# Angle emission properties of complex colloidal nanostructures for energy efficiency applications

**A. Coll**[1], D. Hernández[1], S. Bermejo[1], A. Blanco[2], J. F. Galisteo-López[2], C. López[2], L. Castañer[1] and R. Alcubilla[1]

[1]Universitat Politècnica de Catalunya, Jordi Girona 1-3, 08034 Barcelona, Spain
[2]ICMM-CSIC, Sor Juana Inés de la Cruz, 3, Cantoblanco, 28049 Madrid, Spain

arnau.coll@upc.edu

The optical properties of ordered colloidal structures, or colloidal crystals, have been studied for more than 20 years due to their unique control of the propagation of visible light through it [1]. One of the most representative properties of these 3D periodic structures is their ability to forbid the transmittance of frequency bands through the crystal, making these wavelengths to reflect back whichever the incident angle. On the other hand, 2D nanostructures and gratings have been analyzed in a lot of different applications [2], showing their ability to affect the light in single incoming angles.

The purpose of this work is to study the effects of "coupling" different types of gratings on 3D colloidal crystals, looking for both an angle selective and frequency selective propagation of light across the nanostructure. 3D polystyrene colloidal crystals were made using an Electrospray deposition technique [3] which consists in a pump that introduces the colloidal solution into a needle electrically polarized. The sample is also polarized with an opposite signal to attract the droplets formed in the needle's tip.

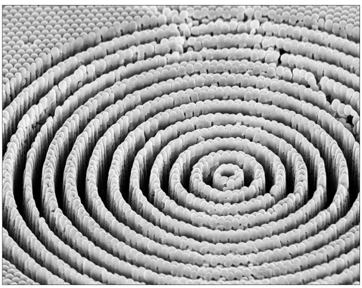

**Figure 1:** 2D grating milled on top of a 3D electrosprayed colloidal crystal.

The structures were made using 360nm polystyrene nanobeads. This crystal's parameters produce a reflectivity peak around 900-950nm wavelength. Within these samples, some 2D structures were milled using a Focused Ion Beam, an example is shown in figure 1. This first tested structure consists in concentric circles of 500nm periodicity and 1 µm depth.

In order to measure the reflectivity of these photonic structures, samples were placed close to an optic fiber of 5µm, reading the reflectivity in the visible spectrum (up to 1□m wavelength) in function of angle. The method used to measure the optical properties of the samples is based in Fourier imaging spectroscopy [4]. Results of the measurements are shown in figure 2.

## References

[1] E. Yablonovitch and T.J. Gmitter, Physical Review Letters, 58 (1987) 2059.

[2] C. Palmer and E. Loewen. Diffraction Grating Handbook. (2005)

[3] S.Bermejo, A.Coll, L.Castañer: "Procedimiento para el depósito ordenado de capas de metamateriales a partir de soluciones coloidales de micro o nano esferas" Patent PCT/ES2012/070476

[4] M. López-García; J. F. Galisteo-López,; C. López. Angle and polarization resolved optical characterization of photonic structures through Fourier imaging spectroscopy. Submitted for publication.

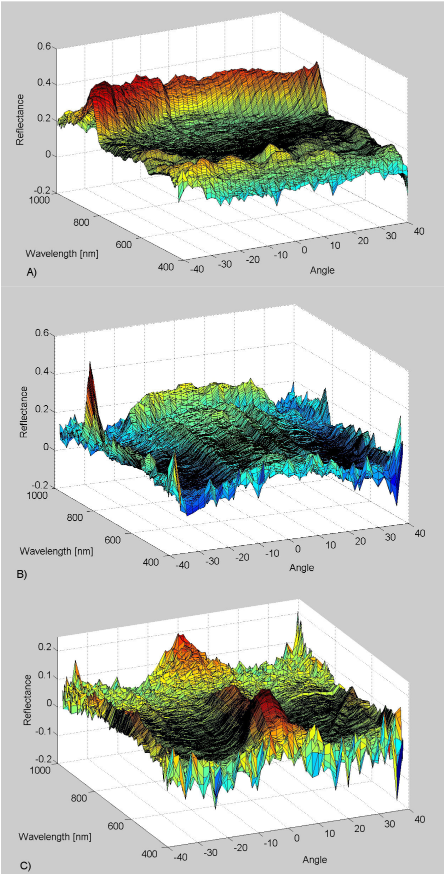


**Figure 2:** Reflectance measurements of the 3D colloidal structure (a) compared with reflectance at the edge (b) and center (c) of the FIB patterned grating shown in Fig. 1.