ABSTRACTS OF THE PAPERS SUBMITTED IN THE COMPETITION

A. Abstracts of the papers submitted as an equivalent of the habilitation thesis

A1. A highly efficient biosensor based on MAPLE deposited hemoglobin on LPGs around phase matching turning point

In this paper we report for a highly efficient sensor able to detect low-level glucose in saliva using ultra-sensitive long-period grating (LPG) fibre structure. Hemoglobin was directly immobilized on the structure by matrixassisted pulsed-laser evaporation (MAPLE) method. Glucose binds to hemoglobin and the result is a glycated hemoglobin, the formation of which we detect. We demonstrate that the implemented technology allows for a clear relationship between glucose concentration and the spectral shift. As a result, a reliable detection of glucose concentration as low as 0.1 mmol/L is demonstrated.

A2. A pitch of helicoid of chiral liquid crystals and surface plasmon excitation: A theoretical study

Surface plasmon resonance (SPR) is widely used in different types of optical detection schemes and for light manipulation. There are a lot of experimental and theoretical investigations about the influence of different media, adjacent to the metal layer, on SPR. However, the influence of liquid crystal (LC) layer is not fully revealed. There are only few publications considering Kretshmann configuration with LC layer sandwiched between the prism and metal layer. Respectively, a lot of questions regarding the influence of LC properties on the surface plasmon resonance (SPR) are still open. The aim of this paper is to fill this gap.

A3. Surface plasmon and guided modes excitation of cholesteric liquid crystal layer

The features of optical excitation of surface plasmon and guided modes in nematic liquid crystal layer (NLCL) are well studied. This problem has never been considered for cholesteric liquid crystal layer (CLCL). There are a lot of open questions, in spite some considerations have been recently performed. The aim of this work is to answer some questions by a theoretical study. A series of guided modes and surface plasmon are excited in CLCL at the condition of attenuated total reflection. The structure we consider has two main differences, compared with the nematic liquid crystal cell: i) the twist angle is a function of layer's thickness; ii) the pitch of the helical structure defines how the wavelength "sees" the refractive index profile of the liquid crystal layer. These special features presume that the critical angles for extraordinary modes

are different than that of NLCL. We propose to use “effective critical angle” defined in terms of pitch length. The effective critical angle explains very well the dependence of number of guided modes on tilt angle and on pitch.

A4. An anisotropic stratified structure for surface plasmon excitation

Surface plasmon resonance (SPR) is widely applied for bio/ chemical sensing. The main problem for all sensors is accuracy and sensitivity enhancement. For SPR sensors the accuracy depends on the characteristics of the plasmon resonance. In this work, we study SPR excitation assisted by liquid crystal layer. We consider Kretshmann configuration where a liquid crystal is sandwiched between a prism and glass plate, while the gold layer is evaporated over the glass plate. We show that the Bragg reflection of cholesteric liquid crystals modifies the plasmon resonance in a way increasing the accuracy of its location. Also, features of plasmon resonance excitation are studied for chiral liquid crystals.

A5. Surface plasmon resonance on the surface: metal - liquid crystal layer

Surface plasmon resonance (SPR) is widely used in different types of optical detection schemes and for light manipulation at sub-wavelength scale. Usually Kretschmann configuration is used for effective SPR excitation. There are a lot of experimental and theoretical investigations about the influence of the dielectric, adjacent to the metal, on SPR. However, till now the influence on liquid crystal layer, adjacent to the metal, is not considered to our best knowledge. The purpose of the present paper is to cover this gap. We simulate the influence of thin layer of liquid crystal, adjacent to the metal, on the SPR characteristics. For this purpose Maxwell equations are numerically solved for layer structure: prism/gold/liquid crystal/air. The light reflection spectra are calculated for chiral structure of ferroelectric smectic C (SmC*) liquid crystal layer. The angular and wavelength response are considered. Special attention is paid to SPR excitation for variation of tilt angle and different angle of incident light. The influence of SPR of the pitch length and cell thickness is also considered.

