FRAUNHOFER INSTITUTE FOR LASER TECHNOLOGY ILT

PHOTOCHEMISTRY AND 3D PRINTING

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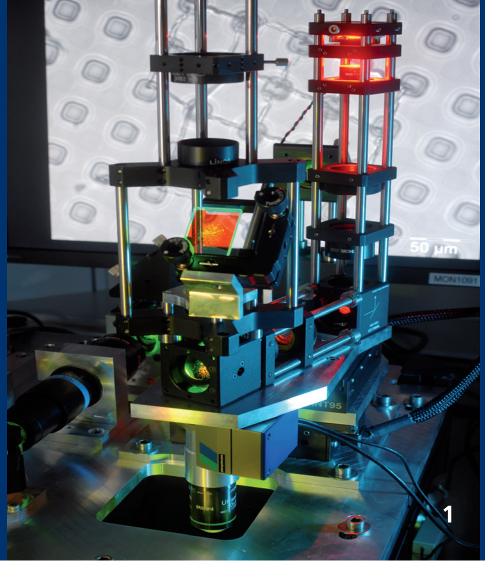
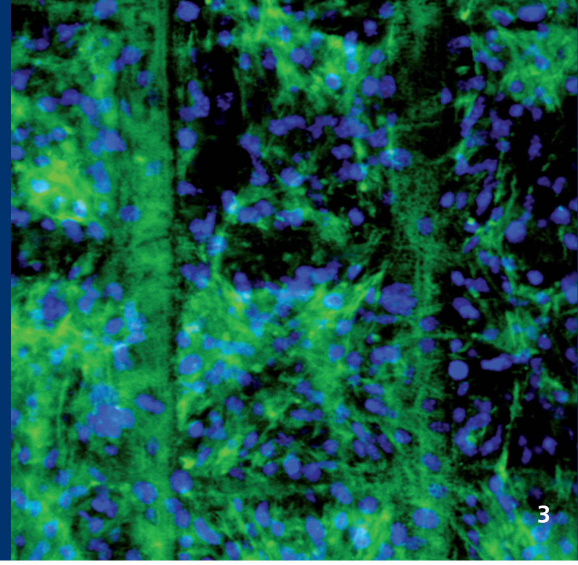
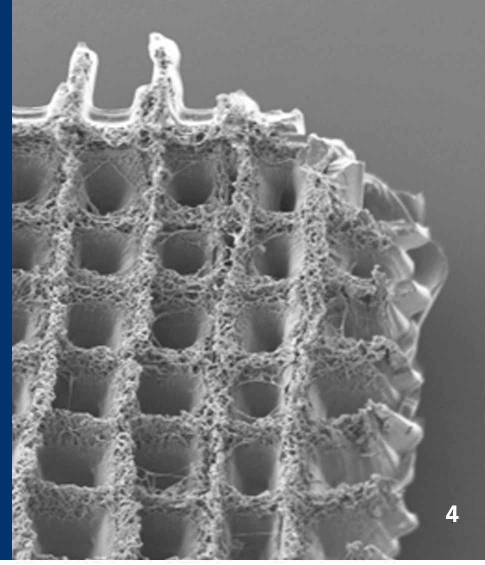
Fraunhofer Institute for Laser Technology ILT

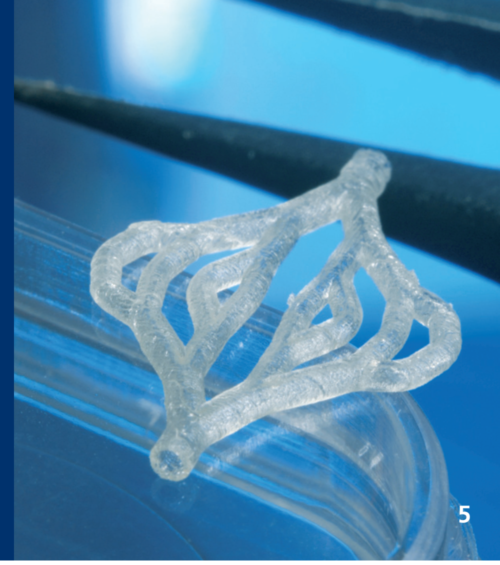
The Fraunhofer Institute for Laser Technology ILT is one of the most important development and contract research institutes in laser development and application worldwide. Its activities encompass a wide range of areas such as developing new laser beam sources and components, laser-based metrology, testing technology and industrial laser processes. This includes laser cutting, ablation, drilling, welding and soldering as well as surface treatment, micro processing and additive manufacturing. Furthermore, Fraunhofer ILT develops photonic components and beam sources for quantum technology.

