LABORATOIRE HUBERT CURIEN
UMR • CNRS • 5516 • SAINT-ETIENNE

cnrs dépasser les frontières

UNIVERSITÉ DE LYON

Ultrafast laser-induced devitrification of metallic glasses

Ph.D. offer: This 3-year scholarship is available at Laboratoire Hubert Curien (LabHC) of Université Jean Monnet in Saint-Étienne, France. The PhD will be performed in the frame of the Auvergne Rhône Alpes region & EUR Manuteh SLEIGHT of Université de Lyon. In addition to LabHC, part of the work will be carried out at the MATEIS laboratory (MATErials engIneering and Science) of the INSA school (Lyon) for material characterization. LabHC is a mixed research unit (UMR CNRS 5516), jointly run by the CNRS (Centre National de la Recherche Scientifique) and University Jean Monnet, which is part of Université de Lyon.

Ph.D. objectives: **This PhD thesis aims at performing surface functionalization by femtosecond laser irradiation, targeting biomedical and mechanical applications by enhancing wettability and mechanical properties of metallic glasses.**

Context: Bulk metallic glasses are elaborated by fast quenching of a melted metal alloy (10^6 K/s down to 1K/s depending on the composition), which inhibits the crystallization process during the cooling stage and results in a metastable "amorphous" phase. This fast cooling step and the necessity to work under very inert atmosphere remains the main drawback for the large industrialization of metallic glasses, along with brittleness and insufficient fatigue resistance issues. The scientific originality is based on the use of ultrafast laser (< 100fs) to address both the surface texturing and materials modifications by local devitrification, through very high heating rate (10^{15} K/s), quenching rates (10^{13} K/s) and involving strong undercooling conditions by appropriate choices of laser processing parameters.

The Ph.D. program **is based on two laser-material strategies to functionalize the surface and related characterization:**
Laser-induced surface topology for wetting properties: By tuning the laser parameters, periodic nano-texturing can be easily achieved to generate ripples known as laser-induced periodic surface structures (LIPSS). Laser irradiation will be performed to design nanostructures organized in 2 dimensions as well as micro-nano periodic patterns varying the spacing from hundred nanometers up to several microns, in order to modify the wettability properties leading to a super-hydrophobic behavior.

Laser-induced nano-crystallization: In specific dose conditions, laser irradiation of amorphous materials can lead to a suitable control of crystallization of the amorphous matrix resulting in the formation of composite consisting of local crystallite sites embedded into an amorphous matrix. In particular, temporal pulse shaping strategy will be exploited to control the rate of phase transition.

Multi-scale characterization of the surface (by EDX spectroscopy (SEM), electron energy loss spectroscopy (EELS), transmission electron microscopy (TEM) and in situ thermal-assisted micro-tensile tests) will be performed to characterize laser treatment. Multi-scale analysis of the MGs' thermal ageing and physico-chemistry properties evolution will be investigated in aggressive or biologic environments.

Keywords*: Ultrashort laser, Phase transition, Metallic glasses, Laser beam shaping*

Qualifications*:* We are seeking a highly motivated candidate for working at the interface between physics, optics and materials science. The candidate should hold a master degree (or equivalent) in physics or closely related field no later than July 2018. The candidate must have sound knowledge in the field of nonlinear optics, solid state physics and material sciences. Additional programming skills (C, Python, matlab, etc.) will be appreciated.

How to apply*:* Interested candidate should send a short cover letter and a resume to:

Prof. Jean-Philippe Colombier
Hubert Curien Laboratory
Jean.philippe.colombier@univ-st-etienne.fr

Salary conditions: The net income salary is around 16300 euros per year (gross salary / year: 20200 euros) with potential extension for teaching position (up to 20000 euros net per year).

Application deadline*:* September 1, 2018.