BIO-OPT-XUV RESEARCH TEAM ADVANCEMENT AT FBME CTU

Workshop #1

Faculty of Biomedical Engineering, Czech Technical University in Prague
Náměstí Sítná 3105, 272 01 Kladno 2

Abstracts

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http://xuv.fbmi.cvut.cz/box

9.15 – 9.45 Session 1

Fiat lux: see and cure!

Pavel Kučera (Czech Technical University, Faculty of Biomedical Engineering and University of Lausanne)

The evolution of living organisms has been significantly influenced by interactions with light. The photo medicine deals with both positive and negative effects that light can induce in humans. This presentation will introduce the principles, use and difficulties of photo diagnosis and phototherapy of epithelial affections and try to define methodological problems to be solved.

From the dark side: prodrugs in medical optics

N. Lange (University of Geneve)

Most targeting strategies in biomedical optics aim at tagging contrast agents onto compounds that specifically address functions abundantly expressed at the site of interest. However, such approaches are intrinsically not background free. Here we would like to demonstrate the design of reporters that are optically silent until they encounter a physiological trigger at the target site, which in turn locally converts them into optically contrast agents.

Fluorescence cytoscopy in the management of bladder cancer: current experience and possible development

P. Jichlinski (Centre Hospitaler Universitaire Vaudois, Lausanne)

Urothelial cancer concerns the whole urinary tract, but its highest prevalence is found in non-muscle invasive bladder cancer (NMIBC) disease, whose management remains a challenge. This disease is highly recurrent and may progress in presence of risk factors (carcinoma in situ, multifocal high grade tumors or multi-recurrent tumors). An accurate diagnosis at initial disease presentation is mandatory to determine the risk profile and is ensured by fluorescence cystoscopy (photo detection), internationally acknowledged by the urological community for this purpose.

However, the variable specificity of the method reduces its diffusion in clinics. Moreover, the light photosensitized cancer tissue interaction (photodynamic therapy) which can induce different cell death mechanisms remains at an early stage and needs further development.

11.00 – 12.30 Session 2

Development of new imaging and spectroscopy methods in biomedicine

Dalibor Pánek, Petr Brůža and Vlastimil Fidler (Czech Technical University, Faculty of Biomedical Engineering)

In this talk, the instrumentation background of the XUV Laboratory at FBME is presented. The key part of the current equipment is a table-top source of extreme ultraviolet radiation based on laser-produced plasma from a gas puffed target. The apparatus serves as a basis for development of new imaging and spectroscopy techniques for bio-structure studies. Preliminary experimental results will also be presented.

Cancer detection with X-ray scatter imaging

C. Rose-Petruck (Department of Chemistry, Brown University, Providence, RI 02912)

Spatial Harmonic Imaging uses the x-radiation scattered off the tissue for image formation. This imaging modality does not require any x-ray optics between the object and the x-ray source. As a consequence, it is suitable for clinical imaging of low-absorption contrast, soft tissue. The applications of this modality to the imaging of the liver vasculature and live cancers are discussed. The imaging modality can be augmented by immunolabeling of cancer cells with nanoparticles. Owing to the large x-ray scattering cross section of nanoparticles, labeled cells can be distinguished from other tissue. Recent in vivo results in mice will be discussed along with the implication for future human in vivo applications.

The relation of this research to project activities KA1, KA2, and KA4 will be discussed. First results from the soft x-ray source located at Kladno are presented. Since this source is strictly monochromatic, it permits testing the x-ray imaging theory. The results provide experimental data for comparison with the mathematical description of the imaging modality and have direct impact on our understanding of the imaging at clinically useful x-ray wavelengths

Biomolecular science, engineering and fluorescence

David J S Birch (University of Strathclyde, Glasgow, Scotland)

Fluorescence spectroscopy provides one of the most powerful platforms for understanding and applying knowledge of biomolecular systems in medicine. In this presentation I will outline the fundamental principles of biomolecular fluorescence, describe its associated instrumentation and techniques and briefly outline some important applications [1]. These include aggregation of peptide of relevance to Alzheimer's disease, the photophysics of melanin as a sun-screen, glucose sensing for diabetes management and nanopores that are capable of trapping and preserving fundamental life-forms and single molecules for research.

