

Direct Transcription of Two-Dimensional Colloidal Crystal Arrays into Large-Area Three-Dimensional Photonic Crystals

A. Vlad(1), A. Froelich(2), T. Zebrowski(3), C.-A. Dutu(1), K. Busch(4), S. Melinte(1), M. Wegener(2) and I. Huynen(1)

(1) ICTM, Université catholique de Louvain, Louvain la Neuve, Belgium;

(2) IAP and DFG-CFN, KIT, Karlsruhe, Germany;

(3) ITF, KIT, Karlsruhe, Germany and DFG-CFN, Karlsruhe, Germany;

(4) HU-Berlin and MBI, Berlin, Germany

Contact: alexandru.vlad@uclouvain.be

Abstract. Amongst the photonic crystals architectures, the 3D design remains the most challenging in fabrication and implementation. This originates from the stringent constitutional, quality and functional requirements. Structuring dielectric materials at the 100-nm scale and with 3D periodicity is not straightforward and several methods have been proposed to address this bottleneck. In this talk, we will discuss a large area 3D structuring strategy for advanced photonic materials by adding the third dimension to 2D etch masks. Surface structuring by nanosphere lithography (NSL) is merged with a novel silicon etching method to fabricate ordered 3D architectures. The SPRIE method, Sequential Passivation Reactive Ion Etching, is a one-step processing protocol relying on sequential passivation and reactive ion etching reactions using C_4F_8 and SF_6 plasma chemistries. Instead of generating smooth and straight etch profiles we have adapted the procedure in such a way that it produces regular size variations in the etch profile. The diffusion of fresh reactants and etch product species inside the etched channels is found to play an important role affecting the structural uniformity of the designed structures and the etch rate drift is corrected by adjusting the reaction times. High quality photonic crystals are thus obtained by adding the third dimension to the 2D colloidal crystal assemblies through SPRIE. Careful adjustments of both mask design and lateral etch extent balance allow the implementation of even more complex functionalities including photonic crystal slabs and precise defect engineering. We demonstrate 3D photonic crystal lattices exhibiting optical stop-bands in the infrared spectral region proving the potential of SPRIE for fast, simple and large-scale fabrication of photonic structures. Structural characterization and numerical modeling corroborate with optical response of the obtained photonic structures. The SPRIE protocol is presently investigated for the realization of tapered structures with axial diameter modulation designed to enhance the light absorption in silicon solar cells or in conductive polymer Schottky junction solar cells.

[1] A. Vlad *et al.*, *Advanced Functional Materials* 2013, 23, 1164; A. Vlad *et al.*, in preparation.