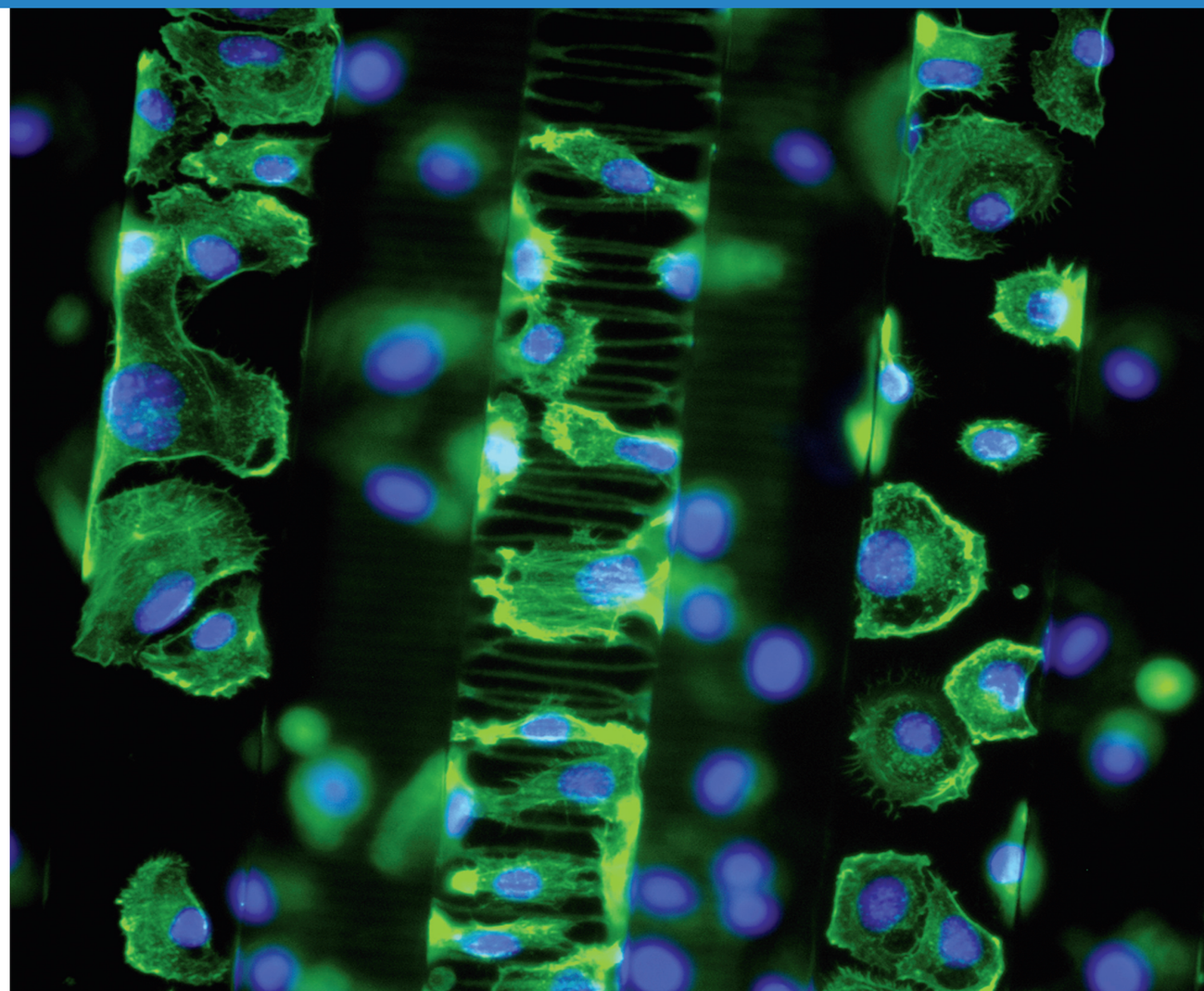
Fraunhofer
ILT

FRAUNHOFER INSTITUTE FOR LASER TECHNOLOGY ILT

BIOFABRICATION



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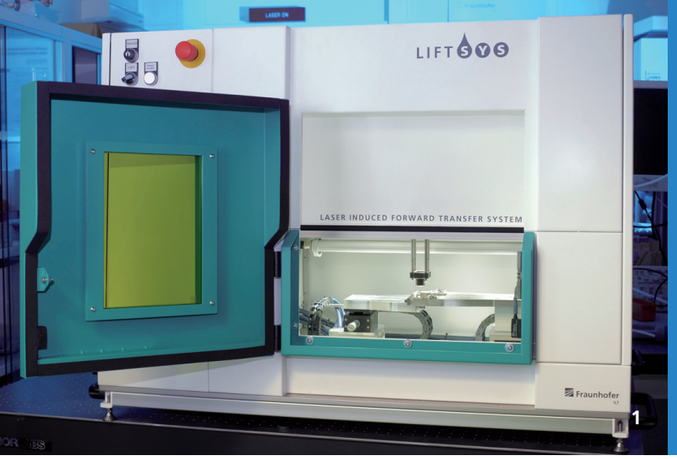
Fraunhofer Institute for Laser Technology ILT

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.



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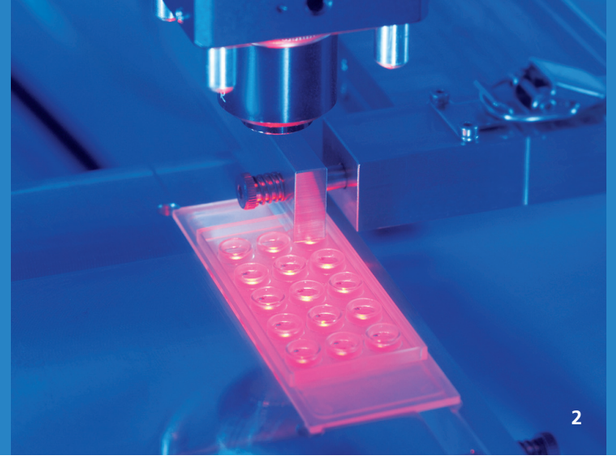
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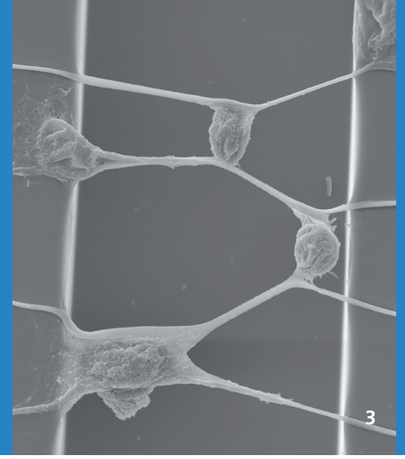
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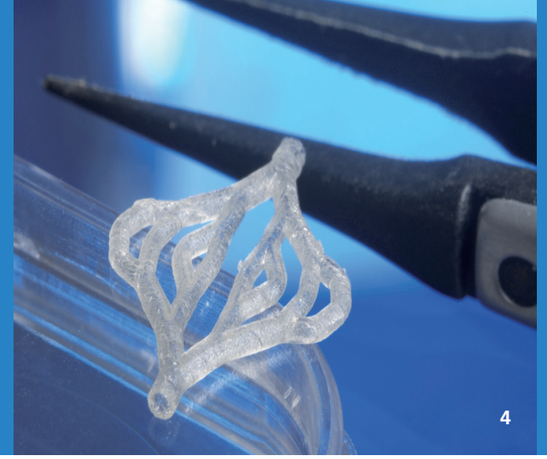
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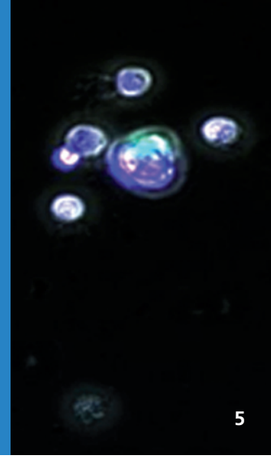
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BIOFABRICATION

Biofabrication is an emerging field where an interdisciplinary approach between engineering, science and medicine enables the design and fabrication of novel tools for biological and biomedical applications. However, current fabrication technologies show certain disadvantages regarding reproducibility, resolution and the necessary amount of expensive materials. The Fraunhofer Institute for Laser Technology ILT developes several technologies and instrumentation for 3D printing of high resolution microstructures from polymers and biomaterials, and for transferring small amounts of biological material.

