FRAUNHOFER INSTITUTE FOR LASER TECHNOLOGY ILT

BIOFUNCTIONALIZATION WITH LASER RADIATION

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Fraunhofer Institute for Laser Technology ILT

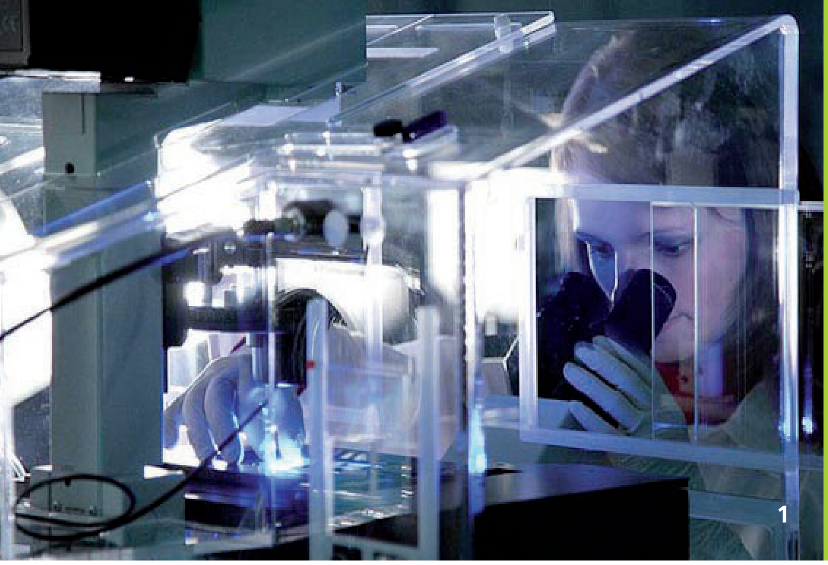
The Fraunhofer Institute for Laser Technology ILT is one of the most important development and contract research institutes in laser development and application worldwide. Its activities encompass a wide range of areas such as developing new laser beam sources and components, laser-based metrology, testing 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.

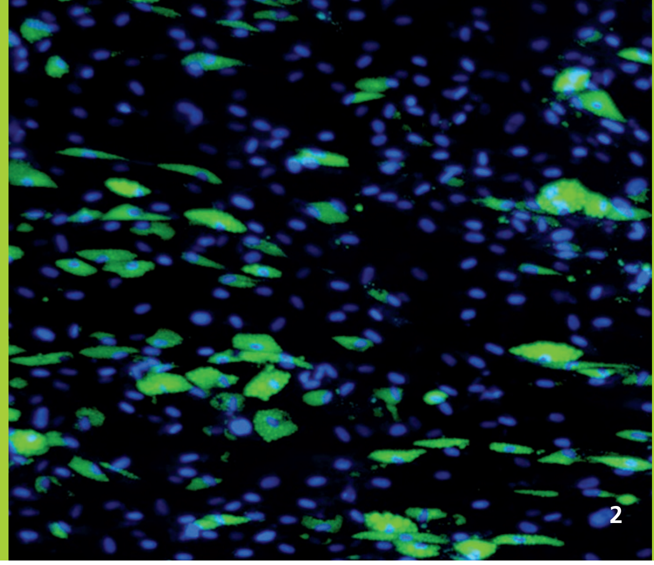
Overall, Fraunhofer ILT is active in the fields of laser plant technology, digitalization, process monitoring and control, simulation and modeling, AI in laser technology and in the entire system technology. We offer feasibility studies, process qualification and laser integration in customized manufacturing 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.

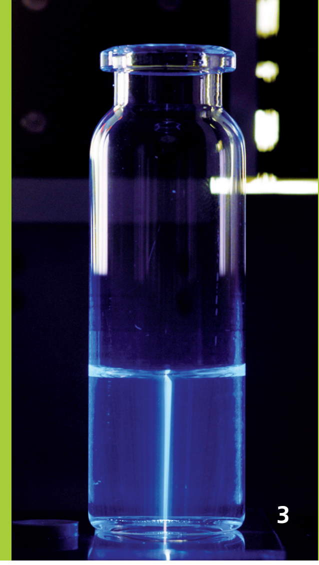
Fraunhofer Institute
for Laser Technology ILT
Director
Prof. Constantin Häfner

Steinbachstraße 15
52074 Aachen, Germany
Telephone +49 241 8906-0
Fax +49 241 8906-121

info@ilt.fraunhofer.de
www.ilt.fraunhofer.de







BIOFUNCTIONALIZATION WITH LASER RADIATION

Due to their high precision and flexibility, laser processes are versatile tools for small-scale production of medical devices. Processing materials with lasers makes it possible to functionalize specific areas of the surfaces when preparing them for medical technology applications. At the Fraunhofer Institute for Laser Technology ILT, experts are developing various methods for use in biomedical engineering.

