Biomedical Optics (SYBO)

jointly organized by
the Quantum Optics and Photonics Division (Q) and
the Molecular Physics Division (MO)

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Overview of Invited Talks and Sessions

(Lecture room e415)

Invited Talks

SYBO 1.1	Thu	11:00–11:30	e415	**Recent advances of Optical Coherence Tomography** — •Wolfgang Drexler
SYBO 1.2	Thu	11:30–12:00	e415	**Vortex-beams for precise and gentle dissection in refractive corneal surgery** — •Alfred Vogel, Sebastian Freidank, Norbert Linz
SYBO 1.3	Thu	12:00–12:30	e415	**Structured Illumination and the Analysis of Single Molecules in Cells** — •Rainer Heintzmann
SYBO 1.4	Thu	12:30–13:00	e415	**Biophotonics - a potential solution to unmet medical needs!?** — •Juergen Popp
SYBO 2.1	Thu	14:30–15:00	e415	**Smart and multimodal light sheet microscopy** — •Jan Huisken
SYBO 2.2	Thu	15:00–15:30	e415	**Laser Applications at the Cochlea: Imaging and Stimulation** — •Alexander Heisterkamp, Nicole Kallweit, Peter Baumhoff, Alexander Krueger, Nadine Tinne, Heiko Meyer, Andrej Kral, Hannes Maier, Tammo Ripken
SYBO 2.3	Thu	15:30–16:00	e415	**Scuplted light landscapes for optical micro-manipulation** — Christina Alpmann, Alvaro Barroso Pena, Eileen Otte, Kathrin Dieckmann, •Cornelia Denz
SYBO 2.4	Thu	16:00–16:30	e415	**Optogenetics: Lighting Up the Brain** — •Gero Miesenboeck

Sessions

SYBO 1.1–1.4	Thu	11:00–13:00	e415	**Symposium Biomedical Optics 1**
SYBO 2.1–2.4	Thu	14:30–16:30	e415	**Symposium Biomedical Optics 2**

SYBO 1: Symposium Biomedical Optics 1

Time: Thursday 11:00–13:00 Location: e415

Invited Talk SYBO 1.1 Thu 11:00 e415
Recent advances of Optical Coherence Tomography — •Wolfgang Drexler — Zentrum für Medizinische Physik und Biomedizinische Technik, Medizinische Universität Wien

Optical coherence tomography (OCT) is one of the most rapidly emerging and innovative optical imaging modalities of the last decades enabling in vivo cross-sectional tomographic visualization of internal microstructure in biological systems. Recent developments in ultrabroad bandwidth laser as well as OCT technology enable three-dimensional ultrahigh resolution OCT with unprecedented axial resolution, approaching resolution levels of con-ventional histopathology, enabling optical biopsy of biological tissue. In addition, multimodal extensions of OCT are recently under development that should provide noninvasive depth resolved functional imaging of the investigated tissue, including extraction of spectroscopic, blood flow or physiologic tissue information. These extensions of OCT should not only enable subcellular resolution imaging, improve image contrast, but should also enable the differentiation and early detection of pathologies via localized biochemical, molecular properties or functional state. The hypothesis is to provide (sub)cellular level resolution visualization of tissue morphology (optical biopsy) and at the same time localized metabolic, molecular and physiologic tissue information in performing a single volumetric multimodal OCT measurement.

Invited Talk SYBO 1.2 Thu 11:30 e415
Vortex-beams for precise and gentle dissection in refractive corneal surgery — •Alfred Vogel, Sebastian Freidank, and Norbert Linz — Universität zu Lübeck, Institut für Biomedizinische Optik, Peter-Monnik-Weg 4, 23562 Lübeck

Vortex beams allow for efficient and precise corneal dissection in refractive surgery. Improved precision is important for LASIK, where excimer laser ablation of stromal material corrects the refractive error after the stroma has been exposed by creating and lifting a thin flap as well as for SMILE, where two intrastromal incisions produce a lenticule that is then removed with forceps through small side cuts. For dissection, ultrashort laser pulses are focused in a raster pattern into the corneal stroma and plasma-induced micro-explosions generate cavitation bubbles that cleave the corneal lamellae.

