# Design and experimental demonstration of complex nanostructured surfaces producing new exotic visual effects

*Three-year PhD position in the "Light in Complex Nanostructures" group at LP2N*

**Mastering visual appearance by controlling the composition of matter is a major challenge** in areas as diverse as glass production, vehicle design, cosmetics, printing and luxury goods. Considerable efforts are currently being made to develop methods to realized new coatings offering unusual, targeted visual effects. Renowned examples include micro-scale textured surfaces, which provide angularly engineered reflection diagrams, and thin-film optical stacks, which can produce vivid iridescent colors.

In this project, we propose to exploit the **remarkably rich optical properties of disordered assemblies of nanoresonators in optical stacks**, namely "complex nanostructured surfaces" (Fig. 1), **to generate visual effects, in reflection and transmission, that are unattainable with other approaches**. Such nanostructures indeed offer many unique optical properties, such as controlled directivity of the scattered light, quasi-total angle-independent light absorption or tunable coupling with guided modes. This great variety of optical effects is due to the manifold geometrical and physical parameters of the system, originating from individual nanoparticle resonances, their short-range interaction with the substrate and collective effects due to long-range interactions between particles. Expectedly, these coherent processes may translate into unusual if not completely new visual effects on the macroscopic scale.

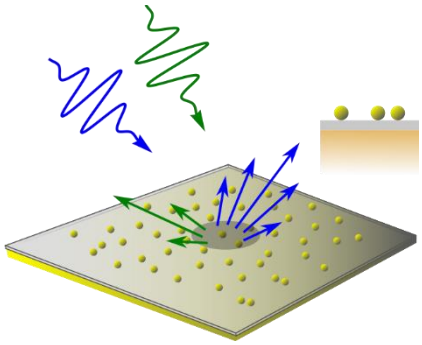

***Figure 1.*** *Complex nanostructured surface, consisting of a disordered ensemble of nanoparticles deposited on a thin-film optical stack.*

The LP2N team recently developed a numerical platform mixing electromagnetic simulations and rendering techniques to generate synthetic images – as physico-realistic as possible – of macroscopic nanostructured objects in realistic lighting environments. Results clearly indicate the high potential of complex nanostructured surfaces could produce unusual visual effects. More recently, the team developed a collaboration with experimental teams at ICMCB (Pessac) and MPQ (Paris) to fabricate complex nanostructured surfaces.

The PhD project proposed here aims to:

1. Demonstrate experimentally our capability to predict the scattering properties of nanostructured surfaces;
2. Understand how the nanostructure parameters can be tuned to control visual appearance;
3. Demonstrate the very first macroscopic surfaces offering novel appearances thanks to nanostructures.

More specifically, the PhD student will design complex nanostructured surfaces with our numerical platform, develop dedicated optical characterization setups for complex nanostructured surfaces and use them to experimentally demonstrate new visual effects.

The PhD student will need to have a solid background in optics and electromagnetism, with a strong interest in experimental physics. As a return, he/she will receive advanced knowledge in a field that is of strong interest to many academics and companies.

To apply, please send your CV, exam results, a motivation letter and recommendation letters to Philippe Lalanne (philippe.lalanne@institutoptique.fr) and Kevin Vynck (kevin.vynck@institutoptique.fr).

**Expected starting date:** October 2019 – January 2020

**Location:** LP2N, Institut d'Optique d'Aquitaine, 1 rue François Mitterrand, 33400 Talence, France

**Philippe Lalanne** is a CNRS Research Director and is an *international expert in nanoscale electrodynamics*. With his colleagues, he has launched new and powerful tools and models in computational electrodynamics, has provided deep insight into the physical mechanisms involved in key nanoscale optical phenomena and devices, and has designed and demonstrated novel nanostructures with record or completely novel performance in their time. To date, he has co-authored about 190 publications in peer-reviewed journals and filed 10 patents. He was the supervisor of 17 PhD candidates and has co-supervised 6 PhD candidates. He is currently working on computational electrodynamics, slow light, quantum plasmonics, and complex optical nanostructures.

**Kevin Vynck** is a CNRS Research Scientist and is *specialized in the theoretical and numerical modelling of wave transport and scattering in complex media*, including periodic structures (photonic crystals, metamaterials) and disordered media (disordered photonic structures, media with fractal heterogeneity, ...). He has co-authored 36 papers in peer-reviewed journals, 1 book chapter and 3 patents. In 2019, he was awarded the CNRS Bronze Medal. He is currently working on coherent wave phenomena in complex ensembles of resonant nanoparticles.