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Chronicle

42nd Winter School on Wave and Quantum Acoustics 41th Winter School on Vibroacoustical Hazards Suppressions

Szczyrk, Poland, February 25 – March 1, 2013

Traditionally you are invited to acquaint yourselves with some information connected with *42nd Winter School on Wave and Quantum Acoustics, 41st Winter School on Vibroacoustical Hazards Suppressions*.

For some years together Winter Scools are also organized the international optical conference – *Integrated Optics – Sensors, Sensing Structures and Methods*.

The Conferences traditionally held at the turn of February and March and now they are again organized in Szczyrk, in beautiful winter scenery.

The Conferences, as in the previous years, have some organizers, i.e. Upper Silesian Division of the Polish Acoustical Society (the main organizer), the Department of Optoelectronics and the Institute of Physics – Science-Didactic Center at the Silesian University of Technology and the Committee on Acoustics of the Polish Academy of Sciences as well as the Committee of Electronics and Telecommunication of the Polish Academy of Sciences.

The Conferences are traditionally sponsored by the Ministry of Science and Higher Education.

The Conferences have the splendid honorary patron – Prof. Dr. Hab. Eng. Andrzej Karbownik, His Magnificence Rector of the Silesian University of Technology.

On behalf of Organizers
prof. Marian Urbanczyk
Chairman Upper Silesian Division of PAN

Abstracts

Applications of precision measurements of electrical conductivity of the solutions

Bald A.

Modern, precise studies of electrical conductivity of electrolyte solutions are one of the main tools of research in physical chemistry of electrolyte solutions. These studies allow to get in a fairly simple way the values of molar limiting conductance, values of association (dissociation) constant as well as the values of the distance parameters of ions. After using a appropriate methods can also determine the values of ion limiting molar conductance. Values of limiting molar conductance are used mainly to describe the interactions of ions with solvent. These values of limiting molar conductance are also important from the application point of view. Extremely important is the role of conductivity research to determining of equilibrium constants of different types. Examples of applications of modern conductivity measurements to solve various problems and determining the value of various physicochemical parameters has been presented. It also discusses the difficulties associated with the interpretation of some of the results of conductivity measurements.

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Some remarks on the experimental aspects of determining apparent and partial molar volumes

Bald A., Klimaszewski K., Trzcińska I.

Apparent and partial molar volumes are the fundamental properties describing solute and its interaction with the solvent. For the determination of these parameters density measurements are used most frequently. However, studies of density of solutions must meet the relevant standards related to the methodology used for research and measurement apparatus. Otherwise, the partial molar volume values can not be determined or these values are unreliable. Specific examples are shown to present difficulties in determining the value of the apparent and partial molar volume and ways to overcome these obstacles and also, what are the restrictions on the use of density measurement. Mainly electrolyte solutions were discussed as creating more research problems.

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Forced pendulum as a low frequency mechanical spectroscopy to probe physical phenomena in semi-crystalline polymers

Boyer S. A. E., Riviere A.

Originally, a sub-resonant forced pendulum suspension is proposed to probe reliable source of information related

to relaxation processes in semi-crystalline polymer materials. The forced pendulum is a prototype permitting accurate damping measurements for a wide frequency scale 10^{-4}–50 Hz under 298–873 K [Woirgard, Mazot, Rivičre, J. Phys., 42 C5 (1981)]. Mechanical loss measurements are carried out as a function of vibration frequency at fixed temperatures.

Internal friction and shear-modulus are obtained from frequency characteristics, as illustrated with the position of the maxima of mechanical loses for the alpha relaxation processes in a polyamide 11.

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Ultrasound research on DHP

Brożyna A., Kaczmarek-Klinowska M., Skumiel A.

Cyclodextrin molecule can form an inclusion complex with a guest molecule. For our study water and ethyl alcohol solutions of nimodipine (derivative of 1,4-dihydropirydine) and methyl-β-cyclodextrin were prepared. Solutions with different guest and cyclodextrin ratio were fixed in both environments. Measurement of velocity (using the resonance method at the frequency of 8 MHz), thermal capacity and density of the samples were conducted. Finally the redundant functions of the molar volume and adiabatic compressibility were calculated. Based on the results of the research the existence of inclusion complex between nimodipine and methyl-β-cyclodextrin molecules can be determined.

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Thermodynamics of dihaloalkanes at high pressures

Chorążewski M., Grolier J.-P.

The knowledge of the thermophysical properties of liquid halogenoalkanes is of high interest on account of their wide usage in science and industrial processes. High temperature – high pressure properties are directly applicable to the designing of chemical processes as well as for the progress of thermodynamic theories. pVT behavior will be useful later in analyzing the effect of pressure on a number of physical and thermal properties, on chemical equilibrium, and to some extent on chemical reaction kinetics.

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1-alkoxymethylimidazolium salicylates: correlation between ionic structure and physicochemical properties

Czech B., Feder-Kubis J., Zorębski M., Chorążewski M., Dzida M., Geppert-Rybczyńska M., Hensel-Bielówka S., Zorębski E., Żarska M.

A new family of ionic liquids, composed of salicylate anion and 1-alkoxymethylimidazole cation, were synthesized and characterized. The acoustic, volumetric, calorimetric and refractometric investigation for this salts was performed. The properties under study are sensitive to the structure of the cation. The sound velocity, density and refractive index decreases linearly with increasing alkoxy chain length substituted in imidazole ring whereas molar heat capacity is changing in opposite way. Elongation of alkoxy chain leads to an expansion of the nonpolar region what influences the interactions and consequently the basic physicochemical properties.

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Photopyroelectric Calorimetry of Magnetic Nanofluids. Effect of Type of Surfactant and Magnetic Field

Dadarlat D., Longuemart S., Turcu R., Streza M., Vekas L., Sahraoui A. H.

Five types of magnetic nanofluids, based on Fe_3O_4 nanoparticles with water as carrier liquid, were investigated by using the two PPE detection configurations (back and front), together with the TWRC technique as scanning procedure. The difference between the nanofluids was the type of surfactant: double layers of Lauric (LA-LA), Oleic (OA-OA) and Miristic (MA-MA) acids and also double layers of Lauric-Miristic (LA-MA) and Palmitic-Oleic (PA-OA) fatty acids were used. In both detection configurations, the information was contained in the phase of the PPE signal. In the BPPE configuration, the thermal diffusivity of the nanofluids was obtained from the slope of the phase of the signal as a function of liquid's thickness. In the FPPE configuration the thermal effusivity was directly measured. The influence of a 0.12 kG magnetic field on the thermal effusivity and diffusivity was also investigated. Due to different surfactants the value of the thermal effusivity of the investigated nanofluids ranges from 1530 $Ws^{1/2}m^{-2}K^{-1}$ to 1790 $Ws^{1/2}m^{-2}K^{-1}$, and the value of thermal diffusivity, from 14.54×10^{-8} m^2/s to 14.79×10^{-8} m^2/s. The magnetic field has practically no influence on the thermal effusivity, and produces a maximum increase of the value of the thermal diffusivity (LA-LA surfactant) of about 4%.