Cutting precision is compromised by the large focus length associated with commonly used IR wavelengths and moderate NAs. The donut-shaped, short focus of vortex beams largely improves the cleavage efficiency along the lamellae, which dramatically reduces the absorbed energy needed for cutting, diminishes bubble formation in the cutting plane as well as mechanical side effects, and leads to a smoother dissection. The new approach is investigated by high-speed photography with 50 Mio frames/s, ex-vivo tissue experiments, and SEM.

Invited Talk SYBO 1.3 Thu 12:00 e415
Structured Illumination and the Analysis of Single Molecules in Cells — •Rainer Heintzmann — Institute of Physical Chemistry and Abbe Center of Photonics, Helmholtzweg 4, 07743 Jena — Leibniz Institute of Photonic Techology, Albert Einstein Str. 9, 07745 Jena

In the past decade advances have been made in the field of microscopy imaging, which have been honored by the Nobel prize in Chemistry 2014. Another high-resolution method is based on transforming conventionally unresolvable details into measurable patterns with the help of an effect most people have already personally experienced: the Moiré effect. If two fine periodic patterns overlap, coarse patterns emerge. This is typically seen on a finely weaved curtain folding back onto itself. Another example is fast moving coarse patterns on both fences of a bridge above a motorway, when approaching it with the car. The microscopy method of structured illumination utilizes this effect by projecting a fine grating onto the sample and imaging the resulting coarser Moiré patterns containing the information about invisibly fine sample detail. With the help of computer reconstruction based on several such Moiré images, a high-resolution image of the sample can then be assembled. Another way to obtain a high-resolution map of the sample is to utilize the blinking behavior inherent in most molecules, used to stain the sample. Methodological advances (Cox et al., Nature Methods 9, 195-200, 2012) enable us to create pointillist high-resolution maps of molecular locations in a living biological sample, even if in each of the required many individual images, these molecules are not individually discernible.

Invited Talk SYBO 1.4 Thu 12:30 e415
Biophotonics - a potential solution to unmet medical needs!? — •Juergen Popp — Leibniz Institute of Photonic Technology, Jena, Germany — Institute of Physical Chemistry & Abbe-Center of Photonics, Friedrich-Schiller University Jena, Germany

Understanding the cause of diseases, early disease recognition, targeted disease treatment, predication of therapeutic response and monitoring treatment success; are the underlying principles of the vision associated with modern biomedicine. In the past years biophotonics has witnessed the development of optical / photonic approaches that are potentially in a position to meet these aforementioned unmet medical needs. In this context spectroscopic approaches like e.g. Raman spectroscopy are especially noteworthy. We will show, that Raman spectroscopy holds great promise as point-of-care approach for a fast identification of pathogens and the determination of their antibiotic resistances, which is crucial for patient*s survival. Furthermore, it will be shown that the combination of Raman approaches with other spectroscopic technologies provides a sensitive and selective diagnostic tool for tissue analysis, i.e. spectral histopathology. We will introduce a combined Raman /FLIM (fluorescence lifetime imaging microscopy) fiber optical probe for in-vivo tissue screening. Furthermore we demonstrate how the combination of CARS (coherent anti-Stokes Raman scattering), SHG (second harmonic generation) and two-photon excited autofluorescence (TPEF) enables the fast and label-free characterization of the morphochemistry of frozen section biopsy specimens and therefore represents high potential for an intraoperative frozen section analysis.

SYBO 2: Symposium Biomedical Optics 2

Time: Thursday 14:30–16:30 Location: e415

Invited Talk SYBO 2.1 Thu 14:30 e415
Smart and multimodal light sheet microscopy — •Jan Huisken — Max Planck Institute of Molecular Cell Biology and Genetics, Dresden, Germany

Light sheet microscopy has become the tool of choice for *in vivo* fluorescence imaging of fragile biological specimens. Low phototoxicity and high speed acquisition have offered unique applications ranging from fast volumetric imaging to extended timelapse experiments spanning the entire embryogenesis of fish and fly. The enormous amounts of data from these instruments (TB/hour) now require a new approach to imaging: we cannot blindly image large samples with uniformly high spatial and temporal resolution.

