2025-2026

Master thesis proposal

Hot electron injection and defect control in Au–TiO_2 nanocomposites probed by ultrafast transient absorption spectroscopy

Keywords: TiO_2, Au nanoparticles, oxygen vacancies, hot electron injection, transient absorption spectroscopy (TAS), x-ray photoelectron spectroscopy, plasmonics

Scientific description:

Embedding plasmonic Au nanoparticles (Au NPs) into TiO_2 thin films enables visible-light harvesting through localized surface plasmon resonance (LSPR) and hot electron transfer to the semiconductor [1]. The efficiency and lifetime of these carriers depend critically on the TiO_2 phase (anatase vs rutile), the density of oxygen vacancies (V_O/Ti^{3+}), and the thermal stability of the nanostructure [2].

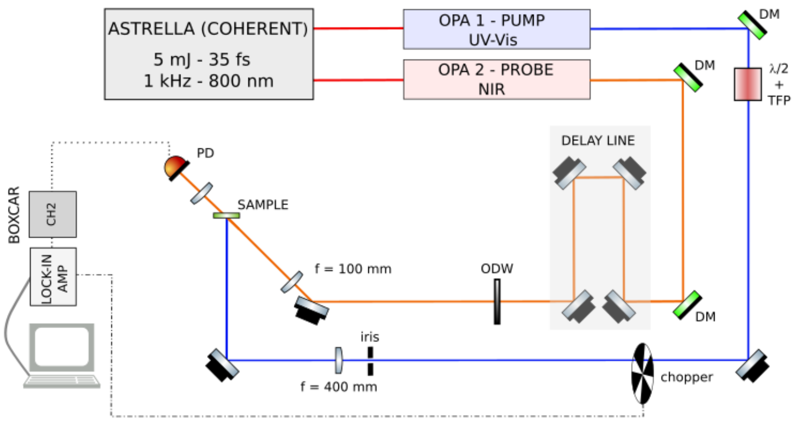

Figure 1. Experimental setup of transient absorption spectroscopy (TAS) on the femtosecond laser platform SUMO @INSP.

The internship will focus on sputtered TiO_2 films with embedded Au NPs produced by pulsed laser ablation in liquids (PLAL) [3,4]. We will combine UV-Vis spectroscopy and femtosecond transient absorption spectroscopy (TAS) at 1.3 µm to quantify hot electron injection under plasmon excitation [5]. Controlled annealing (air vs vacuum) will be used to tune defect density, while XPS and XRD will characterize oxygen vacancies and phase. Reference TiO_2 films without Au NPs will serve to isolate plasmonic contributions. This work will clarify the quantitative role of oxygen vacancies in hot electron injection and carrier dynamics in state-of-the-art PLAL-based nanocomposites.

[1] H. Tang *et al.*, J. Chem. Phys. 152, 220901 (2020).
[2] H. Wang *et al.*, J. Phys. Chem. Lett. 14, 8312 (2023).
[3] D. Amans, W. Cai, and S. Barcikowski, Applied Surface Science 488, 445 (2019).
[4] O. Sublemontier *et al.*, WO2019149763 (8 August 2019).
[5] D. C. Ratchford *et al.*, Nano Lett. 17, 6047 (2017).

Techniques/methods in use:

Thermal treatments under controlled atmosphere (air, vacuum). UV-Vis-NIR spectroscopy. Transient absorption spectroscopy (femtosecond pump–probe). X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS).

Applicant skills:
Good background in solid-state physics and optics. Strong appetite for experiments and data analysis. Competences in laser–matter interaction, ultrafast spectroscopy, or nanomaterials synthesis/characterization, photoelectron spectroscopy or vacuum systems will be appreciated.

Industrial partnership: N

Internship supervisor(s): Anna Levy (levy@insp.jussieu.fr) – Gregory Cabailh (cabailh@insp.jussieu.fr) – Olivier Pluchery (olivier.pluchery@insp.jussieu.fr)

Internship location: Institut des Nanosciences de Paris, 4 Place Jussieu, 75005 Paris.

Possibility for a Doctoral thesis: Y