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A New Photothermal Calorimetry: the Photothermoelectric (PTE) Technique

Dadarlat D., Streza M., Kuriakose M., Depriester M., Sahraoui A. H.

The recently introduced photothermoelectric (PTE) effect is proposed as an alternative for measuring dynamic thermal parameters of solid samples. The front PTE configuration, together with the thermal-wave resonator cavity (TWRC) method as scanning procedure, was used to measure the value of thermal effusivity. The back PTE configuration, together with the chopping frequency of incident radiation as scanning parameter, leads to the direct measurement of thermal diffusivity. The theory of the two detection configurations was developed and applications on some solids, covering a large range of typical values of thermal parameters (aluminum, glass, teflon, polyethylene, $LiTaO_3$), were described, in order to demonstrate the suitability of the method. Some comparison with the photopyroelectric (PPE) method has been done.

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Impact of infrasound noise emitted by wind turbines for human

Dobrucki A., Bogusz B.

The state of knowledge concerning wind turbine noise in infrasound and low-frequency range as well as its in-

fluence into humans are presented in the paper. The infrasound is defined as noise in frequency range below 16 Hz. Low-frequency noise is defined by various authors or standards as the noise with frequency range above 16 Hz but lower than 100, 160 or 200 Hz. Both kinds of noise are produced aerodynamically by rotating wind turbine blades. This noise should be measured in 1/3-octave frequency bands or with using frequency weighting curve G. Infrasound influences the auditory system, internal organs, respiratory system, nervous system and coronary vascular of humans. High levels of infrasound can be perceived by auditory system. Typical values of G-level are equal to 60–70 dB at the distance 300–600 m from wind turbines. The permitted values of infrasound levels are 102 dBG at workplaces and 86 dBG for conceptual works requiring special attention span. This means that the wind turbines are not oppressive sources of infrasound noise.

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Hydration of Na^+ and K^+ with hydrogen maleate and hydrogen carbonate. Car-Parrinello Molecular Dynamics vs. Speed of Sound Experiment

Dopieralski P., Burakowski A., Gliński J., Latajka Z.

Ion hydration plays an important role in many chemical processes an thus significant number of work have been done concerning this phenomena. The importance of metal ions, commonly found in nature, and their numerous applications in the field of chemistry is undeniable, as well as their role in the life processes.

In this work we study the hydration of Na^+ and K^+ cations alone and with hydrogen maleate and hydrogen carbonate anions by means of Car-Parrinello Molecular Dynamics simulations. The influence of hydrogen maleate or hydrogen carbonate ion on hydratation numbers of Na^+ and K^+ will be discussed as well as the opposite effect. Obtained from theoretical investigations hydration numbers will be compared with experimental data from speed of sound measurements.

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Pulse photothermoacoustics of small-volume liquid probes

Egerev S.

Laser sound generation in small-volume liquid probes is considered under the conditions of small laser fluence thus giving rise to the linear thermoacoustic conversion. The results obtained are of great demand by analytical chemistry. The outgoing acoustic signal has some peculiarities if the probe layer has thickness within 10–450 μm. With a laser pulse width of about 20 ns the absorbing probe layer exhibits acoustically thin or acoustically thick properties. This depends on a specific task. Physics of the photoacoustic conversion in the small-volume probes is revealed for both acoustically thin and acoustically thick cases under the general conditions of thermally and optically thin probes. We developed an optoacoustic measurement cell of a layered-prism (LP) optimized type. Using this LP cell we provided precise concentration measurements for a model system.

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Ultrasonic absorption spectra of paramagnetic 1-alkyl-3-methylimidazolium ionic liquids: $[EMIm]_2[Co(NCS)_4]$ and $[BMIm]_2[Co(NCS)_4$

Geppert-Rybczyńska M., Dzida M., Zorębski E., Zorębski M., Chorążewski M., Żarska M., Czech B., Heintz A., Peppel T., Köckerling M.

The ultrasound absorption measurements were performed in two paramagnetic 1-alkyl-3-methylimidazolium ionic liquids, i.e., $[EMIm]_2[Co(NCS)_4]$ and $[BMIm]_2[Co(NCS)_4]$ within the frequency range from 10 to 300 MHz at the temperatures 293.15 and 298.15 K and at atmospheric pressure. The measurements were made by the use of the measuring set operates on the standard pulse technique with a variable path length. The dependence of the quotient $\alpha \cdot f^{-2}$ on frequency changes strongly with temperature. It appears also that within the investigated frequency range the quotient $\alpha \cdot f^{-2}$ is clearly dependent on frequency as early as above 10 MHz both in the case of $[EMIm]_2[Co(NCS)_4]$ and $[BMIm]_2[Co(NCS)_4]$. Thus, in both cases the dispersion characteristics $d\alpha \cdot f^{-2})/df < 0$ is observed. Moreover, the both liquids are rather highly absorbing, i.e., the frequency normalized attenuation (at $T = 298.15$ K and $f = 100$ MHz) are $837 \cdot 10^{-15}$ and $1321 \cdot 10^{-15})$ $s^2 \cdot m^{-1}$, respectively. Above some frequency, the experimental values of $\alpha \cdot f^{-2}$ are smaller than those predicted by the Navier-Stokes relation. The absorption curves indicate that $\alpha > \alpha_{cl}$ at lower frequencies and $\alpha < \alpha_{cl}$ at higher frequencies, and that the frequency for which $\alpha = \alpha_{cl}$ decreases with the increasing temperature. Most probably this kind of behaviour would result from a relaxation mechanism of the viscous type. Similar behaviour has been reported previously for 1-dodecanol and castor oil.

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Acoustic properties of magnetosomes

Józefczak A., Hashim A., Molcan M., Hornowski T., Skumiel A., Kopčanský P., Timko M.

