Workshop on lasers in medicine and life sciences *Szeged, July 20, 2018*

Light as a tool: nanoscale photonics for production technology and life science applications

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Companies in the field of photonics and light-based technologies work on solving key societal challenges, such as energy generation and energy efficiency, healthy ageing of the population, climate change, and security. Photonic technologies have major impact on the world economy with a current global market of € 300 billion per year. Within the European Union, the market share of German photonics companies is as high as 43 percent, with a focus on innovative products and high-tech applications. The Laser- Laboratorium Göttingen (LLG) is one of the leading experts in nanoscale structuring, analysis, and imaging with light. By combining expertise from these areas, LLG achieves synergies that are relevant for socially important issues such as advanced production technologies and health.

The LLG develops materials processing techniques as well as measurement systems for the characterization of light propagation and material analysis. It also deals with imaging techniques with a resolution of well below 100 nanometers in the visible, EUV and X-ray range.

Recent achievements in these fields will be discussed. These include super-resolution microscopy, X-ray microscopy, photonic sensor technology and laser-based surface functionalization.

Specifically, taking a close look at the nanoworld inside (living) cells provides fantastic possibilities for gaining insight into molecular processes. This knowledge is one of the keys to understanding diseases and developing new diagnostic tools, novel drugs, and their therapeutic use. With conventional light microscopy, however, the nanoworld remains hidden. This limitation, the diffraction barrier, can be overcome by using switchable fluorescent markers. For this invention, in 2014 the Nobel Prize in Chemistry was awarded to Stefan W. Hell, Eric Betzig, and William E. Moerner. The LLG is active in this field and develops new methods for high-resolution fluorescence microscopy.

Various measuring devices for assessment of the efficiency and stability of heavily loaded optical components are also developed. This allows the monitoring of the thermal lensing, absorption and degradation behavior of such components. Furthermore, compact EUV/XUV sources for metrological applications with soft X-rays are being developed (e.g. "water window" microscopy).

The LLG also focuses on the development of novel optical measurement techniques mainly based on Raman scattering, IR absorption and fluorescence emission, often combined with chemometric analysis. The strengths of these methods are that they lead to non-destructive, contact-free and fast measurement of substances, structures, complex matrices and biological systems.

Another important research field is the laser-based surface modification, giving rise to numerous functionalities for optical, fluidic, tribological or medical applications. In this field, ultrashort laser pulses are gaining a rapidly increasing importance for a range of emerging applications. The LLG develops various short pulse-based techniques, including beam delivery concepts for the fabrication of micro- and nano-structured surfaces. In particular, medical applications of such surfaces for modifying the cell growth behavior on implants will be surveyed.

Applications and the industrial relevance of these research fields will be discussed.