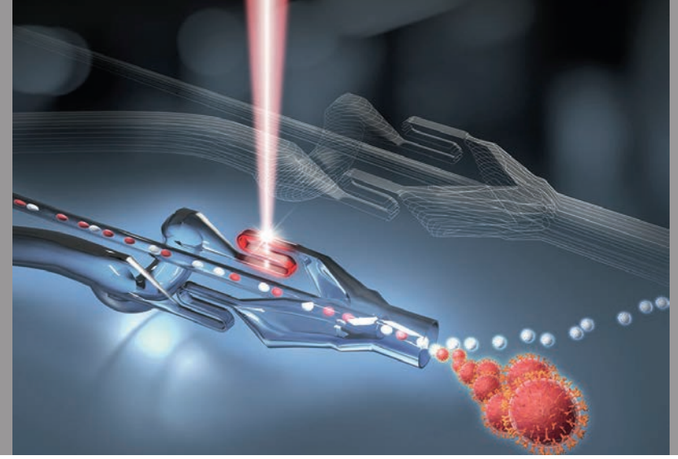
HEALTH

LASER TECHNOLOGY SOLUTIONS FOR INDUSTRY AND SOCIETY



LASER-BASED ANALYSES FOR PERSONALIZED MEDICINE

Lasers offer clinicians a wide range of options for diagnostic and therapeutic applications. As increasingly personalized medicine develops, new demands are being placed on clinical diagnostic procedures. The high sensitivity and selectivity of fluorescence-based laser measurement methods distinguish the laser as a tool for dealing with such diagnostic questions. Together with leading medical experts, Fraunhofer ILT is developing laser-assisted methods for laboratory diagnostics that will enable therapy options tailored to individual patients. A key topic is the development of microfluidic lab-on-a-chip systems, including multiplex diagnostics in routine operation.

Lab-on-a-chip systems for rapid analyses

Cells and biomolecules circulating in the blood are carriers of diagnostic information, the analysis of which is a key to highly effective, individual therapeutic concepts. To make this information accessible, scientists at Fraunhofer ILT are developing microchip-based sorter systems called µFACS (Microchip Based Fluorescence Activated Cell Sorter). With laser-induced fluorescence, clinically relevant cells of a blood sample are detected in microfluidic channels and gently isolated for further investigations. Different cell types can be detected with a single sorting chip and separated into separate sample vessels while maintaining the vitality and divisibility of the cells.

Sorting cells and biomolecules with light

Cells have characteristic proteins that are stored in the cell membrane. These proteins have a structure to which marker molecules can bind. The marker molecules are specifically stained with antibody-dye conjugates, which, in the µFACS system, are excited to emission with laser light and thus made visible. Laser beams of different wavelengths can differentiate differently labelled cells. The fluorescence light is directed via a fiber network to an optical detection system that analyzes the emitted light and assigns it to a specific species of cells.

With focused infrared laser light, the cells can be directed through a network of fluidic branches and then sorted. The measured fluorescence information determines where a cell is sorted. In this opto-fluidic switching process, the cell is always directed at a junction into the branch that has previously been irradiated with infrared light. Complex sorting structures consist of a combination of many such switchable junctions of microfluidic channels. The channels each lead into a collection vessel and allow the simultaneous sorting of different cell species.

Rapid infection diagnostics and resistance tests

This microfluidic sorting process is ideally suited for use in infection diagnostics, for example to detect and isolate pathogens in the blood. In the case of bacterial pathogens, the isolated pathogens can be further cultivated and used to test the efficacy of antibiotics: isolation of the pathogens, subsequent storage in a culture vessel, further propagation and testing of various antibiotics. The individual steps only take a short period of time, so that the overall diagnosis times are also short. Patient-specific, highly specific antibiotic profiles for treating bacterial infections can be established within a few hours. Compared to conventional resistance tests, diagnosis with µFACS saves valuable time of one to two days, which can be decisive for the choice of therapy.

Early detection of tumors with laser light

Tumor cells circulate in the blood at a very early stage of cancer. Their detection can be used to diagnose cancer at an early stage, even before the disease causes symptoms or can be detected with imaging processes. Circulating tumor cells in the blood can be detected with µFACS and isolated in the sorting chip for further clinical examination. After the sorting process, the isolated cells are available for personalized therapy selection with significantly increased therapeutic success.

A single analysis to detect a variety of diseases

The different detection channels of µFACS can be used to simultaneously identify different marker molecules in the blood. Multiplex diagnostics allows up to sixteen different disease markers to be detected in a single marking step and in just one measurement run. In such a multiplex analysis, the marker molecules can be specifically bound by a mixture of different diagnostic particle fractions in a blood sample and detected by particle fluorescence. In the annual routine check-ups with the family doctor, a large number of possible diseases could be diagnosed early from a single blood sample in order to prevent widespread diseases such as cardiovascular diseases.

Selected research results
Medical technology

Further information on the Internet at:
www.ilt.fraunhofer.de/en.html