degree in physics, photonics, acoustics, materials science, or nanotechnology. Technical skills: • Proficiency in finite element simulation tools (COMSOL) and FDTD (Lumerical). • Interest in clean room experimentation (lithography, deposition). • Basic knowledge of biology or biophysics appreciated (for the sensor component). • French proficiency**:** B1 level or higher (CEFR) – mandatory Soft skills: • Highly adaptable and open-minded: Essential for communicating with experts in optics (plasmonics) and mechanics (acoustics). • Autonomy and scientific rigor. • Ability to relocate internationally (France/Canada).
Funding :	Partial funding secured from CNES (French space agency) for this project; additional funding applications are underway (via Canadian project partners, regional grants, and excellence scholarships)
Contacts :	Dr Jean-François BRYCHE : jean-francois.bryche@usherbrooke.ca Pr. Frédéric SARRY : frederic.sarry@univ-lorraine.fr Beginning: Oct. 2026
A propos	The IRL-LN2 is an International Research Laboratory between France (CNRS) and Canada (Québec), located in Sherbrooke (about 2 hours from Montreal). It brings together around a hundred people. The goal of this laboratory is to strengthen scientific and technological cooperation between France and Canada, based on both highly collaborative research with industry and more fundamental research. The LN2 has access to a cleanroom equipped with the most advanced tools for micro-nanostructuring, material growth, and optical, electrical, and

thermal characterization. It is located on the site of the 3IT, the Interdisciplinary Institute for Technological Innovation. Learn more on the website.

The Institut Jean Lamour (IJL) is a fundamental and applied research laboratory in **material science**. It is a joint unit (UMR 7198) of the CNRS and Université de Lorraine and it is attached to the CNRS Institute of Chemistry.
It is a multi-thematic laboratory covering **materials**, **metallurgy**, **nanosciences**, **plasmas**, **surfaces** and **electronics** in response to societal challenges such as **energy**, **environment**, **the industry of the future**, **mobility**, **the preservation of resources** and **health**. Its research work ranges from the design of materials to their industrial applications. Its research work is carried out by **25 groups** organized into **4 scientific departments** and a **technological research team**. It is supported by **8 technical platforms** and **4 support services**.
The IJL is based in Nancy, on the Artem campus, and a few groups are located on other Nancy campuses as well as in Metz and Epinal.
Website: https://ijl.univ-lorraine.fr/en/laboratory/presentation

1. D. S. Bidouba Sanvany, F. Kosior, D. Beyssen, A. Gigodot, E. Gaudion, and F. Sarry, "*Exploring Fluid Dynamics to Analyze Cellular Stress Induced by Surface Acoustic Waves in Biological Applications*," IEEE Open J. Ultrason., Ferroelect., Freq. Contr., vol. 5, pp. 254–268, 2025.
2. *J-F. Bryche*, M. Vega, A. Tempez, T. Brulé, T. Carlier, J. Moreau, M. Chaigneau, PG. Charette, M. Canva, «*Spatially-Localized Functionalization on Nanostructured Surfaces for Enhanced Plasmonic Sensing Efficacy* », Nanomaterials, 2022, 12(20):3586
3. M. Vega, J. Moreau, *J-F. Bryche,* M. Canva *"Plasmonic Film with Diluted Nanostructures for Light Energy Harvesting and Sensing,"* ACS Applied Optical Materials, vol 3, no. 10, p2329-2338, 2025.