3D micro-optical elements by multiphoton lithography and nano-imprinted patterns using high laser induced damage threshold photoresists

Elmina Kabouraki[1], Vasileia Melissinaki[1], Amit Yadav[2], Andrius Melninkaitis[3,4], Konstantina Tourlouki[5], Theodoros Tachtsidis[5], Nikolaos Kehagias[5,6], Georgios D. Barmparis[7],Dimitris G. Papazoglou[1,8], Edik Rafailov[2] and Maria Farsari[1]

1. IESL/FORTH, N. Plastira100, GR-70013 Heraklion, Greece

2. Optoelectronics and Biomedical Photonics Group, AIPT, Aston University, Birmingham B4 7ET, UK

3. Laser Research Center, Vilnius University, Saulėtelioal.10,Vilnius 10223, Lithuania

4. Lidaris Ltd.,Saulėtekio al. 10, Vilnius LT-10223, Lithuania

5. Nanotypos, VEPE Technopoli Thessaloniki, Building C2, Pylea, Thessaloniki 55535, Greece

6. NCSR Demokritos, Institute of Nanoscience and Nanotechnology, P. Grigoriou 27 & Neapoleos Str., Ag. Paraskevi 15341,Greece

7. Physics Department, University of Crete, Heraklion 70013, Greece

8. Materials Science and Technology Department, University of Crete, Heraklion 70013, Greece

Additive manufacturing (AM) has enabled the three dimensional (3D) printing of complex microscale structures and is predicted to play a major role in the future production of integrated photonic circuits. One of the highest resolution AM techniques is multiphoton lithography (MPL), which has allowed the freeform 3D printing of complex micro-optical elements and components such as complex lenses and microscopes objectives, metalenses, axicons, and Fabry–Perot resonator on flat substrates, as well as on optical fibers.

There is a wide variety of transparent photosensitive materials [1} that are used for multiphoton polymerization, including biomolecules, organic photopolymers and hydrogels, or organically modified ceramics. The latter class of materials is particularly suitable for MOE fabrication, as they can be structured accurately with minimal shrinkage, keeping their transparency at visible and near-infrared (NIR) wavelengths. However, most of these materials have a low laser-induced damage threshold (LIDT), as a result of their high organic content. This makes them suitable only for low-power laser applications.

Here, we present a novel formulation of organically modified ceramics materials, with improved LIDT performance, compared to other materials used for MOE fabrication using MPL. These materials were used for the fabrication and characterization of lenses and axicons on glass substrates and on optical fiber tips by MPL. Moreover, we demonstrate that they are suitable for large area ultraviolet light assisted nano-imprint lithography (UV-NIL) processing, allowing for mass-replication.

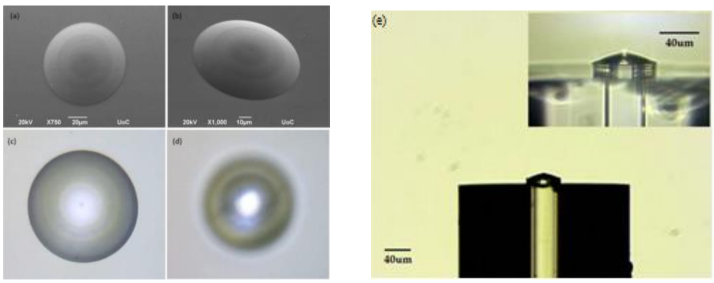

Fig. 1 (a),(b) SEM image of a printed microlens using the MPL technique (c),(d) optical microscope image of the same lens. Digital microscope images at 220X magnification of the fabricated axicons on the endface of the optical fiber.

References: [1] E.Skliutas,M.Lebedevaite, E.Kabouraki, etal.,"Polymerization mechanisms initiated by spatio-temporally confined light," Nanopho-tonics,**10**,1211–1242, 2021.