13.30 – 13.45 Session 3

Fluorescence spectroscopy and microscopy elucidating interaction of antimicrobial peptides with biological membranes

Radek Macháň, Tomáš Steinberger, Martin Hof (J. Heyrovsky institute of Physical Chemistry of AS CR v.v.i., Prague and Faculty of Biomedical Engineering, Czech Technical University in Prague)

Antimicrobial peptides play an important role in innate immunity of all organisms; their interaction with plasma membranes of the microbes is considered to be essential for understanding their biological activity. We are using artificial models of biological membranes such as supported lipid bilayers or large unilamellar vesicles to investigate the mode of interaction of selected antimicrobial peptides with biological membranes. Changes in lipid ordering in the membranes and their permeation induced by antimicrobial peptides are monitored by fluorescence spectroscopy, fluorescence correlation spectroscopy and confocal fluorescence microscopy.

Lateral diffusion in zeolite-supported phospholipid bilayers

P. Jurkiewicz (J. Heyrovsky Institute of Physical Chemistry AS CR v.v.i.)

Two dimensional micro porous zeolite Nano films are used as a support for phospholipid membranes. The zeolite film surface properties, most importantly roughness, can be easily tuned, which affects the coupling forces between the support and the lipid bilayer. We investigate the influence of that coupling on the lateral diffusion of lipids using fluorescence correlation spectroscopy.

14.00 – 15.00 Session 4

Fiber optics for bio-medicine and Cooperation with ICPF AS CR, v.v.i.

Marie Pospíšilová[1], Gabriela Kuncová[2], Vlastimil Matějec[3], Hana Kalábová[1] ([1]Czech Technical University in Prague, [2]Institute of Chemical Processes, AS CR, v.v.i., [3]Institute of Photonics and Electronics AS CR, v.v.i)

In the presentation short introduction to the fiber optics is done what means basic principles and relation describing the light transition via optical fibers together with description what influent its transition. Optical fiber parameters which play important function for its applications in biology and medicine are presented. The second part of presentation is devoted to the profile of ICPF AS CR, v.v.i and its principle parts of cooperation in the KA8.

Optical fibers for chemical sensors and bio sensing

Vlastimil Matějec, Miroslav Chomat, Ivan Kasik, Ondrel Podrazky, Marie Pospislova (Institute of Photonics and Electronics AS CR, v.v.i.)

This lecture will deals with optical fibers for chemical sensors and biosensors developed in the Institute. It will present approaches for increasing the sensitivity of evanescent-wave chemical sensors such as the excitation of PCS fibers by an inclined collimated beam, beveled PCS fibers, sectorial fibers, inverted graded-index fibers. It will show examples of using of chemical- and biotransucers together with optical fibers for detection of pH, oxygen or glucose. Finally, it will deal with taper tips for detecting pH changes in plant cells.

15.15 – 17.00 Session 5

Progress in modeling of high intensity radiation plasma sources

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Accurate computational modeling of transient high energy density multicharged ion plasmas is one of the key factors for scientific and technological solutions in high intensity radiation sources. The innovative multiphysics code based on Z* code is being developed to model high energy density plasma and to develop powerful radiation sources for the various applications from Z-pinches and inertial confined fusion to the EUV lithographic industry. A number of case studies utilizing the

improved code for soft X-ray - EUV range sources based on dense Z-pinch, discharge produced plasma and laser produced plasma are presented, allowing us to highlight on these examples some of the unique features in both Z* and the specific plasma configurations of interests.

Table-top EUV/XUV source for metrology applications

K. Mann, F. Barkusky, P. Grossmann, M. Olschewski, M. Reese (Laser-Laboratorium Göttingen,Göttingen / Germany)

Table-top laser-driven plasma sources for generation of EUV (13.5nm) and XUV radiation in the water window (2.2 – 4.4 nm) were developed and optimized regarding photon flux. Combined with a grazing incidence spectrometer, the XUV source is employed for near-edge x-ray absorption fine structure spectroscopy (NEXAFS) of various elements in the water window, especially at the carbon K-edge. Structural analysis of both organic and anorganic samples with high surface sensitivity is demonstrated, showing good agreement with corresponding synchrotron data. Furthermore, EUV radiation at 13.5nm is focused with a Schwarzschild objective consisting of two spherical mirrors with Mo/Si multilayer coatings. This integrated source and optics system is employed for material interaction investigations and damage / degradation testing of optical elements for EUV lithography, especially Mo/Si multilayer mirrors

XUV Radiation from Gaseous Target Laser Plasma

Pavel Vrba, Mira Vrbová, Petr Brůža, Dalibor Pánek (A Institute of Plasma Physics, Academy of Sciences, CR, Czech Technical University in Prague, Faculty of Biomedical Engineering, CR)