Photo Induced Crosslinking

Photo Induced Crosslinking is a high resolution 3D printing process that allows for the production of customer specified microstructures such as scaffolds for tissue engineering or in vitro test systems. The employed materials range from inelastic to elastic polymers and biological materials such as proteins, meaning that high resolution scaffolds of biological and biomimetic compounds are achievable. Single Photon Polymerization (SLA) and Two Photon Induced Polymerization (TPP) technologies have been developed at the Fraunhofer ILT.

Single photon polymerization employs focused UV laser light in order to cure a photosensitive resin in a layer-by-layer approach. This process allows for the generation of structures on the centimeter scale with a resolution of approx. 10 - 50 µm. In contrast, Two Photon Induced Polymerization achieves a resolution in the micro- to sub-micrometer scale. This process is based on two photon absorption, which is initiated by tightly focusing an ultrashort laser beam in the visible or near infrared range. Crosslinking is initiated only in the focal volume of this laser beam and thereby localized in all three spatial directions.

Laser Induced Forward Transfer (LIFT)

LIFT allows bioactive materials, proteins, bacteria and mammalian cells to be placed gently and precisely on any surface. A pulsed laser source is used to evaporate a sacrificial absorption layer thereby transferring small amounts of material from a target to a substrate. The target consists of three layers: a support layer that is transparent to the wavelength of interest, a transfer layer that contains the substance to be transferred, and an absorption layer between the support and transfer layer. This nozzle free transfer technology allows the handling of smallest quantities of materials without any demand on viscosity or physical state. Highly viscous films, solid materials and even light cells can be transferred. At Fraunhofer ILT the user friendly tool LIFTSYS™ was developed which allows the use of this technology for research groups and industry. A coaxial monitoring system allows the analysis of the transfer layer before the actual transfer. Semi-automated routines perform actions like triggering transfer, positioning of substrates and srcibing of patterns as well as the creation of images for documentation.

This methodology offers new fabrication possibilities. For example, it is possible to generate 3D microstructures inside a closed microfluidic device. The versatility enables scaffolds that closely mimic the natural environment of cells. Generally, the high costs of a TPP prototyping setup hinders the widespread application of this promising technology. Therefore, a cost-efficient table top module has been developed with all necessary features for 3D micro-structuring. This module is specially designed for easy incorporation into other biofabrication processes and is available for SLA and TPP processes.

Process Combination

TPP and LIFT are part of a complex production technology for in vitro assays and artificial scaffolds. Both technologies can be combined with complementary production methods like inkjet printing, plotting, Selective Laser Melting or stereolithography. This technological cross-implementation offers novel and versatile possibilities towards intelligent throughput technologies. For example, by combining inkjet and stereolithography processes with TPP, relatively large structures with high resolution can be produced within a reasonable production time. Additionally, the performance of the engineered scaffolds can be enhanced by subsequent laser assisted chemical functionalization. Such structures can be used in in vitro assays to substitute animal experiments for the certification of medical devices or development of pharmaceuticals.

Application: In Vitro Assays

In vitro assays are a powerful and versatile tool in life science. They offer the possibility to unravel still unknown fundamentals of cell biology in scientific research, assist in drug delivery and enhance the development of personalized medicine by improving diagnostic systems. For drug discovery purposes, precise cell based assays with cell relevant resolutions within micrometer range may be the next step to best mimic the cell's natural environment. Thus these in vivo-like structures can be used to unravel new active agents for pharmaceutical developments.

Application: Scaffolds for Tissue Engineering

During recent years, the progress in regenerative medicine has opened new opportunities of treatment. These opportunities have led to an increasing need for in vitro engineered tissues as well as sustainable biocompatible implants. The challenge is to build artificial scaffolds by technical means which adequately mimic the natural 3D environment of growing cells. For this reason, the Fraunhofer ILT is developing high resolution biofabrication technologies which are able to generate scaffolds based on biological and biocompatible materials, as well as on adapted biofunctionalization processes.

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Front page: Cells on TPP-generated protein structures.
1 LIFT-System.
2 LIFTSYS™-Machine.
3 Cells cultivated on free hanging protein µ-fibres, generated by TPP.
4 Branched, elastic vascular scaffold generated by SLA.
5 LIFT-Pattern.