High brilliant fiber lasers can be used to drill or join polymer parts for catheters and microfluidic components without degradation and under sterile conditions. For dosing systems and miniaturized drug depots, short-pulse lasers can be used to create pores in the millimeter or even micrometer range. Soft and flexible materials such as polymers as well as brittle materials such as ceramics can be processed using this technique.

In addition, structuring and molding processes can be applied to produce components for minimally invasive surgical and diagnostic solutions based on fundamental biological principles, such as the sensory hairs of insects (bionics). This means threadlike structures that extend outwards can be produced with a high aspect ratio by casting laser-generated molds. Targeted photochemical functionalization makes it possible for scientists to control both a surface's wetting and cell adhesion properties.

Surface Functionalization using Laser Ablation

The cells of our body require specific biological stimuli to form tissues. To influence and direct this cell growth, our experts are investigating mechanical, topographical and molecular cues in in vitro cell cultures that can be implemented at precise positions on synthetic surfaces using laser-based modifications. Micro and nano structures alter the substrates' roughness and wetting properties, which, in turn, affect cell adhesion and proliferation. This approach generates guidance structures that foster targeted cell growth. In particular, nanogrooves, which are produced with interference structuring, can change the distribution of the cell's focal adhesions and affect complex mechanisms such as cell proliferation and differentiation.

Functionalization through Photo-immobilization

Another technique involves laser radiation for the selective photochemical functionalization of surfaces. The surfaces are activated by photo-oxidation, which generates anchor groups for covalent immobilization of biomolecules such as peptides, proteins and growth factors. This process also allows researchers to create gradients for certain bio-molecules in order to precisely control how the cells are integrated. In the same way, photo-activatable molecules, or photolinkers, can be used in radiated zones to selectively bond with polymer surfaces and be ready for further functionalization with bioactive compounds.
One possible application of this technique is the development of a new kind of artificial implant for the abdominal wall. The implant is selectively modified with various growth factors so that it integrates well into the tissue without interfering with neighboring organs.

Photo Release of Active Pharmaceutical Ingredients

The group of photolinkers also includes photocleavable linkers: special anchor groups that decompose upon radiation with light of a certain wavelength. Molecules immobilized by one of these linkers can be released in a targeted way.
How to control the time and location of the release of active ingredients – drug delivery – is the subject of intense research. For many areas of medicine, the development of bioactive medical devices represents a promising new form of treatment. One example is a photorelease system for tumor reduction, which uses selective laser radiation to release doses of chemotherapy drugs on demand from tailor-made polymer scaffolds.

Production Processes for Soft-tissue Implants

Besides ablation and photochemical functionalization of implant surfaces, additive processes are another way to produce functional scaffolds for applications such as tissue regeneration. One promising approach here is to make personalized implants from artificial scaffolds, which are seeded in vitro with autologous cells. To that end, scientists at Fraunhofer ILT are developing laser polymerization processes for manufacturing scaffold structures and artificial vascular systems made from biocompatible and biodegradable polymers for subsequent cell seeding.

Contacts

Dr. Elke Bremus-Köbberling
Telephone +49 241 8906-396
elke.bremus@ilt.fraunhofer.de

Dr. Nadine Nottrodt
Telephone +49 241 8906-605
nadine.nottrodt@ilt.fraunhofer.de

Cover page: Standard series for ELISA determination.
1 Live cell imaging of tissue cultures.
2 Stem cells on nanostructured polyimide (published in: König/Ostendorf (Eds.), Optically Induced Nanostructures. Biomedical and Technical Applications, De Gruyter 2015).
3 Drug release through photoactivation.
4 Protein gradient as cell guiding structure.
5 Composite membranes made of silk.