Spontaneous Emission Control Of Colloidal Nanocrystals Using Nanoimprinted Photonic Crystals

N. Kehagias[1], V. Reboud[1*], M. Zelsmann[1, 2], M. Striccoli[3], M. Tamborra[4], M. L. Curri[3], A. Agostiano[3,4], M. Fink[5], F. Reuther[5], G. Gruetzner[5] and C. M. Sotomayor Torres[1]

[1] Tyndall National Institute, University College Cork,Lee Maltings, Cork, Ireland
vincent.reboud@tyndall.ie
[2] LTM-CNRS, Grenoble, France
[3] CNR IPCF Sezione Bari c/o Dipartimento di Chimica, Universita di Bari, Italy
[4] Dipartimento di Chimica, Universita di Bari, via Orabona 4, I-70126 Bari, Italy
[5] Micro resist technology GmbH, Berlin, Germany

We report on the fabrication and optical characterizations of 2D photonic crystals fabricated by standard NIL process in photocurable polymer (mr-l 6000) containing (CdSe)ZnS nanocrystals. These photonic structures are expected to enhance the extraction of the light produced in a polymer layer by giving a low propagation speed to the photons, thus increasing the coupling to the radiative modes out of plane. An enhancement of the light collection is achieved compared to a nanoimprinted unpatterned sample.

Several Si stamps with different two-dimensional photonic crystals geometries have been fabricated and successfully imprinted by NIL in the luminescent polymer. Figure 1 shows stamps and Figure 2 presented nanoimprinted photonic crystals in the modified polymer. The most crucial test for the effectiveness of the whole process is the preservation of the optical properties of the NCs. To test the effect of the nanoimprint lithography on the NCs optical properties, the polymer mr-l 6000 with (CdSe)ZnS NCs is spin-coated on two Pyrex substrates, one which is printed with a flat stamp at 100 ◦C at a pressure of 60 bar for 500 sec. PL spectra from a 10 μm collection spot on the sample were measured normal to the surface and analyzed with an optical spectrum analyzer. A comparison between emission spectra of the (CdSe)ZnS NCs and the printed (CdSe)ZnS NCs in a thin film of mr-l 6000 is presented in Figure 2a. A similar emission is observed before and after the process. This demonstrates that the spectra emission of the NCs were minimally affected by the nanoimprint process. The PL spectra of a nanoimprinted unpatterned sample (gray line) and of two photonic crystals (PhCs) (blue line: triangular lattice constant a=580 nm, red line: honeycomb lattice constant a=500 nm) are shown in Figure 2b. It is observed that the PL intensity for the 580 nm lattice constant PhC is twice as strong compared to that of the nanoimprinted unpatterned substrate. To the best of our knowledge this report is one of the first examples where an emerging lithographic technique and an original class of functional material are combined towards the next generation of photonic device.

The partial support of the EC-funded project NaPa (Contract no. NMP4-CT-2003-500120) and the Science Foundation Ireland is gratefully acknowledged. The content of this work is the sole responsibility of the authors.

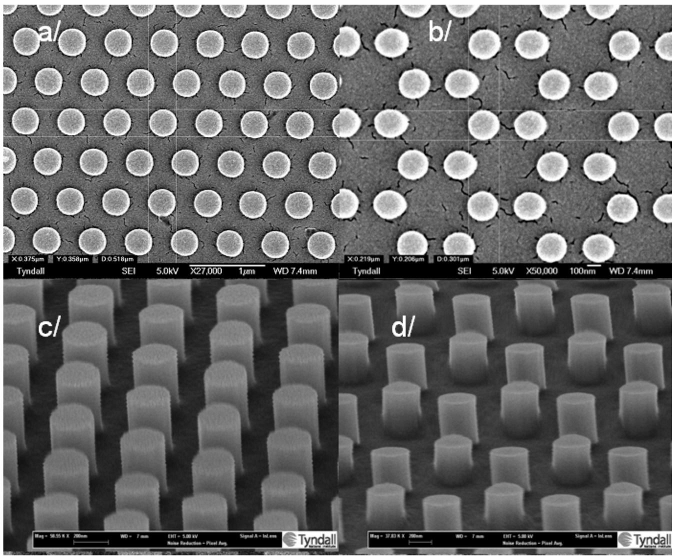

Figure 1: SEM micrographs of silicon stamps containing a two-dimensional array of pillars a/ triangular lattice and c/ the associated tilted view, b/ honey comb lattice and d/ the associated tilted view