The objective of the work is to study the biological magnetic nanoparticles (magnetosomes) as a product of the biomineralization process of magnetotactic bacteria Magnetospirillum sp.AMB-1. This paper presents an ultrasound method based on the measurements of compression wave velocities and determination of the phase velocity of a wave. The obtained data allow the determination of the mechanical characteristics of the suspension. The study of elastic properties shows, that bulk modulus of a bacterial magnetosomes suspension increased with the increase of temperature like in chemically synthesized magnetite nanoparticles suspension

This work was supported by a Polish National Science Centre grant, no DEC-2011/03/B/ST7/00194 and by Slovak Academy of Sciences, in the framework of Centre of Excellence NANOFLUID, projects VEGA No. 2/0043/2012, APVV 0171-10 and Ministry of Education

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Non-Critical Fluctuations of Liquids – Cinderella of Ultrasonic Spectroscopy?

Kaatze U.

In basic research ultrasonic broadband spectroscopy of liquids is mainly focused on chemical relaxations and critical fluctuations in local concentrations. Chemical relaxations follow Debye-type relaxation behaviour. In contrast, near a critical demixing point binary and ternary liquid mixtures display spectra with broad distribution of relaxation times. In applications small-band spectra related to the scattering of ultrasonic waves from suspensions and emulsions are often used.

In this paper attention is directed to a less popular field in the broadband ultrasonic spectroscopy of liquids. Many liquid systems reveal spectra which are only slightly broader than a Debye relaxation term. They can be favourably represented by relaxation functions following from models of non-critical fluctuations in the local concentrations. The so-called unifying model of non-critical concentration fluctuations is briefly presented and some implications for our understanding of aqueous solutions are discussed which follow from the description of relevant ultrasonic spectra in terms of this model. Also considered in the light of non-critical fluctuations are surfactant solutions close to the critical micelle concentration. An alternative model for the theoretical representation of solutions of pre-micellar and improper micellar aggregates is indicated.

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On the correlation between thermal and electric properites of C-SiC ceramic composites

Kaźmierczak-Bałata A., Mazur J., Drewniak Ł., Bodzenta J.

The carbon silicon carbide (C-SiC) ceramic composites have an outstanding thermomechanical and thermochemical properties, required for lightweight constructions and future engine components. The carbon/carbon silicon carbide (C/C-SiC) composites are high ceramic friction materials used for high speed and high energy braking. The nanostructures of SiC are applied as a basic material for high temperature electronic devices. It was found that pure material is stable up to 2000°C and electronic devices based on SiC perform in temperatures over 200°C.

In this work seven samples of C-SiC composites were examined. A few of them were covered with Au layer and others contained epitaxially growth graphene layer. The samples were produced by sintering method. The thermal diffusivity was determined by continuous wave photothermal technique. The front sample surface was illuminated by the intensity modulated light and the temperature disturbance caused by absorption of this light was detected by infrared (IR) radiometry from the rear surface of the sample.

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Volumetric properties of electrolytes in water – 2-methoxyethanol mixed solvent

Klimaszewski K., Bald A.

Density of KCl, KBr, NaCl and NaBr solutions in mixtures of water with 2-metoxyethanol has been measured at 298.15 K. The values of the apparent molar volumes of tested electrolytes were calculated on the basis of density values. Data from the measurements of the electrical conductivity indicated incomplete dissociation of electrolytes in mixtures with a high alkoxyethanol content which is related to the low permittivity of such mixtures. Therefore, in order to determine the value of the partial molar volume, was used an appropriately modified Redlich-Meyer equation. This equation takes into account the presence of in solution: free ions and undissociated forms of electrolyte (ion pairs) and contains three parameters which should have been determined. Two of these parameters, i.e. the partial molar volume of the electrolyte in of a completely dissociated form and the partial volume of the ion-pairs, are very important for description of the electrolyte-solvent interactions.

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Sensitivity of phase transition of ferronematics in combined electric and magnetic fields

Kopcansky P., Tomasovicova N., Timko M., Majorosova J., Zavisova V., Koneracka M., Tomco L., Mitrova Z., Jadzyn J., Chaud X.

Ferronematics are colloidal suspensions of nematic liquid crystals and magnetic nanoparticles. We have studied the combined influence of electric and magnetic fields on the orientational structure of ferronematics based on a thermotropic nematic 4-trans-4′-n-hexyl-cyclohexyl-isothiocyanato-benzene (6CHBT). The 6CHBT liquid crystal have been dissolved in in phenyl isothiocyanate and doped with the rod-like or chain-like magnetic particles. In such mixture, the phase transition from isotropic to nematic phase is via droplet state, i.e. coexistence of nematic and isotropic phase. The obtained results showed that combination of the electric and magnetic fields can change the character of phase transition form isotropic to nematic phase via droplet state in such systems. Moreover, the magneto-dielectric measurements of structural transitions showed the magnetic field induced shift of phase transition temperature from isotropic to droplet state. All results have direct influence on the construction of liquid crystalline sensors of magnetic field.

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Characterization of pure and modified TiO_2 layer on glass and aluminum support by beam deflection spectrometry

Korte D., Pavlica E., Bratina G., Franko M.

TiO_2 thin films used as photocatalysts in environmental application were studied by beam deflection spectroscopy (BDS) coupled to multiparameter fitting of a novel theoretical model to the experimental data, as well as by AFM measurements. Two groups of films were prepared: pure and N-doped TiO_2 deposited on glass support, as well as

pure, N- and C-doped TiO_2 deposited on aluminum support. The results show a correlation between the thermal parameters of the examined films and their transport properties such as value of energy bad gap, carrier life time or concentration and kind of introduced dopants. Furthermore, the material's thermal conductivity and thermal diffusivity depend on the porosity and the surface roughness of the material, which usually change when the material is used as photocatalysts in water purification processes. Thermal and mechanical properties of the thin film photocatalysts also depend on the support to which the TiO_2 layer is deposited. All of these features determine the performance of the TiO_2 films in their photocatalytic application and can be deduced from BDS measurements. This work confirms the suitability of BDS as a method for noncontact and nondestructive evaluation of thin film TiO_2 photocatalysts, which is also the basis for improving their efficiency.

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Diffusion beyond the Stokes-Einstein theory: effects of inhomogeneity and nonlinear friction

Lisý V., Tóthová J., Glod L.

