Machine Learning predicts printing parameters for Multi-Photon Polymerization Three-Dimensional Direct Laser Writing (3D-DLW)

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ABSTRACT

There is a range of techniques that have been developed for the determination of the magnitude and order of non-linear processes. In most cases interest has focused on characterizing instantaneous two-photon absorption (2PA)[1]. Furthermore, the rapid technical development of ultrashort laser systems has created exciting possibilities for very precise localization of laser energy in time and space; allowing for non-linear interaction processes. A promising three-dimensional (3D) microfabrication method is based on two-photon polymerization (2PP) with ultrashort laser pulses[2]. When focused into the volume of a photoresist, the pulses initiate 2PP process via 2PA and subsequent polymerization. After illumination of the desired structures inside the photoresist volume, follows the washing out of the non-illuminated regions so polymerized material remains in the prescribed 3D form. This allows microfabrication of any computer-aided design (CAD) generated 3D structure by direct laser writing (DLW) into the photoresist volume. Most photoresists absorb in the ultraviolet (UV). These materials can therefore usually be excited by 2PA of visible or near-infrared (NIR) light[3]. There are also, however, many cases in which non-linear absorption involves more than two photons; thus, in this study we will consider the characterization of general multi-photon absorption (MPP) correlating directly the properties of the features produced by MPP with the process parameters. Linewidth, power threshold, polymerization and damage thresholds, dynamic range and fabrication resolution have been object of investigation in our experiments. Moreover, this study complements the understanding of MPP making use of machine learning for linking directly the various MPP printing parameters to the produced features.

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