Overall, Fraunhofer ILT is active in the fields of laser plant technology, digitalization, process monitoring and control, simulation and modeling, AI in laser technology and in the entire system technology. We offer feasibility studies, process qualification and laser integration in customized manufacturing lines. The institute focuses on research and development for industrial and societal challenges in the areas of health, safety, communication, production, mobility, energy and environment. Fraunhofer ILT is integrated into the Fraunhofer-Gesellschaft.









PHOTOCHEMISTRY AND 3D PRINTING

Additive processes for the direct manufacturing of functional components are constantly being updated by researchers. The Fraunhofer Institute for Laser Technology ILT is developing laser-based 3D printing processes with which to manufacture microscale polymer structures for applications in optics and medical technology.

Additive manufacturing processes that use lasers to produce a component based on digital 3D data are – amongst others – known as 3D printing. In contrast to subtractive processes such as milling, turning and drilling, 3D printing takes an additive approach in which material is introduced, applied or deposited. One example of how Fraunhofer ILT employs 3D processes is in the hardening of what are known as photoresins. Unlike melting or sintering processes, the photonic energy here is used to initiate a localized photochemical reaction such as polymerization and polyaddition. These have the effect of solidifying a liquid, which makes it possible to manufacture polymer components layer by layer at resolutions ranging from just a few to several hundred micrometers for the rapid manufacturing of larger structures.

Photochemistry in 3D Printing

Photochemistry is the general term for a group of reactions that are triggered by the application of light. Some of these reactions can be initiated directly, others only through the addition of a photoinitiator or a photosensitizer. It is possible to polymerize liquid resins in a targeted way by directing the light so that it strikes only specific areas. This can be done with the help of a laser scanner (stereolithography SLA) or with a light source similar to a video projector (digital light processing DLP). In this process, small monomer molecules are joined together to create large connected polymer molecules. The characteristics of components printed in this way depend on various process and material parameters. Scientists at Fraunhofer ILT are working on manufacturing functional components such as biocompatible components. By optimizing the combination of materials to fit the process parameters, our researchers can deliver specific product characteristics.

1 *MPP module.*

2 *DLP components with biocompatible dye.*

3. *Optical fluorescence micrograph of a cell-populated SLA blood vessel structure (green: cytoskeleton, blue: cell nuclei).*

4 *REM image of a biocompatible SLA blood vessel structure.*

5 *Elastic, biocompatible SLA blood vessel structure.*

Biocompatible Functional Components

Biological tissue can be repaired or even completely replaced (tissue engineering) using biofabrication, which combines additive process technologies with knowledge gained from cell biology and chemical material development. Scientists at Fraunhofer ILT are working on how to use additive manufacturing processes to produce scaffold structures that can be populated with autologous cells ready for culturing. It is then possible to produce artificial tissue-like structures by applying mechanical and biological stimuli. Our researchers are employing 3D printing to produce scaffold structures made of polymers and biomaterials. A combination of thiol-ene click chemistry for polymerization with special process engineering allows the production of scaffold structures that fulfill biomechanical requirements as regards mechanical stability, elasticity and biocompatibility.

Multiphoton Polymerization

A further option for producing biocompatible (micro)structures with specific mechanical characteristics is to use multiphoton polymerization (MPP). This high-resolution 3D printing process can polymerize both monomers and proteins either with or without initiators. It uses highly focused ultrafast laser radiation to deliver a nonlinear absorption process in a highly localized volume pixel (voxel). The resolution of the structures produced is in the sub-micrometer range.

In contrast to processes that are based on linear absorption, here only the focus volume is affected. This opens the door to new process opportunities such as the manufacture of microstructures in closed systems, for instance in microfluidics components. However, the high resolution demands a lower processing speed. At Fraunhofer ILT, we combine multi- and single-photon techniques to harness the advantages of both processes and compensate for their disadvantages.

Transparent Functional Components

Besides mechanical and cell biological characteristics, the optical characteristics of the components produced are also important. Fraunhofer ILT is aiming to create highly refractive polymers for 3D printing and make them suitable for multi- and single-photon processes. This approach sees us developing new, tailored manufacturing methods for consumer optics and light-shaping elements such as Fresnel lenses, LED collimators and microlenses.

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