A6. Long-Range Surface Plasmon Supported by Asymmetric Bimetallic Structure

With this study, we prove that an asymmetric bimetallic structure can support long-range surface plasmon (LRSP) and propose a procedure for its optimization. By applying different criteria we prove that the plasmon which is supported by the structure is indeed LRSP. Unlike all known asymmetric structures supporting LRSP, our structure provides prism excitation and can be used as a biochip for biosensing. Moreover, we show that the structure supports a plasmon with the same propagation constant as LRSP and which is excited at the interface of metal and buffer. This plasmon can be used as a reference channel providing information for the temperature of the structure.

A7. Dual-mode surface-plasmon sensor based on bimetallic film

We propose a plasmonic structure, based on a silver-gold two-layered metallic film, where two surface plasmons (SPs) with equal propagation constants are excited simultaneously at different wavelengths. We show theoretically that the bimetallic film provides unique opportunities for manipulation of plasmons and optimization of the accuracy and cross-sensitivity. The structure can be used as an effective self-reference SP sensor in wavelength-interrogated design.

A8. Plasmon Modes Management

A new plasmonic structure based on bimetallic layer is proposed. We analyze the structure and show that bimetallic film plays a crucial role in the management of surface plasmons. The roll of the buffer is discussed, as well. Up to three surface plasmons can be excited simultaneously in the structure. Two of plasmons can be used for two-plasmon spectroscopy. The third plasmon can be used for controlling the temperature of the structure

B. Abstracts of additional papers out of habilitation thesis

B1. Dataset of MAPLE Parameters for Hemoglobin Deposition upon long period gratings

Matrix-assisted pulsed laser evaporation (MAPLE) is an alternative and complimentary method to pulsed laser deposition. MAPLE has been demonstrated to be a less harmful approach for transporting and depositing delicate, highly sensitive molecules. Metalloproteins are considered sensitive molecules since their bioactivity is determined not only by their chemical structure but also by conformational changes that can be altered by deposition methods. Here we report a dataset of MAPLE deposition parameters of haemoglobin (Hb) that ensures the retention of its bioactivity. Methods for parameters optimization are also described. The data and analysis should be valuable for researchers interested in application of MAPLE techniques for metalloprotein immobilization since it provides a unique opportunity for direct immobilization. The data presents the results of previously conducted experiments on the basis of which is based the research article entitled “A Highly Efficient Biosensor based on MAPLE Deposited Hemoglobin on LPGs Around Phase Matching Turning Point”

B2. Development of a composite polymer-dye medium for tunable laser emission

We demonstrate optically pumped laser medium with emission in the visible spectral range from binary solutions of Rhodamine 6G and Rhodamine B in epoxy resin as matrix without appending additional scattering centers. A frequency doubled Q-switched Nd: YAG laser was used for pumping. The generation's behavior is similar to random laser (RL) with no external optical resonator. The influence of the nanostructured morphology of the medium on the laser properties was investigated by means of SEM, AFM, TEM, SAED, Spectrofluorimetry and Spectrometry. The laser emission is characterized by high intensity – energy per pulse – 300 μJ, threshold pump energy 1.7 mJ, relatively low beam divergence of 70 mrad (for RL) and spectrally narrowed major peak at 597 nm. The new gain medium was also investigated in a conventional tunable resonator. Generation with continuous tuning in the spectral range 590–610 nm was obtained. This new effective nanostructured medium, which shows with high optical and energy parameters, can be used in speckle-free laser imaging, time-resolved microscopy, high speed optical converters and others photonics applications.

B3. Thin hemoglobin layers deposited by MAPLE technology

Biosensing applications require high performance, including real-time monitoring of physiological events, detection of toxins, and advanced diagnostics. Such functionality will necessitate biosensors with increased sensitivity, specificity, and throughput, as well as the ability to simultaneously detect multiple analytes. To this end, we elaborate on one of bioprinting technologies - the matrix-assisted pulsed-laser evaporation (MAPLE) that is an advanced method for biomaterial deposition.