We propose smart microscopy as a solution, in which illumination and detection are adaptively adjusted to obtain meaningful information at any time without any *a priori* knowledge about the sample. Only the regions in the sample that change over time or exhibit interesting new information will be illuminated and detected. Alternative modalities such as optical projection tomography offer additional information about the location and state of the sample that are used to optimize light sheet acquisitions. This presentation will give an overview of the latest developments in light sheet microscopy that lead towards a smart and gentle microscope.

Invited Talk SYBO 2.2 Thu 15:00 e415
Laser Applications at the Cochlea: Imaging and Stimulation — •Alexander Heisterkamp[1,2], Nicole Kallweit[2,3], Peter Baumhoff[4], Alexander Krueger[2,3], Nadine Tinne[2,3], Heiko Meyer[2,3], Andrej Kral[2,4], Hannes Maier[2,4], and Tammo Ripken[2,3] — [1]Institute of Quantum Optics, Leibniz University Hannover, Hannover, Germany — [2]Cluster of Excellence Hearing for all,

Hannover, Germany — [3]Laser Zentrum Hannover e.V., Hannover, Germany — [4]Institute of Audioneurotechnology, Hannover Medical School, Hannover, Germany

Using laser radiation, tissues and cells can be studied, characterized and manipulated with high resolution and low side effects. By optical tomography, single hair cells or their excitation can be visualized in model systems and even in vivo in an animal model. Using optoacoustics, sound generation within tissue can be induced. These processes can be employed for imaging or stimulation of the cochlea. In our investigations we studied the excitation of hair cells within the cochlea by laser irradiation and determined the underlying mechanisms. Further optical procedures allow the excitation of action potentials in neural cells as well and are currently studied with respect to applicability. For optical imaging, usually high resolution techniques such as confocal microscopy or histology are used to study the structure of the cochlea. However, optical penetration depth is limited by scattering within the osseous composition of the cochlea. Thus, we applied decalcification and optical clearing techniques to allow tomographic imaging of the cochlea ex vivo and generated 3D data of these structures.

Invited Talk SYBO 2.3 Thu 15:30 e415

Sculpted light landscapes for optical micro-manipulation — Christina Alpmann, Alvaro Barroso Pena, Eileen Otte, Kathrin Dieckmann, and •Cornelia Denz — Institute of Applied Physics, University of Muenster

The modulation of the spatial polarization, amplitude and phase distribution of light covers a broad range of applications, e.g. in laser machining, high-NA microscopy or optical micro-manipulation where these properties are used to shape the focal field in three dimensions.

In the last years, the holographic modulation of amplitude and phase have been widely employed in optical trapping techniques to create three-dimensional optical potential landscapes that allow manipulating several microscopic particles. In particular, we have shown that such tailored light fields are ideally suited for the organization and structuring of soft and biomatter entities, as e.g. zeolite L nanocontainers or bacterial molecular motors. Beside the modulation of amplitude and phase, polarization modulation enriches light shaping. While phase gradients can be used in order to exert orbital angular momentum, polarization structured light fields offer the possibility of spatially varying spin angular momentum affecting the trapped micro-particle.

In this contribution, we present our recent results in holographic generation of sophisticated tailored light fields which, in comparison to established holographic optical tweezers, provide remarkable higher trapping and control of complex particle orientation, and discuss the principles and applications of phase, amplitude and polarization modulated light for optical micro-manipulation.

Invited Talk SYBO 2.4 Thu 16:00 e415

Optogenetics: Lighting Up the Brain — •Gero Miesenboeck — Centre for Neural Circuits and Behaviour, University of Oxford, United Kingdom

An emerging set of methods enables an experimental dialogue with biological systems composed of many interacting cell types*in particular, with neural circuits in the brain. These methods are called *optogenetic* because they employ light-responsive proteins (*opto-*) encoded in DNA (*-genetic*). Optogenetic devices can be introduced into tissues or whole organisms by genetic manipulation and be expressed in anatomically or functionally defined groups of cells. In a decade and a half, optogenetic control has developed from a far-fetched idea to a widely used technique. My talk will illustrate how this happened, drawing on the earliest and latest results from my lab.