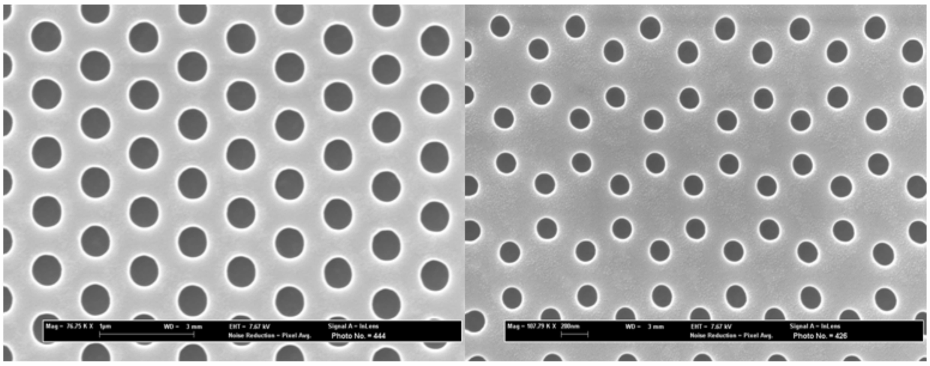

Figure 2: SEM micrographs of nanoimprinted triangular and honeycomb photonic crystals in mr-l 6000, in which (CdSe)ZnS NCs have been incorporated

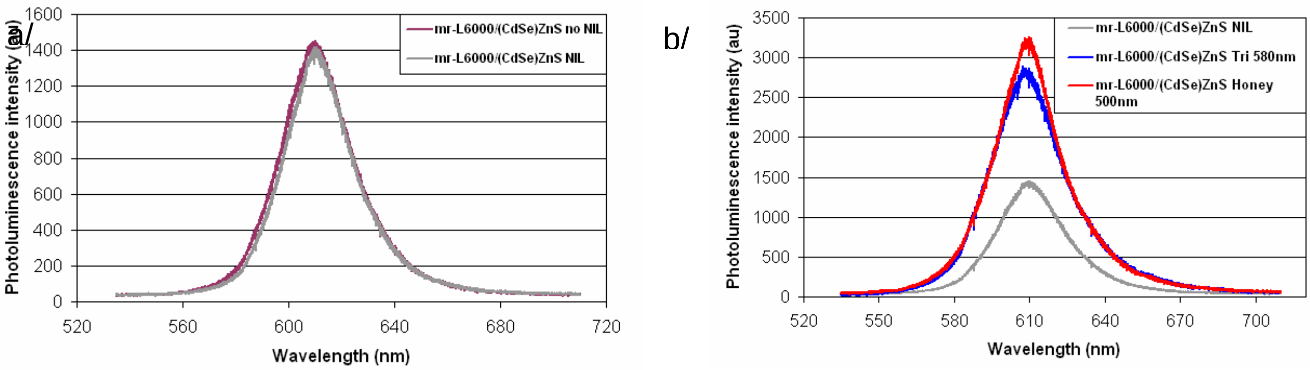

Figure 3: a/ Emission spectra for (CdSe)ZnS NCs taken before (violet solid line) and after (gray solid line) the nanoimprint process. b/ PL spectra of nanoimprinted unpatterned mr-l 6000 with (CdSe)ZnS NCs on a SOI substrate (gray line), PL spectra of a 2D photonic crystal with a 500 nm honeycomb lattice constant and of a 2D photonic crystal with a 580 nm triangular lattice constant.