PhD thesis proposal

Multiphysical modeling of plasmonic nanomaterials

3-year PhD position

Funding: ANR project MIXUP (Color image multiplexing by laser structuring of plasmonic materials for security and personalization of ID cards)

Application open from February 2019

Starting date: between June and October 2019

The student will be located at

Laboratoire Hubert Curien UMR CNRS 5516
18 Rue du professeur Benoit Lauras
42 000 SAINT-ETIENNE, FRANCE

And will collaborate with: Institut Fresnel, UMR CNRS 7249
Domaine Universitaire de Saint Jérôme,
13013 MARSEILLE, FRANCE

Subject

In a context where government agencies develop enhanced security policies and technologies to track and protect the correct identity of every person, the MIXUP proposal aims at developing a breaking approach in the field of physical authentication of ID documents such as passports, ID cards, driving licenses or visas. This approach uses lasers to implement color image multiplexing on plasmonic nanomaterials by controlling the size, shape and organization of silver nanoparticles in semiconductor thin films [Liu17]. The concept of color image multiplexing relies on the encoding in a single pixel plane of several images that can be displayed independently in different modes of observation (like transmission, reflection, with or without polarized light).

The PhD student will contribute to the MIXUP project with fundamental studies aiming at establishing the link between nanostructures and hypercolors and at understanding the mechanisms at the origin of the laser-induced transformations of such plasmonic nanocomposite systems. Hypercolors are colors observed in different illumination and observation modes. In our samples these colors, or more generally the spectral response of the material in different modes, are directly related to the film nanostructuring, which includes the size, shape, organization and depth of metallic nanoparticles in the film, the refractive index of the nanoparticles and of the film, and the film surface topography. Such data are not always accessible through post mortem characterizations, but electromagnetic simulations can be carried out to better understand the role of some structural parameters on the color (or spectral response) of the material.

Recently, an electromagnetic simulation code dedicated to these kinds of nanocomposite films has been developed at Hubert Curien lab [Bak16] (figure 1). On his side Fresnel Institute has been working since several years

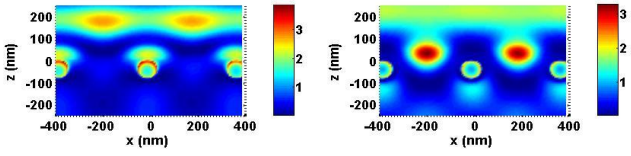

Figure 1: Near field simulations of an nanoparticle grating embedded in a semiconductor thin film

on the modeling of light matter interaction with a specific care given to the analysis of disordered and stratified media. We expect the PhD student to focus his/her efforts on simulations and parameters optimization by carrying out systematic comparisons with optical experiments. The role of the different parameters and of their statistical distribution on the excitation of Fano-like resonances in the nanostructured films produced by laser will be investigated and their effect on the production of hypercolors useful for multiplexing will be explored.

In a second part of the PhD work, the student will develop new codes improving the performances of the previous ones. He or she may then be involved either in the implementation of electromagnetic, thermal, multiphysical or charge transfer models. The theoretical work during the PhD will be driven also by the experimental results that will be obtained by the other teams of the MIXUP project, which also involves an industrial partner, HID Global CID, developing security solutions for documents.

References

[Bak16] S. Bakhti, A. V. Tishchenko, X. Zambrana-Puyalto, N. Bonod, S. Dhuey, P. J. Schuck, S. Cabrini, S. Alayoglu, N. Destouches, "Fano-like resonance emerging from magnetic and electric plasmon mode coupling in small arrays of gold particles", Scientific Reports, 6, 32061, 1-12 (2016)
[Liu17] Liu, J. Siegel, M. Garcia-Lechuga, T. Epicier, Y. Lefkir, S. Reynaud, M. Bugnet, F. Vocanson, J. Solis, G. Vitrant, N. Destouches, "3D self-organization in nanocomposite layered systems by ultrafast laser pulses", ACS Nano, 11 (5), 5031–5040 (2017)

Candidate profile

The PhD candidate must have an advanced level in programming with at least one of the following languages: C++, Python, Matlab and be graduated in Physics or in Applied Math for Physics or in a related topic. He or she must show a strong motivation to carry out theoretical and modelling work in collaboration with experimental physicists. An experience in electromagnetic modelling and in plasmonics would be greatly appreciated. The abilities to take initiatives and to work with autonomy are compulsory to properly carry out this thesis. The candidate must be open-minded and curious, able to rapidly implement codes from models that are new for him and to learn by him(her)self through bibliographic studies.

Application

Send us as soon as possible:

- ✓ **your CV with a possible list of publications and conferences,**
- ✓ **a motivation letter,**
- ✓ **your Bachelor and Master transcripts,**
- ✓ **references or recommendation letters.**

Interesting candidates will be interviewed by Skype for a first discussion during the 15 days following their application.

Contacts:

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