Master Internship / PhD Offer

CROCONANO project: Hot electron-assisted colloidal growth of plasmonic nanoantennae (Croissance colloidale de nanoantennes plasmoniques assistée par électrons chauds)

Supervisors: Christophe Labbez (Interfaces Dpt.), Julien Boudon (Nanosciences Dpt.) & Benoît Cluzel (Photonics Dpt.), Laboratoire Interdisciplinaire Carnot de Bourgogne, Université de Bourgogne Franche-Comté, France

Abstract: The objective of the CROCONANO project is to control the crystalline growth of gold nanoparticles using ultra-short laser pulses. To do this we will exploit the coupling between plasmonic properties and transient electronic excitations of gold nanoparticles in colloidal solution to locally modify their surface reactivity and thus direct their preferred growth directions. The project associates three departments of the laboratory ICB (Dijon, France) into a multidisciplinary project team combining all the necessary skills in ultrafast plasmonics, interface reactivity and nanoparticle synthesis. For this project, we will hire a master student for a 5 month internship starting in February 2021 who will join the project as a PhD student in October 2021.

Positioning: Hot electron technologies are a growing field of research. Indeed, hot electrons are out-of-equilibrium charges in a metal or a semiconductor under optical or electrical excitation, which can be transferred to another medium in order to initiate or catalyze another process. The catalysis of chemical reactions and the photodetection by means of hot electrons are among the most explored paths to date. The work carried out in plasmonics at ICB in recent years has shown that metallic nanoparticles are efficient sources of hot electrons whose spatial distribution, temperature and relaxation dynamics are controlled by the resonances of localized surface plasmons. These same gold nanoparticles are also widely used in many fields, from industrial chemistry to anti-pollution devices, medicine and optoelectronics. Obtained by colloidal synthesis, they possess a state of crystallinity well suited to a large set of optical, electronic and chemical properties all strongly related to the morphology of the nanoparticle. However, even if colloidal synthesis currently offers a great diversity of shapes, the rapid formation of nanoparticles in suspension and the limited control of reaction parameters (temperature, concentration, stabilizer...) restrict homogeneity and reduce our ability to elaborate nanoparticles with more complex arbitrary shapes and optimized properties.

The CROCONANO project proposes to explore an original approach for the colloidal synthesis of gold nanoparticles with arbitrary shapes assisted by pulsed laser. This approach is based on the photogeneration of hot electrons for the in situ control of the nucleation and the preferential growth directions of the nanoparticles and/or the modification of the morphology of previously formed colloids synthesized in the framework of the project. To face the various facets of this ambitious project, the CROCONANO project puts in synergy three teams from three complementary scientific departments of ICB lab which gather all the necessary expertizes in photonics, colloidal synthesis and reactivity of the interfaces to carry out this multidisciplinary work. In the first phase of the project, we will seek to establish the link between plasmonic resonances, the population of photoexcited hot electrons and the preferred growth directions of a precursor with a well-controlled geometry (colloidal flakes or nanorods). Distinguishing nucleation-growth mechanisms due to thermo-plasmonic effects from those due to hot electron catalysis will be one of the challenges of this project. Monitoring growth under continuous and pulsed laser excitation will allow to characterize these mechanisms selectively in order to model them by mesoscopic simulation. We will then study how the modifications during synthesis of the laser illumination

conditions (duration, repetition rate, wavelength, polarization) dynamically modify crystal growth through plasmonic modes and photogenerated hot electrons. The morphology and the state of crystallinity of the obtained colloids will be characterized using the facilities available on the ARCEN CARNOT platform (SEM, TEM, XRD, RAMAN) of the laboratory.

In this project, we will hire a master student for a 5 month internship starting in February 2021 and, then, he/she will join the project as a PhD student in October 2021. The candidate must have a strong taste for experimental sciences as well as a high motivation and team spirit to work on a subject at the interface between disciplines. During the internship, he/she will conduct the preliminary experiments to follow-up the nucleation kinetics and the crystalline growth under various chemical and physical conditions (oversaturation, concentration, temperature, illumination…). During the PhD, he/she will be in charge of the preparation of precursors and the implementation of pulsed laser-assisted growth with an *in situ* follow-up by coupling a static and dynamic Rayleigh scattering facility (SLS/DLS) to a tunable femtosecond laser chain. He/she will participate in the analysis of results, their modeling by mesoscopic simulation tools and an international mobility at the University of Hokkaido (1 month) will be set up in order to model the thermoplasmonic effects involved in the proposed experiments.

Applications for this offer must be send to :
benoit.cluzel@u-bourgogne.fr
Julien.boudon@u-bourgogne.fr
christophe.labbez@u-bourgogne.fr
with the following documents:
- A full CV including undergraduate details
- A transcript of your academic records