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Additive Manufacturing of Microstructured Optical Waveguides Using Two-Photon Polymerization

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Abstract : Background: The field of photonics has witnessed substantial growth, with an increasing demand for miniaturized and high-performance optical components. Microstructured optical waveguides have gained significant attention due to their ability to confine and manipulate light at the subwavelength scale. Conventional fabrication methods, however, face limitations in achieving intricate and customizable waveguide structures. Two-photon polymerization (TPP) emerges as a promising additive manufacturing technique, enabling the fabrication of complex 3D microstructures with submicron resolution. Objectives: This experiment aimed to utilize two-photon polymerization to fabricate microstructured optical waveguides with precise control over geometry and dimensions. The objective was to demonstrate the feasibility of TPP as an additive manufacturing method for producing functional waveguide devices with enhanced performance. Methods: A femtosecond laser system operating at a wavelength of 800 nm was employed for two-photon polymerization. A custom-designed CAD model of the microstructured waveguide was converted into G-code, which guided the laser focus through a photosensitive polymer material. The waveguide structures were fabricated using a layer-by-layer approach, with each layer formed by localized polymerization induced by non-linear absorption of the laser light. Characterization of the fabricated waveguides included optical microscopy, scanning electron microscopy, and optical transmission measurements. The optical properties, such as mode confinement and propagation losses, were evaluated to assess the performance of the additive manufactured waveguides. Conclusion: The experiment successfully demonstrated the additive manufacturing of microstructured optical waveguides using two-photon polymerization. Optical microscopy and scanning electron microscopy revealed the intricate 3D structures with submicron resolution. The measured optical transmission indicated efficient light propagation through the fabricated waveguides. The waveguides exhibited well-defined mode confinement and relatively low propagation losses, showcasing the potential of TPP-based additive manufacturing for photonics applications. The experiment highlighted the advantages of TPP in achieving high-resolution, customized, and functional microstructured optical waveguides. Conclusion: his experiment substantiates the viability of two-photon polymerization as an innovative additive manufacturing technique for producing complex microstructured optical waveguides. The successful fabrication and characterization of these waveguides open doors to further advancements in the field of photonics, enabling the development of high-performance integrated optical devices for various applications

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