M2 Research internship

Silver nanostructures and luminescence amplification

Phosphors based on rare earth (RE) ions play an increasingly important role in a variety of industrial applications(e.g. bio-imaging and labeling, displays, lighting, solar cells, thermometry, X-ray imaging). Interest in these materials is related to their luminescent properties over a wide spectral range from ultra-violet (UV) to infra-red (IR), their high quantum efficiencies close to the theoretical maximum (100%), and their long emission lifetimes (up to a few milliseconds). However for thin film applications and with the downscaling of many optical devices, the improvement of their emission efficiency remains a key challenge.

During the last few years, the maturity of nanophotonics, together with the mastering of nanofabrication, has enabled novel solutions to tailor light-matter interaction at the subwavelength scale. These technologies can now be used to improve the efficiency of light absorption, emission, or extraction of RE doped thin films.
Thanks to photonic structures, it is possible to enhance both light extraction and absorption of such emitting layer. Recently, we have demonstrated theoretically and experimentally that a PhC structure can efficiently enhance le luminescence properties of a down-shifting layer (up to 77 times). However, this approach based on lithographic fabrication technologies, requires a complex and multistep fabrication, which is time-consuming and not cost-effective.
Another concept combines a rare-earth doped thin layer with plasmonic resonances in the UV and visible ranges by using nanostructures made of gold, silver or aluminum. In practice, and summarizing the current state of the art, even if the fluorescence enhancement obtained with such coupling is limited to factors of a few tens, this method is a simple way to tailor the light-matter interaction and enhance the optical properties of the surrounding material. In that respect, new nanoarchitectures combining Ag nanoparticles and conversion layers based on the use of RE ions are currently developed at iLM in collaboration with an industrial partner.

In this study, it is therefore intended to fabricate and characterize new nanoarchitectures combining Ag nanostructures and a luminescent layer. The goal is to take advantage of silver nanostructures to enhance and control the emission of the optically active material. Adjusting the geometrical parameters of the Ag nanostructures will be an important point, because it can provide control over their plasmonic resonances, as well as over their optical scattering properties.

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The Msc student will investigate the deposition of silver by Pulsed laser deposition (PLD) and/or evaporation. Both the deposition parameters and the post annealing-treatments will be optimized to obtain silver nanostructures with plasmonic properties in the visible range. Simulations based on effective index and analytical model theory will be performed to understand the resonances and the scattering diagram. Optimized silver nanostructures will be then deposited on luminescent layers (provided by the industrial partner) for evaluation of their optical performances. During this project, atomic force microscopy (AFM), absorption spectroscopy and emission spectroscopy will be used to control the properties of the silver nanoparticles and of the whole stack (i.e., silver deposited on luminescent layers).

We are seeking highly motivated student with a strong interest for experiments in optic, photonic, material science or related field. The successful candidate will work in the *Materials and Photonic Nanostructures* group of iLM, which has strong skills (i) in the field of plasmonic and coupling between radiative light and guides modes and ii) in the design, the elaboration and the study of thin films whose composition and structure are chosen to provide new optical and spectroscopic properties. This project is collaboration with a French industrial partner. The position is only open to European Citizen Candidates.

PhD opportunity: several directions are possible for a PhD project depending of the preliminary results obtained during the master project.

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