PHOTOSENSITIZED AND NON-PHOTOSENSITIZED MATERIALS FOR MULTIPHOTON LITHOGRAPHY

Dimitra Ladika[1,2], Antanas Butkus[2], Michalis Stavrou[1], Gordon Zyla[1], Vasileia Melissinaki[1], Edvinas Skliutas[2], Elmina Kabouraki[1], Frederic Dumur[5], David Gray[1], Saulius Juodkazis[2,3,4], Maria Farsari[1], Mangirdas Malinauskas[2]

[1]Institute of Electronic Structure and Laser, Foundation for Research and Technology-Hellas, 70013 Heraklion, Greece
[2]Laser Research Center, Faculty of Physics, Vilnius University, Sauletekio Ave. 10, LT-10223 Vilnius, Lithuania
[3]Optical Sciences Centre and ARC Training Centre in Surface Engineering for Advanced Materials (SEAM), School of Science, Swinburne University of Technology, Melbourne, Australia
[4]WRH Program International Research Frontiers Initiative (IRFI) Tokyo Institute of Technology, Nagatsuta-cho, Midori-ku, Yokohama, Japan
[5]UMR 7273, Aix Marseille Univ., CNRS, ICR, 13397 Marseille, France
dladika@iesl.forth.gr

3D direct laser writing employing Multiphoton lithography (MPL) has emerged as a powerful tool in Additive Manufacturing (AM) at very small scale, both for scientific and industrial applications in various fields, such as micro-optics, tissue engineering and photonics [1]. MPL is based on the phenomenon of multiphoton absorption that is carried out as follows: an ultrafast laser beam is tightly focused inside the volume of a transparent photosensitive material, which typically incorporates a photosensitive molecule, the photoinitiator (PI). The PI absorbs simultaneously two or more photons of the incident light and produces free radicals, which eventually will induce photopolymerization, confined within the beam focus. The choice of a high-performance photoinitiator directly influences the speed, resolution, and quality of the 3D micro/nano structures. Upon this fact, the synthesis of novel photoresists and high-performance PIs for MPL has been the subject of investigation during the last decades [2]. To this end, this work introduces novel PIs [3], named as triphenylamine-based aldehydes, suitable for MPL. In this context, the two-photon absorption cross sections and 3D micro/nanostructures fabricated with the PIs will be shown. Furthermore, a wavelength-independent and non-photosensitized material for MPL is introduced. This is crucial for specific applications due to the two drawbacks of PIs: toxicity and fluorescence. Specifically, wavelengths of 517 nm,780 nm, and 1035 nm are shown to be suitable for fabricating 300 nm features even at high scanning speeds (up to 100 mm/s) [4]. To conclude, the importance of efficient PIs is highlighted in this work, underlying their potential applications in photonics, optoelectronics etc. On the other hand, the limitations of a PI are minimized by excluding it from the material and studying the material's structuring properties for future applications in bio-scaffolds, tissue engineering, micro-optics etc.

---

[1] Wang, H. et al. Two-Photon Polymerization Lithography for Optics and Photonics: Fundamentals, Materials, Technologies, and Applications. Adv Funct Mater 2214211 (2023)

[2] Wloka, T. et al. From Light to Structure: Photo Initiators for Radical Two-Photon Polymerization. Chemistry - A European Journal 28, (2022)

[3] Ladika, D. et al. Synthesis and application of triphenylamine-based aldehydes as photo-initiators for multi-photon lithography. Applied Physics A 2022, 128, 1-8 (2022)

[4] Ladika, D. et al. X-photon 3D lithography by fs-oscillators: wavelength-independent and photoinitiator-free. PREPRINT (Version 1) available at Research Square 0-13 (2023)