Incoherent water window radiation from laser plasma created in gaseous target by Nd:YAG laser is studied. Computer and laboratory experiments are compared. For computer modeling the RMHD code Z* is used. The laboratory measurements are performed with the LLG equipment. Particular attention is paid to “water window” spectral range

Emission Properties of Non-equilibrium Gadolinium Plasma at 6.x nm Waveband

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Recent results on spectral measurements for Gd and Tb plasmas show the capabilities to use these elements for the next generation of EUV and soft X-ray radiation sources. The maximum emission points located on spectrum are around 6.8 nm for gadolinium and 6.5 nm for terbium. In 0.2 nm range the necessary emission may be obtained from Gd XVII – Gd XXI ions and Tb XVIII – Tb XXII ions. These highly charged ions have a high ionization potential and for equilibrium case the temperature of plasma needs to be heated to 100 eV and higher to produce the sufficient fraction of them.

Discharge and laser produced plasmas used in soft X-ray and EUV sources are in non-equilibrium state as a rule. This leads to the mismatch between of actual conditions of the plasma and its theoretical/computational estimations, because of different effects like non-Maxwellian electron

distribution, self-absorption etc. leading to change ionic compound, state populations, emission intensity and spectrum.

In the report the emission properties of non-equilibrium Gd plasma is considered and the optimal emission conditions are explored. Plasma modeling is performed by using RMHD Z* code. Kinetic parameters for non-equilibrium plasma including inelastic ion interactions with non-thermal electrons, emission and absorption data are obtained in the approach based on Hartree-Fock-Slater (HFS) quantum-statistical model and distorted waves approximation.

Capillary discharge XUV source in the range 2-50nm developed at FNSPE CTU.

A.Jančárek, M.Nevrkla, J.Novak, P.Vrba, M.Vrbova (CTU Faculty of Nuclear Sciences and Physical Engineering)

water window and lasing at 46.9nm with several working gases was developed andtested during several last years. It can be used for applications in biomedicine and technology.

17.00 – 17.45 Session 6

New skin perfusion imaging technology: Concept of contactless sensing and visualization in VIS and NIR

V. Blazek et al. (Chair for Medical Information Technology, Helmholtz-Institute for Biomedical Engineering, RWTH Aachen University, Aachen, Germany)

The phenomena of rhythm fluctuation of arterial blood pressure were discovered in the 18th century. Since the first continuous recording of the blood pressure, a series of investigations have been developed, which deal with the problem of acquisition of the rhythm fluctuation of the circulation. However, the formation of such rhythm hasn't been explained till now. A practical, noninvasive acquisition of the perfusion rhythm on skin can be realized by optoelectronic method with the help of quantitative photoplethysmography (PPG).

Recently, use of modern optoelectronic technique, namely, new camera based sensor and signal processing strategies allows contactless measurement of cutaneus perfusion with simultaneous time and spatial resolutions (PPG Imaging).

The possibilities of this concept will be explained and the application of the technology in some areas with examples and perfusion protocols will be portrayed.

Optoelectronical studies of skin perfusion rhythmicity

V.J. Kumar et al. (Department of Electrical Engineering, Indian Institute of Technology Madras (IITM), Chennai, India)

It has been established that skin perfusion signal rhythms, obtained through the method of photoplethysmograpy (PPG), have myriad of applications in noncontact sensing and diagnostics. However, most of the existing analysis leading to signal detection is performed with empirical relations derived from physical experimental data. In this talk, for the first time an analytical model for a PPG, derived from fundamental principles of interaction of light with biological cells is presented.

The experimental verification of the proposed model for arterial as well as venous blood perfusion dynamics is discussed. An application of the model for the computation of oxygen saturation in arterial blood using the method of pulse oximetry highlights the practicality of the proffered model.

Possible indo-European collaborative avenues on these and associated biomedical research activities will also be presented.

Selected Ion Flow Tube Mass Spectrometry for breath analysis and other applications

Patrik Španěl (J. Heyrovsky Institute of Physical Chemistry AS CR v.v.i.)

Selected ion flow tube mass spectrometry, SIFT-MS, is a technique for real-time measurement of concentrations of trace gases and vapours of volatile compounds in humid air including exhaled breath. It is based on chemical ionization using H3O+, NO+, and O2+ precursor (reagent) ions via ion/molecule reactions proceeding during an accurately defined time. Absolute concentrations of trace gases can be calculated from the ratios of ion count rates using the know reaction rate constants with a limit of detection being typically 1 parts-per-billion, ppb. SIFT-MS is used in several areas of research including non-invasive breath analysis for clinical diagnosis and for therapeutic monitoring, environmental research and security related research.