



BIOP 2005 - List of abstracts

Dual Polarisation Interferometry - Adding Structure to Function

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Farfield Sensors Limited has developed and commercialised Dual Polarisation Interferometry (DPI), the first analytical technique for the dynamic measurement of structural change in molecular systems as they function. The 30 minute presentation will focus on the principles behind the DPI technique and how it was developed from the original idea of a biosensor platform. Examples of DPI data will then be presented showing applications in both biophysics and nanotechnology, focusing on the high information content of DPI's multi-parameter measurements for interpreting molecular behaviour.

Optical waveguide sensor for monitoring living cell morphology

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Optical waveguide sensors have been used so far to detect biological materials at the surface of the sensor in aqueous cover media. These devices are based on the phenomenon that any change in the refractive index of the cover media shifts the effective refractive index of the surface mode. This change is detected through an evanescent optical field decaying exponentially from the surface of the sensor. Until recently, the penetration depth of this evanescent field was limited to ~100 nm. This reduced the sensitivity when aiming at refractive index changes far from the sensor surface, for example in the case of detection of bacteria or living cells that are 1-10 microns in size.

Recently a new type of waveguide design with the so-called *reverse symmetry* was suggested to overcome the fundamental limitations of the cover penetration depth. In this design the refractive index of the waveguide substrate is lower than the refractive index of the aqueous cover media, i.e. lower than 1.33. With this new configuration the penetration depth can be tuned, in principle, up to infinity by simply choosing the right thickness of the waveguiding film. In this way the waveguide can be tailor-made to embed larger biological substances into its evanescent field. This feature makes the reverse symmetry waveguide well suited for the monitoring of cell morphology.

In the present work a sensor with reverse symmetry is realized by depositing a thin polystyrene film onto nanoporous silica with a refractive index of 1.2. An embossed surface relief grating in the PS film is used as coupling element. As a result, significant changes in the incoupling peak height and peak shape were observed during cell attachment and spreading. It is suggested that the area under the incoupling-peaks reflects the initial cell attachment process, while the mean peak position is mostly governed by the spreading of the cells.

- [1] R. Horvath, L.R. Lindvold and N.B. Larsen, "Reverse-symmetry waveguides: theory and fabrication" *Applied Physics B* **74**, 383 – 393 (2002)
- [2] Horvath R, Pedersen HC, Skivesen N, Selmeczi D and Larsen NB, "Monitoring of living cell attachment and spreading using reverse symmetry waveguide sensing" *Applied Physics Letters* (2005) (cover image)



Nanophotonics

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Nanophotonics is one of the most rapidly growing subfields of optical research. It covers a lot of subjects ranging from ultra-compact components for telecommunications via optics of nanoclusters to sensors and bio-photonics. A common feature is that the optical performance relies significantly on nano features, which are smaller than the classical diffraction limit. Since the field has only existed for a few years it has not yet found so many applications, but the future looks very promising.

Three key areas of potential applications are cheaper components with more functionality for telecommunications, biosensors, and optoelectronics. During the talk I will present a couple of examples illustrating the rapid progress of the field.

Quality control and inspection with terahertz waves

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Terahertz radiation is relatively unknown to the broad public. However, in the recent years there has been a tremendous increase in research activities related to the application of waves in this frequency band for inspection of a wide range of materials. Terahertz radiation penetrates most packing materials, and is highly sensitive to the water content and chemical composition of the product under investigation. I will review the unique properties of THz radiation from the perspective of quality control and inspection of packaged products.

Polymer dye lasers for lab-on-a-chip integration

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We present a part of the current work in the research group "Lab-on-a-chip lasers and Nanoimprint Lithography" of Associate Professor Anders Kristensen. The group is located at the Department of Micro and Nanotechnology (MIC) at the Technical University of Denmark (DTU). One of the sub goals of the group is to develop visible laser light sources for integration on polymer based lab-on-a-chip or bio-chip circuits, without increasing the price of the systems.

