PhD position

Ultrafast laser interaction for chemical and topological functionalization of surfaces

Funding: 3-years scholarship funded by EUR-Manutech Sleight program

Start date: January 2024 – December 2026 (the starting and ending dates can be discussed)

Consortium:

- Laboratoire Hubert Curien (UMR CNRS 5516), Université Jean Monnet Saint-Étienne (LabHC)
- Laboratoire Georges Friedel, École des Mines de Saint-Étienne (LGF)
- Center for Research in Photonics, University of Ottawa (CRPuO)

Project:

The goal of this work is to exploit ultrafast laser-matter interaction to generate new surface functionalization by not only creating topographical texturation but also by modifying and controlling the chemical state of the irradiated substrate, in particular oxidation processes and stoichiometry modifications in the case of alloys.

Ultrafast laser processes have become a favored method for texturing material surfaces, in particular metals. Irradiation with ultrashort pulses (ps time-scale and below) generates Laser-Induced Periodical Surface Structures (LIPSS) on multiple scales, ranging from tens of nanometers to several micrometers in period. Applicative domains include wettability, tribology, diffractive effects, etc. Many questions remain on the role of laser-induced chemical processes, in particular oxidation, on the changes of a surface's properties compared to the influence of topographical structuration. This is very relevant when considering that detrimental surface aging is associated with chemical processes, and thus could be limited by a good control of the surface chemistry.

Surface texturing by ultrafast laser will be performed under controlled environment to identify the chemical mechanisms taking place on the surface during and after irradiation. This experimental work will be completed by theoretical modelling using a TTM-MD approach (two-temperature model coupled to molecular dynamics) as well as in situ XPS measurements to reproduce thermal cycles. Spatial, temporal and polarization control of the ultrashort laser pulses will be implemented to control the laser-matter interaction at the time scale of the laser energy relaxation to modify the thermodynamic evolution of the surface during its high speed cooling thus changing the induced chemical modifications. The project proposes to explore functional properties and applications such as the catalysis and CO_2 reduction of these chemically controlled surfaces.

Environment:

Although the student will be mainly based at Saint-Étienne and spend his time between LabHC and LGF, regular mobilities at CRPuO will be funded by the consortium. The various surface irradiation and characterizations will be performed at LabHC, LGF and CRPuO. Usual topographical studies will be performed by using SEM and AFM, and the surface chemistry characterization will be carried out using XPS (including in situ XPS), TEM-EELS and HR-EDS spectroscopy equipment. The PhD student can expect to be formally trained and acquire experience on most of these equipments. The project will be developed within a multidisciplinary team of experimental and theoretical collaborators.

Requirements:

The applicant should be highly motivated by the domains of physico-chemistry, materials and optics, and should hold a master degree (or equivalent) in one or several of those fields. She/He will be expected to possess strong organization skills and teamwork ability, as she/he will have to travel and partly coordinate the work between three international laboratories. Knowledge in the fields of non linear optics, solid state physics, material sciences and physico-chemistry will be strongly appreciated.

How to apply:

Interested applicants are invited to send their CV, **before the 30/09/2023**, to:

Florence Garrelie, Professor: Florence.Garrelie@univ-st-etienne.fr

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