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Institut d'Electronique, de Microélectronique et de Nanotechnologie
UMR CNRS 8520

Master or Engineer internship 2024-2025

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Title: Development of Molecular Switches based on Self-Assembled Monolayers

Abstract : The aim of this Master 2 internship is to extend studies carried out as part of the EVOLMONET project, funded by the ANR (Agence Nationale de la Recherche), in partnership with chemists of MOLTECH-Anjou laboratory (Angers). These studies have led to the development of metal-molecule-metal molecular junctions capable of functioning as switches in the terahertz (THz) range at room temperature[1]. These devices are based on self-assembled monolayers (SAMs) of molecules featuring a π-σ-π structure. This structure comprises two conjugated (π) moieties linked by a non-conjugated (σ) spacer, a configuration that enables the device to exhibit negative differential conductance (NDC) — a phenomenon in which an increase in voltage across a device results in a decrease in current. When the devices are irradiated at 30 THz, they show reversible suppression of this phenomenon, paving the way for innovative applications in high-frequency communications and sensing.

A key perspective of this work is the ability to modulate NDC effects through chemical engineering, thus allowing the tuning of the devices' frequency response. This can be achieved by modifying the conjugated groups (π), the non-conjugated spacer (σ), or the anchoring groups.

-> The proposed work will involve forming SAMs on gold substrates, using new molecules with a π-σ-π structure synthesized by our collaborators, in order to improve the observed phenomena. These layers will be characterized using classical techniques such as ellipsometry, XPS spectroscopy, and atomic force microscopy (AFM). Then, conductive mode AFM (C-AFM) will be used as a top electrode to create molecular junctions, allowing the study of their electronic transport properties at the nanoscale. In a second phase, the focus will be on analyzing the effect of irradiation on these junctions.

The student will participate in the fabrication and characterization of SAMs, C-AFM measurements, and analyze the results to understand the mechanisms involved in these molecular switches without and with irradiation. This project offers the student a unique opportunity to explore cutting-edge research in nanoelectronics and molecular switches, with significant implications for next-generation sensor and detection technologies.

[1] I. Hnid *et al.*, "Molecular Junctions for Terahertz Switches and Detectors," *Nano Lett.*, vol. 24, no. 8, pp. 2553–2560, 2024, doi: 10.1021/acs.nanolett.3c04602.