Our approach is to define lasers entirely in polymer. We present three kinds of single mode polymer dye lasers, fabricated by UV-, electron beam- and nanoimprint lithography. The gain in the lasers is supplied by the laser dye Rhodamine 6G pumped optically with an external light source. Also we present examples of how the polymer lasers can be integrated with other polymer components to form functional devices.



Ikke-invasiv enkeltcelleafbildning i øjets nethinde åbner nye forskningsfelter for molekylærbiologi og industri

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Optisk Koheræns Tomografi (OCT) af nethinden har en axial opløsning i området 3 til 10 um. Dette giver mulighed for at sammenligne funktion med anatomi in vivo idet klassiske undersøgelses metoder af synsevne og synsfelt kan korreleres til patologi af de enkelte celletyper i nethinden. Et eksempel på dette er atrofi af specifikke celletyper efter okklusion af retinale kar og arvelige sygdomme, hvor man kender genet, men hidtil ikke har vidst hvilken funktion genet har i nethinden. Særligt med avanceret billedbehandling og 3D fremstilling kan kvantitative målinger supplere den kvalitative information og anvendelsen af OCT i oftalmologi er stærkt stigende.

Ultrafast lasers for non-invasive examination assessment and treatment of ocular physiology and anatomy in health and in disease

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The transparent tissues that form a window to the inside of the eye enable assessment and treatment of ocular physiology and anatomy in health and in disease. Highly energetic optical radiation, beginning from the blue end of the visible spectrum, is deleterious to biological molecules even at low fluence. Consequently, there is a theoretical advantage to the use of multi-photon technology in the eye. Experimental use includes treatment of malignant tumors using the intrinsic chromophore melanin as a photodynamic agent. With single-photon processes, the desired effect can only be achieved with ultraviolet, which does not penetrate beyond the most anterior structures of the eye, the cornea and lens, where ultraviolet causes photokeratitis ("snow-blindness") and cataract. Using infrared or red assures high transmittance even in the cloudy optical media of elderly persons and enables multi-photon effects to be elicited in the posterior of the eye. Ultrafast lasers with high stability and moderate cost of operation will remove barriers to the exploration of new and potentially highly beneficial modalities of treatment of eye diseases that include age-related macular degeneration, tumors, and retinitis pigmentosa.

Super-continuum kilder til biofotonik

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Development of a time and wavelength resolved spectroscopic system for analysis of turbid samples

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A novel system for time-resolved diffuse remission spectral measurements has been constructed, based on short light continuum pulses generated in a photonic crystal fibre, and a spectrometer-equipped streak camera. The system enables spectral recordings of absorption and reduced scattering coefficients of turbid media in the wavelength range 500 - 1150 nm with a spectral resolution of 10 nm and a temporal resolution of 30 ps. Several samples have been investigated, for example apples and pharmaceutical tablets. The optical properties are calculated by fitting the solution of the diffusion equation to the time-dispersion curve at each wavelength. More advanced evaluation schemes combining time-resolved measurements with conventional steady-state measurements have also been tested. These methods allow the wavelength range to be extended further to include longer wavelengths.

Optical tweezers: an optimal nano-tool for bio-materials

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During the last decade the technique of optical tweezers has undergone a revolution. With proper detection schemes, they can now be used not only for 3D manipulations, but also for force-distance measurements with sub-nanometer and sub-pico-Newton resolution. This little presentation will show how optical tweezers are used in practise. Also, there will be highlights elucidating the power of the technique with emphasis on studying biological systems from the single molecule to whole cell level.

Efficient generation of continuous-wave yellow-orange light using sum-frequency in periodically poled KTP

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We present highly efficient sum-frequency generation between two CW 1064 and 1342 nm laser lines of two Nd:YVO₄ lasers using periodically poled KTP. This is an all solid-state light source in the yellow-orange spectral range. Lasers in the yellow spectral region have over the past decade found an increasing number of applications. The yellow spectrum corresponds to the peak absorption of several popular fluorescent dyes, as well as the sodium “D” and “d” line around 594 nm, usually excited by the yellow HeNe lasers at 594 nm. A great need exists in the field of biomedical optics for light sources in the yellow-orange spectral range, due to the high absorption in hemoglobin.

