Quantum Dot Based 3D Photonic Devices

E. Kabouraki,[1,2,*] I. Sakellari,[1] D. Gray,[1] M. Farsari,[1] M. Vamvakaki[1,2]

[1]*Institute of Electronic Structure and Laser (IESL), Foundation for Research and Technology-Hellas (FORTH)*

[2]*Department of Materials Science and Technology, University of Crete, Greece.*

In this study, we present our recent results on the fabrication of 3D high-resolution photonic nanostructures containing Cadmium Sulfide (CdS) quantum dots (QDs) that exhibit 3rd order non-linear effects and stop-gaps at visible wavelengths. These structures are fabricated using direct laser writing (DLW) and novel, organic-inorganic hybrid materials.

DLW by multi-photon polymerization is a nonlinear optical technique which allows the fabrication of 3D structures with a resolution beyond the diffraction limit. The polymerization process is initiated when the beam of an ultra-fast laser is focused in the volume of a transparent, photopolymerizable material. Multi-photon absorption takes place within the focal volume, where polymerization occurs. By moving the focused laser beam in a three-dimensional manner within the material, 3D structures can be fabricated. The materials used in this work are photostructurable organic-inorganic hybrid materials, prepared using the sol-gel process. This versatile technique has been exploited for the incorporation of inorganic networks into polymer matrices, using as monomers molecules that carry an inorganic part (which serves as the precursor to the inorganic network) and a polymerizable organic group (which acts as the precursor to the organic polymer). Moreover, a polymerizable quencher has been incorporated within the material, allowing the fabrication of features well below the diffraction limit, as well as cadmium based quantum dot precursor moieties. Next, the microstructures were reacted with Na_2S, leading to the *in situ* synthesis of CdS quantum dots within the volume of the 3D structures that provide to the material intensity dependent refractive index which was measured using the z-scan technique. The z-scan results reveal the characteristic peak-valley graph of a 3rd order non-linear material. Microstructures with spatial resolution below 100 nm and minimal shrinkage distortion were developed [1].

Excellent quality photonic crystal woodpile structures with period as low as 400 nm have been fabricated and we show for the first time the existence of third order nonlinear effects as well as diffraction patterns and higher order stop-gaps at visible wavelengths.

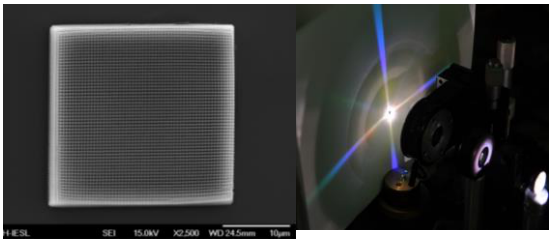

Figure 1: A 500 nm period photonic crystal structure (left) and the diffraction pattern of the same structure (right)

References

[1] I. Sakellari et al., ACS Nano, **6**, 2302 (2012).

* elmina@iesl.forth.gr