The Langevin equation describing the Brownian motion of particles is studied in the case when the friction is modeled not by the usually used Stokes force but nonlinearly depends on the particle velocity. The intensity $D(v)$ of the thermal random force driving the particles then also depends on the velocity, and the equation of motion should contain an additional "spurious" force proportional to the derivative of $D(v)$. This force is chosen in the kinetic representation, for which the stationary probability density for velocities is the Maxwell distribution and simultaneously the generalized Einstein relation is obeyed. A general formula for the diffusion coefficient of the particle is obtained and then specified for various models of dissipative forces studied in the literature, e.g., those for active Brownian motion. We also discuss the effects of inhomogeneity in the diffusion and a choice of the appropriate stochastic calculus. The correspondence between the kinetic representation for $D(v)$ and the Stratonovich concept in the description of spatially dependent diffusion has been established.

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Optimization of a thermal lens microscope for detection in a microfluidic chip

Liu M., Novak U., Plazl I., Franko M.

The optical configuration of a thermal lens microscope (TLM) was optimized for the detection in a microfluidic chip. Influence of the flow velocity on the TL signal was analyzed theoretically and experimentally. Optimizations regarding the pump and probe beam parameters (beam waists, offsets, mode missmatching) were made. It was found that an appropriate pump-probe beam offset for certain flow velocity will provide not only a higher sensitivity but also a better response linearity of TLM over three orders of magnitude of concentration. Diffraction-limited pump beam excitation is advantageous for space-resolved measurement, while a larger pump beam with ten times lower power density is favorable for higher sensitivity. As an application, this optimized TLM was used to study the diffusion of ferroin between two aqueous streams in a microreactor chip. The diffusion profiles at different distances from the mixing point were recorded by scanning the TL signal along the cross-section of the microchannel. High sensitivity of TLM enabled accurate detection of small changes in absorbance (7×10^{-6} AU in a 50 μm channel) which provides a powerful tool for depicting the governing transport characteristics in a microfluidic chip by incorporating convection and diffusion terms along with the parabolic velocity profile.

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Photoacoustic Transformation at Opposite-Interaction of Electromagnetic Waves in Magnetoactive Two-Layer

Mityurich G., Sviridova V., Serdyukov A.

The paper considers thermooptical generation of sound in magnetoactive two-layered medium in the conditions of the tunnel electromagnetic interference of electromagnetic waves. It studies the conditions of complete suppression of the amplitude of photoacoustic signal depending on the type of polarization of opposite-interacting waves, the difference of their initial phases, the values of intensity of either opposite-interacting beam. The given paper provides an effective method of management the thermooptical generation of sound in magnetoactive structural element in the conditions of the tunnel electromagnetic interference of electromagnetic waves.

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Study of molecular packing properties of dense simple liquids based on acoustic and thermophysical data

Postnikov E., Goncharov A., Melent'ev V.

We analyze the inverse reduced fluctuations: a form of ratio for speeds of sound for the substance and the model ideal gas of the same molecules at the same density and temperature. We have shown that there exists a relatively wide (up to 25% of reduced density range for each phase) region, where the dependence of relative fluctuation on density has strong exponential character along a liquid-vapour coexistence curve of simple liquids within the region corresponding to dense liquids. These results support the assumption that the structure of a uniform cell packing for substances' molecules and the the model of hole theory of liquids. This conclusion is confirmed by direct numerical calculation using lattice fluid model with mean-field quadratic potential energy of attractive interactions.

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The use of multifrequency induction heating for temperature distribution control

Smalcerz A., Golak S., Przyłucki R.

The paper presents possibilities of controlling temperature field distribution in induction heated charge. The change of the distribution was obtained with use of sequential one-, two-, and three-frequency heating. The study

was conducted as a multi-variant computer simulations of strongly coupled to each other fields: the electromagnetic and the temperature fields. For the analysis, the professional calculation package using the finite element method Flux 3D was used.

The problem of obtaining an appropriate temperature distribution in a heated charge of, a complex shape is very important in many practical applications. A typical example is a quenching of gears. For such applications, it is required to obtain, a surface and in desired depth, uniform temperature distribution on the tooth face and top land and on the bottom land of the gear. The obtained temperature should have proper distribution and value. Achieving such a defined distribution is very difficult. During the study more than 50 different calculation variants were examined.

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Crack depth evaluation by infrared lock-in thermography

Streza M., Dadarlat D., Longuemart S.

This paper describes an approach to evaluate linear opened surface cracks by means of lock-in thermography. The presence of a defect or a discontinuity close to a heated region causes anomalies of heat flow distribution. Highlighting these disturbances provides information on position and depth of discontinuities.

For describing and interpreting the interactions between a modulated laser induced heating spot and a crack, a 3D heat flow simulation model has been developed by using a FEM computer package. The model considers an aluminium metallic block with a linear open crack of length L, width l and depth h, the circular heat source of power P being located at a distance d from the crack. Amplitude and phase of the temperature modulation of the irradiated surface, at the excitation frequency f, have been extracted by computing a temporal discrete Fourier for each pixel of the temperature image. In order to enhance the thermal contrast the proposed procedure exploits the second spatial derivative of the amplitude image. The minimum of this quantity provides information concerning the crack geometry. Information regarding the depth of the crack can be revealed by changing thermal diffusion length of thermal wave in the vicinity of the crack.

Aluminium test specimens with linear open cracks have been investigated and the results are compared with FEM simulation. This approach allows a classification of the cracks according to their depths.

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Heating Characteristics of Magnetic Fluids based on various carrier liquid. Concentrations

Timko M., Molcan M., Rajnak M., Kovac J., Kopcansky P., Skumiel A., Jozefczak A., Majorosova J., Zavisova V., Koneracka M., Tomco L., Mitrova Z., Jadzyn J., Chaud X.

The heating ability of magnetic fluids based on various carrier liquid with different magnetic particle concentrations was studied. The calorimetric measurements were carried out in an alternating magnetic field up to 2500 A·m^{-1} amplitude and of 500 kHz frequency. The obtained law-type dependence of the temperature increase rate, $(dT/dt)t = 0$, on the amplitude of the magnetic field indicates the presence of superparamagnetic particles in the tested samples since $n = 2$. The specific absorption rate (SAR) defined as the rate of energy absorption per unit mass increases with an increasee of the volume fraction of the dispersed nanoparticles and with increasing of density of carrier liquid.

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Theoretical analysis of the influence of dopants on the temperature dependence of thermal diffusivity of single crystals

Trefon-Radziejewska D., Bodzenta J.