B4. DYE Doped Polymer Medium for Photonics Applications

The development of new materials for different optical applications is one of the most important topics for the photonics industry. In the present work we study the optical properties of a new photonics medium consisted of an epoxy based polymer as matrix with dissolved binary solutions of Rhodamine 6G and Rhodamine B. Detailed study of the spectral dependence of fluorescence of the new medium has been performed. It was found that the intensive fluorescence follows the spectral dependence of dyes' transmission in spectral interval 390 - 780 nm. The new medium's fluorescence was studied by means of spectrofluorimeter FluoroLog 3-22. The stimulated emission was obtained with irradiation by SHG Nd:YAG laser with parameters: energy – 50 - 100 mJ, wavelength – 532 nm, repetition rate 1 Hz and pulse duration of 10 ns and measurement by high-resolution nanosecond Michelle 5000 spectrograph (ICCD detector). Studies have shown that stimulated radiation is characterized by very narrow

lines of radiation throughout the fluorescence spectral range. The medium can be made with different rigidity depending on the concentration of different solvents. It is remarkable that in a wide range of solvents and dyes concentration the medium properties are determined by mixture as a whole. The relationship between the optical properties of this new material and its nanostructured morphology is shown. Due to the large tolerance of rigidity the material can be made in different forms and dimensions, as well bulk medium, optical active fibers and thin films.

B5. Comparative study on the bio-activity of hemoglobin and myoglobin as recognition materials in biosensors

It was studied the bio-activity of hemoglobin (Hb) and myoglobin (Mb) films directly deposited or incorporated in matrix. The direct immobilization was performed by spin coating. The matrix-assisted pulsed-laser evaporation (MAPLE) technique was used for the matrix-assisted immobilization. The bio-activity was studied by measuring the resonance shift of Surface Plasmon Resonance (SPR). For the purpose, Hb and Mb films were deposited on a SPR transducer. Actually, we elaborated the first SPR sensor based on hemoglobin and myoglobin, to the best of our knowledge. The performance of both type of SPR chips – direct and MAPLE immobilized was studied by SPR registration of the binding activity of myo- and hemo- globin ligands with carbon monoxide (CO), carbon dioxide (CO_2) and nitric oxide (NO).

B6. PERSPECTIVE LASER MEDIUM FOR RANDOM LASING

Random lasers are a novel disorder-based laser light source with many photonics applications. In the present work we study the optical properties of a new unordered medium consisted of an epoxy resin as matrix with dissolved different binary solutions of Rhodamine 6G and Rhodamine B. The choice of these dyes is related to their great application in laser physics. A detailed study of the spectral dependence of fluorescence is performed. The spontaneous emission is very intensive and follows the spectral dependence of dyes transmission and exceeds 750 nm. The threshold of the laser medium is 1.6 mJ for 10 ns pulse at second harmonics of Nd:YAG laser, and full width at half maximum (FWHM) is around 1.5 nm. Slope efficiency of the medium is 16%. The laser generation without resonator was studied also and lasing emission at 597 nm was observed. The fact can be explained by random lasing provided by the medium. This is in good relation and in accordance with the intensive scattering inherent to the medium which is registered. Not used additional scatter centers such as ZnO nanorods or Ag, Al, Al_2O_3, TiO_2 agglomerates and others in our experiments.

B7. Direct immobilized nanostructured myoglobin for CO detection by surface plasmon resonance

Announced is a nanostructured myoglobin (Mb) layer directly immobilized by modified pulsed laser deposition. The biological activity of Mb nanostructured layer is proven by its CO sensing capacity.

B8. Color plasmons and trains of plasmons

We show that a broadband surface plasmon can be excited in a thin metal film. A train of two plasmons can be excited at conditions near the condition of broadband surface plasmon excitation. Also, a method for independent multichannel checks of biochips by wavelength addressing is proposed.

B9. Modified channeled spectrum for fast measurement of thin films

A simple and effective technique for the simultaneous measurement of the refractive index and the thickness of thin films is proposed. The method is based on the spectral dependence of the visibility of interference fringes that result from thin-film interference when the film is illuminated with a white light. The film is on the special substrate, and an optical contact is provided between them. The measurement consists of finding the local change of the fringes' visibility in the observed channeled spectrum expressed as the seaming change of the fringes' periodicity. The method can be applied for real time optical inspection during the manufacturing of thin polymer films.

