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Tailoring the visual appearance of a surface by using plasmonic particles onto a stratified substrate

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Mastering visual appearance by controlling the composition of matter is a major challenge in diverse areas such as vehicle design, cosmetics, or luxury goods. Considerable efforts are currently made to develop scalable fabrication techniques to produce new coatings offering exotic visual effects. In this communication, we will show how to exploit the rich optical properties of disordered assemblies of resonant nanoparticles in optical stacks to generate new visual effects in reflection. The influence of two structural parameters will be discussed.

INTRODUCTION

The use of nanostructured surfaces for visual appearance design is currently receiving growing attention, yet studies have so far been restricted to the generation of structural colors, generally obtained by engineering individual nanoresonators in a periodic lattice [1] [2]. The potential of complex nanostructured surfaces for visual appearance design has not been explored yet. Towards this aim, we will show how recent numerical developments mixing electromagnetic simulations and rendering techniques to generate synthetic images of macroscostructured objects in realistic lighting environments as well as bottom-up approaches creates unusually striking visual effects [3]. We will present results on the first demonstrator made of disordered assemblies of plasmonic nanoparticles on dielectric layered surfaces over a large area (centimetric dimension). The nanostructured surface produced by a bottom-up approach offers the possibility to produce samples over a large scale at lower cost than top-down processes (lithography). The optical properties of the metasurfaces will be compared with simulations, to understand the phenomena at the origin of the appearance changes as a function of the viewing angle.

RESULTS AND DISCUSSION

Macroscopic samples (on the order of cm^2) of disordered ensembles of silver nanocubes with edge lengths of 90 nm, placed on stratified media (Fig. 1.a), were fabricated (Fig. 1.b). The silver nanocubes were synthesized by using a multi-step protocol in aqueous phase, inspired by the work of Bronchy et al [4]. The size of the cubes can be altered by modifying the quantity of germs introduced into the reaction medium.

These objects were deposited by dip-coating [5] on a silicon substrate covered with a dielectric layer (SiO_2) with a lower index and controlled thickness. This approach makes it possible to modulate the coverage fraction of the particles on the substrate from 1 to 20 %.

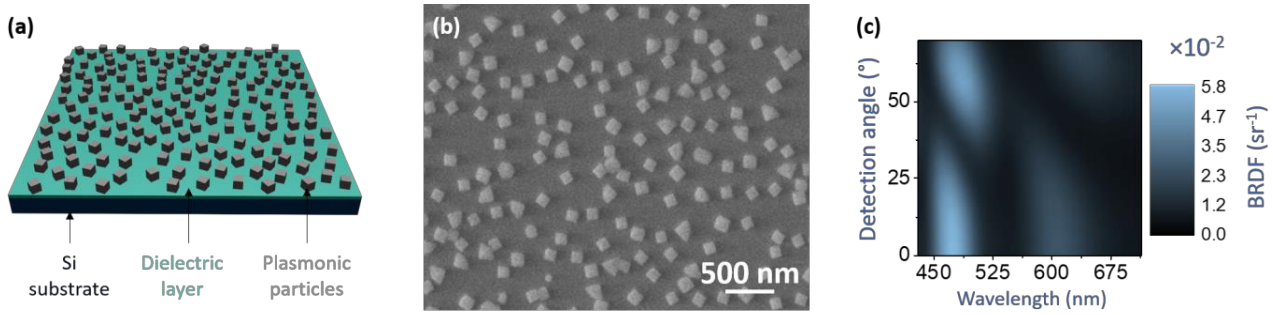

Figure 1: (a) Scheme of the nanostructured surface consisting of a disordered ensemble of nanoparticles deposited on a thin-film stack offering unusual spectral reflectance properties. (b) Example of a SEM image of the nanoparticles onto the dielectric layer. (c) Example of a scattering diagram by gonio spectrophotometer at normal incidence

The optical properties of the surfaces (spectral and angular) were characterized using a gonio-spectrophotometer (Figure 1.c). We will show how the variations of the thickness of the dielectric layer (h_0) and the cube density (D) affect the visual effect of the macroscopic nanostructured surfaces. Compared to the theoretical study [3], the experimental results confirm the validity of the rendering model.

CONCLUSION

We have investigated the potential of complex nanostructured surfaces, made by a bottom-up approach, for the control of visual appearance at the macroscopic scale. The observed visual effects rely on nano-objects exhibiting strong scattering resonances and controlled particle assembly on planar substrates. The contribution of the different components of these surfaces to a dependency on the angle of the observed effects will be discussed and compared to simulations.

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