Engineering plasmonic colours using different dewetting processes

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Project Type: Master project

Context: Plasmonic metals include gold, silver and aluminum. They have a very strong interaction with light and produce many interesting effects when they are used to make nanostructures. Plasmonic colours are, in contrast to dyes, structural colors since they arise out of resonant interaction of light with metallic nanostructures. Size, shape and material of the nanostructures are principal factors, which bias the interaction. In addition, near field coupling between the nanoparticles also influences the optical response of the plasmonic configuration. The distance between the structures, which relates to the density of the nanostructures strongly affects the near field coupling. Using top-down approaches such as focused ion beam (FIB) and e-beam lithography (EL), which are very versatile techniques, shape and position of the nanostructures can precisely be determined. However, those techniques are of serial nature and, therefore, not well adapted for structuring large surface areas. Moreover, those techniques are costly and require sophisticated tools. Dewetting, a bottom-up approach, provides a cheap and efficient method to coat large areas with plasmonic particles. The method is based on the optimisation of the free surface energy of the substrate at hand. A thin layer of plasmonic material is deposited onto the substrate prior to a suitable e.g. thermal treatment enabling surface diffusion and, therefore, a reorganisation of the deposit.

Project overview: The present project aims coating of large areas with plasmonic nanoparticles using a bottom-up dewetting approach. The dewetting process will be optimised to achieve controlled size distributions and densities of the nanoparticles and, furthermore, adapted to generate custom-made coloured substrates. The achieved coatings will be experimentally characterised with respect to size distribution and density of the particles using scanning electron microscopy (SEM) combined with image analysis. In addition, characterisation using optical microscopy and spectroscopy will be carried out and compared with numerical results achieved by simulation tools developed in the NAM laboratory.

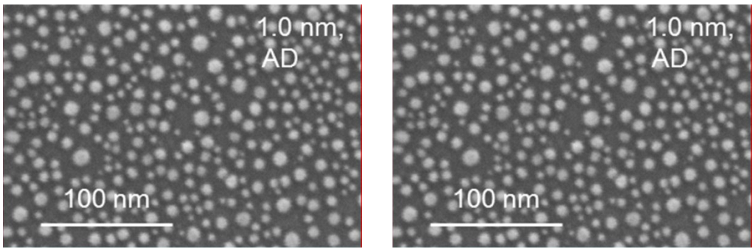

Figure. Gold thin film (left) as deposited on SiO2 and (right) after annealing [1].

What the student will do. During the course of this project, the student will use the cleanroom facilities of CMI and be introduced in the basics of nanofabrication and characterization using electron microscope. A personal introduction to the physics and chemistry of surfaces, the optical spectroscopy and numerical calculations of plasmonic systems will also be provided. The project is very comprehensive and the candidate should engage in the three facets of nanofabrication, optical characterization and modelling, with the support of the responsible scientific assistant. An ideal candidate is highly interested in near field optics, physics and chemistry of surfaces and working with cleanroom facilities.

Benefits. Through this project, the student will gain hands-on experience in nanotechnology, optics and numerical simulations. The project provides the opportunity to discuss and confront results obtained from experiments and simulations to build a solid scientific contribution.

References.

1. G. Seguini, "Solid-state dewetting of ultra-thin Au films on SiO_2 and HfO_2" Nanotechnology vol. 25, p. 495603 (2014).
2. M. Kamiko, " Influences of ultra-thin Ti seed layers on the dewetting phenomenon of Au films deposited on Si oxide substrates",Physica E, vol. 99, p. 320 (2018).