The thermal diffusivity dependence on temperature of YAG, YVO_4 and GdCOB single crystals was determined. Samples were doped with different concentrations of rare earth ions such as ytterbium, neodymium, thulium, and transition metal ions such vanadium. Determination of the thermal diffusivity was based on an analysis of propagation of thermal wave in the sample.

Obtained results confirmed, that the influence of doping on the thermal diffusivity of investigated materials strongly depends on temperature.

The thermal diffusivity of all investigated samples decreases with increasing of sample temperature from 30°C to 300°C, but the drop in the thermal diffusivity is the highest for pure single crystals. The introduction of dopant ions into a crystal lattice leads to a significant reduction in the thermal diffusivity at lower temperatures in comparison with pure crystals. However, the influence of dopants becomes less pronounced with increasing temperature, and in the case of weakly doped crystals it becomes negligible at higher temperatures.

The interpretation of obtained thermal diffusivity dependence on temperature for pure and doped single crystals was based on the Debye model of lattice thermal conductivity of solids. It was assumed that the decrease in thermal diffusivity with temperature and increasing concentration of impurities is caused by shortening of the phonons mean free path due to phonon-phonon and phonon-point defect scatterings.

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Peculiarities of hydrogen bond formation in solutions of proton acceptors in ethylene glycol: calorimetric study

Varfolomeev M., Zaitseva K., Solomonov B.

Hydrogen bonds significantly influence on physical-chemical properties of organic compounds in the liquid state. They can be formed between different molecules or between the fragments of one molecule. Thousands of works were devoted to the determination of the thermodynamic functions of hydrogen bonding. Based on experimental data different empirical relationships were obtained. They allow us to calculate the free energy and enthalpy of hydrogen bonding between molecules. However, it should be noted that all these empirical relationships can be applied only to the calculation of the thermodynamic functions of for-

mation of bimolecular H-complexes in an inert solvent (usually carbon tetrachloride), or in an environment of "pure base". Apparently they couldn't be applicable to the analysis of solute-solvent hydrogen bonds in self-associated liquids, such as water, aliphatic alcohols, formamide, glycols, etc., the use of which is of great practical and theoretical importance. This is due to the fact that the formation of solute-solvent hydrogen bonds in self-associated liquids differs from the process of the formation of H-complexes of 1 : 1 in an inert solvent. The presence of a very small number of experimental data on the thermodynamic functions of hydrogen bonding in self-associated solvents due to the limitations of traditional method of H-bond study IR and NMR spectroscopy.

In present work we have studied hydrogen bonding of proton acceptors in solutions of ethylene glycol by the solution calorimetry method. Enthalpies of solution at infinite dilution of nitriles, ketones, amines, ethers and esters in ethylene glycol were measured ($T = 298.15$ K). Based on the experimental data enthalpies of solvation of proton acceptors were determined. Obtained values were compared with enthalpies of solvation of studied molecules in methanol and water. Enthalpies of hydrogen bonding of proton acceptors in ethylene glycol solutions were first time determined. It was shown that for weak proton acceptors enthalpies of hydrogen bonding in ethylene glycol can be positive (endothermic process). Reasons of such behavior were discussed.

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Investigations of subsurface damaged layer by piezoelectric photothermal spectroscopy

Zakrzewski J., Maliński M., Strzałkowski K., Firszt F.

Photothermal spectroscopy has found the wide range of application as a method of monitoring nonradiative recombination of excited carriers generated by optical absorption in semiconductors. One of them is surface quality monitoring after different procedure of sample preparation. Mechanical, chemical and thermal treatment of surface can create the damaged subsurface layer which introduces additional defects states in the material. Lately, it was shown that piezoelectric spectroscopy can be a useful tool to monitor the state of surface. In this method, the stress and strain of a sample due to the absorption of electromagnetic radiation is detected by a piezoelectric transducer.

The amplitude and phase of piezoelectric spectra are necessary for the proper interpretations, however in some cases, they do not give the clear results. To minimize uncertainty, the new procedure of measurements is proposed. It involves the detection of the signal in front and rear configurations and measurements with illumination at different surfaces of the samples. Four pairs of amplitude and phase spectra are obtained which are interpreted to receive the consistent optical and thermal parameters. The model based on Blonskij's one was chosen to calculate the thermal and optical parameters of investigated material.

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High pressure physicochemical properties of biodiesel components

Żarska M., Dzida M.

The main components of biodiesel derived from coconut oil or babassu oil such as ethyl caprylate, ethyl caprate, ethyl laurate, and ethyl myristate are studied. The speeds of sound were measured within the temperatures from 293 to 318 K and at pressures from 0.1 to 101 MPa. The densities and heat capacities were measured under atmospheric pressure in the temperature range from 283 to 353 K and 286 to 341 K, respectively. The densities, heat capacities, isentropic and isothermal compressibilities, thermal expansions, and internal pressures as functions of temperature and pressure were calculated using experimental results. The densities of ethyl esters decrease with increasing their molecular weight below intersection temperature while at higher temperatures densities increase with increasing molecular weight. The intersection temperature probably moves toward higher temperatures with increasing pressure. For a given temperature, differences between densities of the ethyl esters increases with increasing pressure. With increasing molecular weight the effect of temperature on thermal expansivity decreases with pressure. It is approximately independent of temperature for ethyl laurate and ethyl myristate at pressures higher than 80 and 60 MPa, respectively. The pressure and temperature dependence of internal pressure of the esters is the most similar to that of alkanes.

7 Integrated Optics – Sensors, Sensing Structures and Methods
Szczyrk, Poland, February 25 – March 1, 2013

Abstracts

Application of Photonic Crystal Fiber in optical fiber current sensors

Barczak K.

Optical fibers may be applied in the technique of measuring electric current., particularly as so-called optical current transducers (OCT). They are small in size, cheap, light and safe. Their sensitivity, however, connected with the Faraday effect, is rather poor, and they are also susceptible to considerable disturbances (deformations of the fibers). Their sensitivity can be increased by lengthening the path of effect, but this involves also an increase of noise and greater fluctuations of the measured signal due to changes of internal stresses induced by external factors. These negative phenomena can be reduced by applaying fibers less sensitive to deformations [1, 2]. The author supposes that photonic crystal fiber (PCF) with a glass core may display such properties. Orifices in the cladding can to some extent prevent the propagation of deformations from outside the core, and thus decrease the birefringence of the fiber induced by elastooptic effects. The papers presents preliminary measurements of typical photonic crystal fiber exposed to mechanical vibrations.