B10. Vortex polarimetry

Optical vortices have been applied for the purpose of polarimetry measurement. Vortex polarimetry combines the features of null polarimetry and imaging Fourier polarimetry providing one shot measurement. Different polarimeter systems and limiting accuracy factors are discussed.

B11. Spectral-domain interferometry for simultaneous measuring the refractive index and thickness

A new method for real-time and simultaneous measuring the refractive index and thickness of thin films is proposed. The method is based on spectral dependence of phase-shifting on reflection at one of film's surface. The measurement consists in localizing t- phase shift observed in a channel spectrum.

B12. Left handed composite materials in the optical range

The purpose of this paper is to show that semiconductor nano-structures built from non-magnetic InAs/GaAs nano-rings can exhibit simultaneously negative effective permittivity and permeability over a certain optical frequency range. The structures are resonant and have this property near the edge of absorption of the nano-rings. This can be particularly interesting in the investigation of the challenging problem of development of left-handed composite materials in the optical range.

B13. Optimization of second harmonic generation in non-linear film structure

The problem about optimization of second harmonic generation (SHG) by a laser beam in a non-linear medium with dimensions less than the beam size has not been solved yet. We present a theoretical method providing an optimization of SHG in the case of non-linear film non-waveguide structure. We have found that even in the case of perfect phase matching there is an optimum length for maximum non-linear interaction. The dependence of generation efficiency on different type of non-linear profiles has been established and related with experimental results.

B14. All-Fiber Optic Parametric Oscillator Based on Second Order Nonlinearity

An all-fiber parametric oscillator based on (χ) 2 nonlinearity is presented. Nonlinear process takes place in a new type fiber coupler - (χ) 2 grating - assisted coupler which consists a part of fiber - ring resonator.

C. Abstrats of patents and utulity models

C1. Многофункционален оптичен противопожарен сензор

The utility model refers to a multifunctional optical fire detector. The functionality is the ability to detect carbon monoxide, smoke and temperature simultaneously and continuously. Detection is performed entirely by optical methods, which means that no voltage is applied to the detection device and no electric current flows. This allows the use of the detector in explosive production premises or storage warehouses, as well as in the presence of other aggressive agents. The detector can be built into a fire protection system in large premises. This is easy and inexpensive, since it is based on technological solutions used in optical communications. Due to its versatility, the detector is universal and satisfies the often contradictory requirements for fire protection of various destinations.

C2. Устройство за достъп до управление на МПС чрез установяване на идентичност и след неинвазивно установяване на алкохолно съдържание в организма

The utility model refers to a device that provides a personal indentification (through biometric control of the structure of the veins of the finger), while non-invasiv alcohol detection is performed. In case of positive personal identification and established concentration of alcohol below the permissible norms, the device gives access to driving. The utility model aims to further protect vehicles from encroachment and restrict driving after drinking alcohol. It is used in public transport and in driving personal vehicles. Government and insurance organizations are interested, given the fact that in Europe about 25% of accidents are alcohol inspired.
The device advantage, according to the invention, is that it combines biometric personal identification (based on venocode) with non-invasive determination of the alcohol concentration by reliable and reproducible photo-thermal radiometry. The device thus described may be designed for installation in vehicles for the prevention of theft or alcohol inspired driving by connection to the immobilization system. The device may have a version for stationary installation giving access to premises requiring identification and control of alcohol use of personnel. Alcohol detection is fast, reliable and non-invasive.

C3. Оптичен сензор за измерване на силни токове

The optical sensor for high currents measuremets is used in industry and in particular for measuring current in powerful power distribution devices (substations), for control of technological processes for production of non-ferrous metals by electrolysis or by induction furnaces. The optical sensor is also applicable in all cases requiring measuremenst of electric current of tens or hundreds of kiloamperes. The sensor uses a laser as a source of optical radiation, emitting both a signal and a reference wave, sufficiently spectraly separated so that the polariser can polarize only the shorter wavelength, emitted by the laser.