PhD proposal 2017-2020

Saint-Etienne (France) – Berkeley (USA)

Multiscale dynamics of laser-induced NP self-organization in composite films

Location: The PhD student will be involved both at Laboratory Hubert Curien (LabHC) in Saint-Etienne, France, and at Lawrence Berkeley National Laboratory (LBNL), Berkeley, CA, USA.

Length: 3 years from 10/01/20017. The starting date can be postponed to a later date in 2017.

Subject: Metal nanoparticles (NPs) are key players in modern strategies to fabricate composite materials with exceptional properties, not offered by nature. Tailoring the spectral response of their localized surface plasmon resonance through a tight control of the nanoparticle shape, size, orientation or organization allows addressing a broad range of applications. We have recently demonstrated that femtosecond (fs) laser irradiations can lead to the formation of 3D self-organized systems, effectively combining buried sub-wavelength metallic NP gratings and periodic surface structures. This strategy of 3D laser-induced self-organization paves the way for a new generation of nanostructuring processes, in which composite multilayer stacks could be designed to sustain guided waves in specific layers and provide self-organization of NPs at pre-defined depths. Applications of such systems can be found in diffractive and polarization-sensitive optics, with great promise for high-density optical image encoding and security.

In order to optimize laser-induced self-organization processes and the associated optical properties we need to better understand their generation. In this PhD project we aim to develop innovative characterization techniques to probe *in situ* and at different time scales from the fs to the second, the chemical, physical and optical mechanisms behind them. The ultrafast dynamic of metallic NPs has always been investigated with a controlled temperature rise to avoid modifying the system too much; and because most signals depend on the NP size, diluted ensembles of homogeneous NPs or single NPs are preferentially characterized. One of the main challenges of the thesis is to carry out *in situ* time-resolved spectroscopic characterizations of the self-organization process to better describe the mechanisms involved, from the charge transfers from NPs to the matrix to the coalescence and Ostwald ripening mechanisms triggered by the temperature rise.

Expectations: The PhD candidate should have a strong motivation to answer the most important questions of the fundamental laser-induced physics and chemistry of metallic nanoparticles in thin films. The project involves experimental research using and developing ultrafast laser instrumentation, spectroscopy, microscopy, modelling of plasmonic systems and data analysis.

Grant: PhD grant from University Jean Monnet Saint-Etienne + Stipend during the stays in Berkeley.

Deadline for application: May 1st, 2017

Contact information: The PhD student will be co-supervised by
Nathalie Destouches, Professor, LabHC. Email: nathalie.destouches@univ-st-etienne.fr
Daniel S. Slaughter, Staff Scientist, LBNL. Email: dsslaughter@lbl.gov

References will be provided upon request.