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Optical and electronic properties of thin boron-doped diamond films grown by pacvd: boron level studies

Bogdanowicz R., Ficek M., Śmietana M., Jasiński J., Gnyba M., Ryl J., Sobaszek M., Gołuński Ł.

Significant attention of researchers in the world is focused on so-called "non-active" anodes such as boron doped diamond (BDD) electrodes. They could be used effectively in electrochemical sensors designed for environment monitoring and biomedical applications. Due to these advantages authors are going to use the BDD as a sensing film in optical sensors, including fibre optic sensors. The preliminary studies of electronic and optical properties has been performed to determine the best parameters of CVD synthesis and film for optical purposes. The main parameter of the BDD films, boron level, was particularly investigated. The thin film microcrystalline diamond have been deposited in a MW PE CVD process on silicon wafers and glass substrates. Surface resistivity of BDD electrode was studied using four-point probe measurements. The molecular structure of BDD films as well as the sp3/sp2 phase ratio were determined by Raman spectroscopy. The scanning electron microscope was utilized to investigate the film morphology. The surface analysis made by SEM showed a small variation of surface morphology for boron-doped films. Studies of optical constants, thickness and optical energy band gap were performed using spectroscopic ellipsometry in the wavelength range from 260 to 820 nm. The Δ and Ψ were fitted with a double-layer Tauc-Lorentz (TL) dispersion model.

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Silicon carbide on silicon photodiode stacks for sensing applications in the ultraviolet to visible range

Borecki M., Kociubinski A., Korwin-Pawlowski M. L., Duk M., Szmidt J.

The capabilities of optoelectronic sensors can be extended by use of spectral data processing. A popular range of wavelengths that are used is from UV at 260 nm, where DNA absorbs radiation, to the visible, where the results can be directly observed by the human eye. This wide range can be examined with a spectrophotometer, but in many situations the use of that kind of instrument is not desirable because of its cost and complexity. On the other hand, sensing of a sample using one beam with different wavelengths at the same time is required when the sample is in movement or in a dynamical state, as happens in analyzing the sedimentation of a mixture. Using LEDs as light sources is advantageous because of their low cost and ease of electronic modulation which makes the sensor more immune to background radiation. The LEDs radiation can be coupled to beam with a fiber optic bundle. There are a few ways of constructing the device that allows in one optical axis simultaneous detection of a UV and VIS radiation beam. First is the use of commercially available components, such as Si and Si UV enhanced photodiodes with dichroic mirrors. Second is the use of hybrid technology to build photodiode matrices that use SiC and Si components or Si UV enhanced components and matrices of optical filters. The third possibility is the use of stack of detectors using one transparent-to-VIS radiation element that absorbs and detects UV radiation [1]. For such a construction we made SiC photodiodes which were transparent-to-VIS radiation and had an active area of 10 mm^2. As the back Si photodiode we used a large area commercial photodiode – BPYP 44A that is sensitive from 400 to 1100 nm. Both photodiodes were mounted in the center of 1″ printed board rings fitting into a SM1 tube from THORLABS. This enables of use of standard THORLABS micromechanical components for the construction of detectors and for positioning and coupling of optical fibers. We characterized the fabricated SiC photodiodes, which showed a sensitivity of 0.2 A/W in the range from 275 nm to 375 nm and a transparency for VIS radiation almost flat and of 20%. These structures can be connected to dual channel optical power meters or to dedicated optoelectronic interfaces.

Acknowledgments

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intelligent classification of organic and biological liquids" [1] M. Borecki, M. Bebłowska, K. Kopczyński, Z. Mierczyk, J. Szmidt, "Multilayer semiconductor photodetector", Polish Patent application # Z-397020 of November 17, 2011.

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Influence of the glass matrix of tellurite glasses on the spectroscopic properties

Burtan B., Reben M.

The Pr3+ doped oxyfluoride glass-ceramic containing PbF_2 nanocrystals has been presented. Transparent glass ceramic was obtained by heat treating the glass from the SiO_2–PbO–Na_2O–PbF_2 system at the first crystallization temperature. The thermal conditions of PbF_2 nanocrystallization in the oxyfluoride glass have been presented. Cerammization of glass was studied by DTA/DSC, XRD and TEM methods. X-ray diffraction analysis of the transparent glass-ceramic revealed that the PbF_2 nanocrystals are precipitated in the glass matrix. It has been found that nanocrystallization of PbF_2 strongly depends on the ratio between the components and amount of PbF_2. Formation of the PbF_2 nanocrystals have been obtained as a low phonon host for rare earth active ions in oxide glassy matrix. The optical properties of glass were determined by UV–VIS spectroscopy in transmission which was carried out in order to assess the absorption spectra of the rare earth doped glasses. The spectral dependence of ellipsometric angles of the oxyfluoride glass samples, have been studied. The influence of nanocrystallization of PbF_2 onto changes of refractive index of oxyfluoride glass were examined. The optical measurements were conducted on Woollam M2000 spectroscopic ellipsometer, in spectral range of 190–1700 nm.

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Polarimetric optical fiber sensors for dynamic strain measurements in composite materials

Domański A. W., Bieda M., Lesiak P., Sierakowski M., Makowski P., Poczęsny T., Prokopczuk K., Sobotka P., Woliński T. R.

Optical fiber Bragg grating sensors are the most popular sensing systems for strain monitoring including also composite materials. However, there are some disadvantages in their applications due to limited points of measurements, troubles with temperature desensitization and relatively high cost of detecting systems. In comparison, polarimetric optical fiber sensors possess possibility of temperature compensation, dynamic and integral system of strain monitoring as well as low cost of photo-detecting elements. In the paper we present results of an experimental analysis with different kinds of birefringent optical fibers leading to an optimal set-up for dynamic strain monitoring in composite materials.

Acknowledgment

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Temperature cross-sensitivity for highly refractive index sensitive nanocoated Long-Period Gratings

Grochowski J., Myśliwiec M., Mikulic P., Bock W. J., Śmietana M.

