Fabrication and analysis of 3D low THz metamaterials

S. Papamakarios1,2, O. Tsilipakos2,3, A. Koulouklidis2, S. Tzortzakis2,3, M. Kafesaki2,3, M. Farsari2

1) Department of Physics, University of Crete, Vassilika Vouton, Heraklion, 71409, Greece

2) Institute of Electronic Structure and Laser, Foundation for Research and Technology – Hellas (FORTH – IESL) , 100 Nikolaou Plastira Street, Heraklio, 70013, Greece

3) Department of Materials Science and Technology, University of Crete, Vassilika Vouton, Heraklion, 71409, Greece

The creation of fascinating optical effects such as negative refractive, optical magnetism, and cloaking has become a human dream since the late 1940s, when artificially designed materials, so-called optical metamaterials, were investigated. They are therefore highly interesting for many future applications in many fields. Fabrication of 3D optical metamaterials, which would enable the use of their full potential, remains challenging due to the limitations of conventional manufacturing techniques. An approach that has been proved to be suitable to overcome this challenge is multi-photon lithography (MPL)[1], which is a true 3D printing technique with high resolution down to sub-100 nm.

In this work, the high potential of using MPL for metamaterial research is further underlined by demonstrating a procedure to process metamaterials operating at low THz frequency (1-10 THz) and generate novel devices as perfect absorbers and electromagnetic waves attenuator. In these frequencies there is no natural element that can interact with electromagnetic fields. Simulation by Finite Differential Time Domain (FDTD) method were done to design the materials' geometry giving the optimal dimensions and properties for the structure. As a photosensitive material for the MPL an organic – inorganic photopolymer SZ2080™ was used. After MPL processing, the structures were further processed using selective electroless plating to cover the polymer with silver via chemical procedure, so the spectral characterization (absorbance, transmittance, reflectance) can be done at THz frequencies.

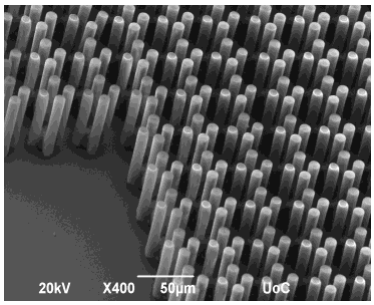

Figure 1: SEM image of the metasurface coated with silver via chemical procedure, showing the resolution of MPL method.

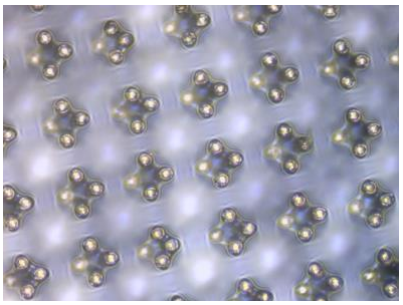

Figure 2: Image taken after the metalization process with a simple optical microscope.

[1] Farsari, M., Chichkov, B. Two-photon fabrication. *Nature Photon* **3,** 450–452 (2009), https://doi.org/10.1038/nphoton.2009.131