Today copper vapor lasers (578 nm) and various dye-lasers are used in the medical clinics for dermatological treatment. These lasers are, however, generally large in size, inefficient (need water cooling), complicated to operate and both the gasses and liquids used in these lasers are highly toxic. Recently, milliwatts of 605 nm radiation have been generated using frequency-doubled quantum-well semiconductor lasers [1]. However, the power level of these devices is still too low for many applications.

The aim of this project was to make an all solid-state light source that can substitute the present technology at higher power levels in the yellow-orange spectral region. The system should be cost efficient, compact in size and with a high efficiency, allowing operation without water-cooling or special power installations. In the following a setup is presented, where more than 700 mW of 593.5 nm CW power was generated using an all solid-state diode laser pumped system, with a total diode pump power of less than 7 W. The system is based on sum-frequency generation between the 1064 and the 1342 nm laser line of two Nd:YVO₄ lasers using periodically poled KTP [ref 2-5]. Different cavity configurations have been tested and compared both in terms of conversion efficiency and stability.

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- [2] H. M. Pask and J. A. Piper, “Efficient all-solid-state yellow laser source producing 1.2-W average power”, Opt. Lett., 24, 1490 (1999)
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- [4] Y. F. Chen, S. W. Tsai, S. C. Wang, Y. C. Huang, T. C. Lin and B. C. Wong, “Efficient generation of continuous-wave yellow light by single-pass sum-frequency mixing of a diode-pumped Nd:YVO₄ dual-wavelength laser with periodically poled lithium niobate”, Opt. Lett., 27, 1809 (2002)
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Optisk kohærenstomografi

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Optisk kohærenstomografi, i daglig tale kaldet OCT fra det engelske navn "optical coherence tomography", kan siges at være optikkens version af ultralyd. Brugen af lys i stedet for lyd giver anledning til billeder med en væsentlig højere opløsning (1~15 μ m), men tilgængæld falder indtrængningsdybden til ca. 1-2 mm når objektet er væv. Inden for den medicinske verden arbejder man på at forfine teknikken således at den kan give lægen en "optisk-vævsprøve", der non-invasivt giver ham samme oplysninger som fra en biopsi. Ligesom for ultralyd er der også anvendelsesmuligheder udenfor hospitalerne. Bland eksemplerne kan nævnes skanning af fødevarer som korn og kød, karakterisering af polymer materialer, og måling af laktykkelser. I denne præsentation vil vi kort kigge på teknikken bag OCT, og derefter se på teknikkens muligheder, begrænsninger og anvendelser.

Organic nanofiber demonstration at BIOP 05

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At the University of Southern Denmark a new kind of high-quality organic single crystals has been invented, namely light emitting ORGANIC NANOFIBERS. These new kind of fibers are several orders of magnitude smaller as compared to conventional fibers, thus promising a huge increase in packing density if one uses them as optical waveguides.

By the growth process itself the nanofibers have optimum morphological dimensions for the use in microminiaturized optoelectronics and nanophotonics reaching lengths from several ten microns to millimeters with heights of several tens of nanometers and widths of hundred to several hundred nanometers. They are chemically inert, can withstand temperatures up to 150 degrees Celsius and have a perfect polarized characteristic spectroscopic signature with strong emission in the technologically interesting blue spectral range. They can be made also from functionalized molecules, which opens up the possibility to use them in sensor techniques.

The start-up company NANOFIBER A/S (www.nanofiber.dk) delivers valuable protocols for mass generation and transfer of organic nanofibers as well as prototypical on-demand devices. Among those devices are a SNOM standard and a fluorescence calibration sample.

At BIOP 05 Nanofiber A/S will provide the possibility for hands-on experiments on the fibers: to observe directly polarized luminescence and spectroscopy of individual nanofibers and nanofiber ensembles.