There is a demand for highly sensitive refractive index (RI) devices simultaneously insensitive to temperature changes, especially when applied for biosensing purposes. We investigated here temperature sensitivity of Long-Period Gratings (LPGs) coated with 100 nm-thin silicon nitride (SiNx) film. The LPGs with period of 500 μm were induced in standard Corning SMF28 fibre using electric arc and then nanocoated with SiNx by Radio Frequency Plasma Enhanced Chemical Vapour Deposition (RF PECVD) method. As a sensorial effect we investigated resonance shift with temperature variations (range from 20°C to 70°C) for selected external media, i.e. water (nD = 1.3281) and glycerine (nD = 1.4552). For peak observed at 1510 nm, the RI sensitivity of 3147 nm/RIU and temperature sensitivity of 0.22 nm/°C (H_2O) were obtained which give temperature-RI sensitivity ratio (T/RI) of 6.99e-5 RIU/°C. For peak observed at 1560 nm, when the LPG was immersed in glycerine, the sensitivities of 857 nm/RIU and 0.19 nm/°C (glycerine) were observed which leads to T/RI ratio of 2.24e-4 RIU/°C. The influence of the nanocoating is discussed and compared to the results obtained for bare LPGs.

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Modal birefringence measurements of the planar optical waveguide

Gut K.

The modal birefringence can be determined basing on the interference of scattered light may be utilized. By adjusting the polarization input beam appropriately, it was possible to excite the modes TEi and TMi simultaneously. A definite pair of modes was selected by changing the angle of the beam input to the prism. Placing an additional polarizer in front of the camera we can observe oscillations of the intensity of light (in the direction of its propagation) connected with the interference of scattered light from the modes TE and TM. Determining the distance between the first and the last distinct maximum (minimum) and the number of oscillations between them we determine the beat length and can calculate the modal birefringence of the investigate waveguide.

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Multispectral systems of imaging scenery in critical infrastructure protection, threat identification and recognition

Karol M., Szustakowski M., Zyczkowski M., Markowski P., Ciurapinski W.

The surveillance system more often use devices working on different bands that are used not only for detection but also to recognize and identify threats. The paper presents the possibility of protection, detection and identification of risks, achieved through the use of multispectral detection systems in critical infrastructure facilities. The authors consider the benefits of active sensors based on other wavebands, such as as millimeter-wave radar, terahertz cameras,

infrared camera and shows the ability to detect and identify the target using data collected by these sensors. Also discussed the issue of fusion data from different sensors and opportunities that the whole system obtained by application of data fusion.

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Hyperspectral Imaging Infrared Sensor Used For environmental monitoring

Kastek M., Życzkowski M., Piątkowski T., Dulski R.

The paper presents the detection of gases using an infrared imaging Fourier-transform spectrometer (IFTS). The Telops company has developed the IFTS instrument HyperCam, which is offered as short or long wave infrared device. The principle of HyperCam operation and methodology of gases detection has been shown in the paper, as well as theoretical evaluation of gases detection possibility. The calculations of optical path between IFTS device, cloud of gases and background have been also discussed. The variation of a signal reaching the IFTS caused by the presence of a gas has been calculated and compared with the reference signal obtained without the presence of a gas in IFTS's field of view. Verification of theoretical result has been made by laboratory measurements. Some result of the detection of various types of gases has been also included in the paper.

Keywords: gas detection, hyperspectral detection, imaging Fourier-transform spectrometer, stand-off detection.

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Effect of temperature on upconversion luminescence in Yb3+/Tb3+ co-doped germanate glass

Kochanowicz M., Dorosz D., Żmojda J., Miluski P., Dorosz J.

In the article effect of temperature on the cooperative energy transfer in germanate glass doped with Yb3+/Tb3+ under 976 nm laser diode pumping was investigated. The optimization of Tb3+ concentration on the upconversion luminescence was determined. Measured strong luminescence at 489, 543, 586, 621 corresponding to 5D4→7FJ (J = 6, 4, 3) transitions and luminescence at 381, 415, 435 nm resulting from 5D3, 5G6→7FJ (J = 6, 5, 4) transitions. The highest upconversion emission intensity was obtained in the germanate glass doped with 0.7 Yb2O3/0.7 Tb2O3. The effect of temperature on the luminescent properties of germanate glass in the range of 5–250°C indicates the presence of competing phenomena: an increase in the effective absorption cross-section of Yb3+ ions donor as a function of temperature and migration of energy between pairs of ions Yb3+ – Yb3+ and of multiphonon excitation levels 7FJ.

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Fabrication and Characterization of 4H-SiC Light Emitting Diode

Kociubiński A., Duk M., Kwietniewski N., Borecki M.

Silicon carbide is a suitable semiconductor to manufacture LEDs which emit in the blue-violet part of spectrum. In this papaer, we discuss 4H-SiC LED fabrication and characterization. We used implantation technique to obtain p-n junction in the epitaxy layer. Ohmic contacts were deposited on the epilayer structure using evaporation, etching and liftoff. Various characteristics of the devices were measured including current vs. voltage, contact resistance, and output spectra.

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The concept of an optical sensor system for the temporary blood chamber volume measurements in the POLVAD-EXT

Konieczny G., Pustelny T.

The presentation includes the preliminary research of the newly developed temporary blood volume measurements optical system for using in the in the extracorporeal Polish Ventricular Assist Device (POLVAD-EXT). The proposed solution is basing on the measurement of the light reflected from the membrane in different configurations of light emitters and light detectors analyzed using the principal component analysis (PCA) method for estimating the blood volume. The measurement technique used in the experiment is described, measurement circuit and preliminary static measurements results of the developed measurement system are included and preliminary analyses of the measurements are shown. Future development plans are stated.

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Long period gratings usage possibility on planar gradient waveguides

Kotyczka T., Rogoziński R.

In this analysis the possibility of long period gratings usage as visible range spectrum filters on planar gradient waveguides (LPWG) was presented. The influence of technological proceses as well as gratings parameters on received resonance profiles and spectrum characteristics was shown. These calculations was based on the real material properties (BK7 glass doped with potassium ions) as well as specific technological processes.

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Hidden object detection system based on fusion of THz and VIS images

Kowalski M., Palka N., Piszczek M., Szustakowski M.

Image fusion can be used in wide range of security applications like detection and identification of hidden objects. This is a very urgent and demanding problem at the present time. Finding objects hidden under clothes is one of key issues of public places security. The aim of image fusion is to combine information from multiple images of the same scene. The result of the fusion is a new image which gives more information and is more suitable for human perception. Image fusion can be used for further image-processing tasks such as segmentation, feature extraction and object recognition. Our goal is to build a system for harmless humans screening and detection of hidden objects. Visual detection of hidden objects can be achieved using various imaging methods but some of these methods are harmful

for humans. The THz radiation band can be applied for screening humans because this radiation does not point any harmful ionizing effects so it is safe for human beings. In the paper we demonstrate results of various fusion methods applied for THz and VIS images. The research is focused on dangerous objects detection – guns, knives and bombs hidden under some popular types of clothing.

