Mid-infrared Resonant Laser Swelling of Biocompatible Polymers

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Laser swelling is based on the local expansion of polymers irradiated with laser intensities below the ablation threshold, allowing for surface shaping while maintaining optical-quality roughness without post-processing such as wet etching. We used resonant (C–H bonds stretching) near-surface absorption of mid-infrared (3.2–3.5 μm) laser pulses in biocompatible polymers (polymethylmethacrylate, polydimethylsiloxane, hydrophobic acrylic) to form smooth transparent convex (gaussian-like profile) and flat-top tracks with 7–100 μm width (FWHM) and up to 2.7 μm height (top-view phase change about 12 rad at 633 nm) following freeform trajectories on the surface of the sample and confirmed the tehcnological potential of the method by writing a 20 μm-period sinusoidal phase diffraction grating. The onset of swelling was related to reaching the glass transition temperature in the center of a 5–10 times wider laser-heated material redistribution zone, also characterized by a permanently reduced refractive index and the absence of chemical changes detected by Raman microspectroscopy. The technique is perspective for precise manufacturing of dye-free biocompatible polymer phase micro-optic elements including intraocular lenses, flat optics, compound eyes, and other microimaging systems.

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