PhD proposal

Plasmonic thermochromic materials for ultrafast optical modulation

This **co-tutored PhD** (double doctoral degree) is part of a partnership between the **Institut National de la Recherche Scientifique** (**Montreal**, Quebec, Canada) and the **Light, Matter and Interfaces** laboratory (LuMIn) (**Université Paris-Saclay**, France). It is **funded by INRS**. The student will work on both sites.

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- **Background**

Metallic nanoparticles (NPs) under light irradiation are efficient nanoscale heat sources thanks to the *localized surface plasmon resonance* phenomenon. This conversion process can be exploited, in particular for the design of new functional materials. Beyond this, the use of pulsed laser irradiation remains little explored, even though it allows to strongly localize the heat produced and to generate other exploitable effects (electronic photoemission, near-field optical modulation, photoluminescence). The LuMIn laboratory has a recognized expertise in this field of *ultrafast plasmonics*.

In addition, thermochromic materials show an insulator-metal phase transition when their temperature exceeds a certain value or when illuminated by ultrashort light pulses. The transition temperature can be varied by doping. INRS is an expert in the synthesis and characterization of this type of materials.

In this project, we will combine the properties of plasmonic objects and those of VO_2, a thermochromic material, for the fundamental study and development of new functional materials.

- **Principle and objectives**

The laser illumination of the material allows the high local heating of the NPs and the phase transformation of the thermochromic material in contact over a nanometer distance. This rapid phase change results in a modification of the optical properties of the entire material. The expected response time is very short (ps). In addition, the strong electromagnetic field generated around the NPs and the electronic photoemission from the NPs can participate in the phase transition of VO_2.

The proposed research work includes the following steps:

- Elaboration of VO_2 thin films containing gold or aluminum NPs by pulsed laser deposition (PLD) and electron-beam lithography (typical dimensions: thickness 100 nm, area 1 cm^2).
- Morphological and optical characterization of the materials.
- Measurement (time-resolved broadband laser spectroscopy) and modeling of the dynamics of the optical response of the material.
- Analysis of the mechanisms involved.

INRS : PLD, e-beam lithography, equipment for the characterization of materials
LuMIn: spectrophotometry, femtosecond laser transient absorption spectroscopy; appropriate models.

- **Major novelties of the project**

- Coupling of plasmonic nano-objects and a thermochromic material, using reliable, reproducible techniques that allow the realization of macroscopic surfaces.
- For the first time, phase transition induced by ultrafast nanometric photothermal conversion.
- Exploitation of the plasmonic properties of aluminum.