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Measurement of longitudinal strain sensitivity in highly birefringent polymer microstructured optical fibers

Kuczkowski M., Lesiak P., Szeląg M., Bieda M., Ertman S., Budaszewski D., Domański A., Woliński T.

In this work, we present results of our research on highly birefringent polymer fibers based on photonic crystal fiber. These new fibers are characterized by a very low Young modulus in comparison to standard silica fibers. Our research was concentrated to measure the value of the longitudinal strain sensitivity in four polymer fibers made by Kiriama Pty Ltd.

By applying strain we can observe periodic changes (sine like) in light polarization described by the Stokes vector. The amplitude of the signal depends on the azimuth of the input polarization introduced to the fiber and the period of the function depends on the fiber birefringence. In this paper, a comparison between strain sensitivity in different highly birefingent polymer fibers has been presented.

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All-optical steering of self-traped beams in liquid crystalline planar waveguide

Laudyn U. A., Kwaśny M., Sala F. A., Karpierz M. A.

Optical reorientational nonlinearity in nematic liquid crystals causes that spatial solitary waves (nematicons) are created for a light power of a few tenths of milliwats. The low absorption allows to observe nematicons propagation distance over lengths in a few milimeter range. Additionally, it was demonstrated that a weak signal beam can be guided in a channel formed by a nematicon. We report on the experimental studies the possibility of steering of such nematicons by another beams in chiral structure being the array of planar waveguides. Because of a low power necessary for steering, such a configuration can be applied in all-optical switching and routing elements for integrated optical systems, where electric fields cannot be used.

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Measurement of temperature sensitivity in highly birefringent polymer microstructured optical fibers

Lesiak P., Szeląg M., Kuczkowski M., Ertman S., Budaszewski D., Domański A., Woliński T.

In this work, we present results of our research on highly birefringent polymer fibers based on photonic crystal fiber. Our research was concentrated to measure the value of the temperature sensitivity in four polymer fibers made by Kiriama Pty Ltd.

Typical highly birefingent photonics crystal fibers are very low sensitive to temperature changes. Fibers based on poly(methyl methacrylate) are characterized by high thermal sensitivity. These value is somewhat larger than those for silica fiber and are consistent with the values expected on the basis of the bulk polymer properties. In this paper, a comparison between sensitivity in different highly birefingent polymer and standard fibers has been presented.

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Balance of polarization in a hybrid fiber optic sensor

Markowski P., Szustakowski M., Życzkowski M., Karol M.

This paper presents the effect of light polarization on a hybrid fiber optic sensor. Hybrid sensor is defined as a combination of interferometer sensor and modalmetric sensor. Hybrid sensor system based on effect outputting interferometric sensor of interference as a result of changes made by the modalmetric system. Balance polarization in the arms of classical interferometer sensor leads to improved contrast interference pattern at the output of the interferometer. Aim of this study is to present a balance light polarization effects in a hybrid system.

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Photonic crystal fibers selectively infiltrated with polymers

Mileńko K., Woliński T. R.

Photonic crystal fibers are a special type of optical fibers, where cladding is composed of periodically arranged micron sized air channels while the fiber core is defined as a defect in the structure. The structure of the photonic crystal fiber allows for the air channels to be infiltrated with liquid materials such as liquid crystal (LC), alcohol and polymers. In this way we obtain new class of fibers that play important role in sensing applications because the infiltration enhances the sensitivity of the fiber to external physical parameters.

In this paper we will demonstrate the air channels of photonic crystal fibers selectively infiltrated with polymer materials. Two polymer materials used for infiltration are: Polydimethylsiloxane (PDMS) that is a silocone elastomer and silicon oil DC-704. The influence of the infiltration on the light propagation properties of the fibers and its applications in sensing will be also presented.

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Pattern Recognition Algorithm for Eye Tracker Sensor Video Data Analysis

Murawski K., Różanowski K.

The aim of this paper is to discuss research conducted at the Military Institute of Aviation Medicine as well as the Military University of Technology. The essence of the research is to develop patterns recognition algorithm for the analysis of data received from Eye Tracker sensor. Data analysis can be done using computer vision algorithms. In the article the state of the art pattern recognition algorithms was presented. Particular attention was paid to the

possibilities and limitations of their use. The main part of the paper is the presentation of the author's pattern recognition algorithm. Received results of their operation were compared with the results obtained by the commercial system to track the activity of the eye. An operation of developed method is also illustrated by examples.

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An Infrared Sensor for Monitoring of Meibomian Gland Dysfunction

Murawski K., Różycki R., Murawski P., Matyja A., Ręka s M.

Meibomian Gland Dysfunction (MGD) is the one of the most common eye disorders observed in clinical practice. It applies to almost 50% of the population, especially people using contact lenses. It is believed that MGD is the most common cause of abnormal stability and integrity of the tear film. Despite this, there is no commercially available equipment for the diagnosis. The article proposes the construction of an optical sensor and a computer system for the rapid, non-invasive diagnosis of MGD. The designed hardware and software as well as preliminary results of clinical research are also described.

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Effect of wet etching of arc-induced Long-period Gratings on their refractive index sensitivity

Myśliwiec M., Grochowski J., Krogulski K., Mikulic P., Bock W. J., Śmietana M.

High performance optical refractive index (RI) sensors are important for advanced chemical and biological sensing applications. In this paper we present highly RI sensitive operation of Long Period Gratings (LPG). LPGs were fabricated with electric arc technique using Corning SMF28 optical fibre. As was previously reported, reduction of LPG cladding diameter results in increase of RI sensitivity and the red shift of resonant wavelengths. We used wet chemical etching in hydrofluoric (HF) acid solution to improve operation of the sensor. Optigrating software by Optiwave was used to simulate mentioned sensitivity improvement effect. As a result of simulations and experiments we obtained significant increase in RI sensitivity by applying appropriate etching time resulting in desired fibre thinning. What is more, we discuss further improvement of the sensitivity by deposition of nanocoating on the surface of the LPGs.

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Partial spectrum method for detection of covered materials in the TDS-THz setup

Palka N.

A signal processing method which can identify covered materials in a reflection configuration in the Time Domain Spectroscopy (TDS) setup is reported. THz radiation can transmit through most of covering materials like plastic foils, paper, clothes, etc. and can be detected after reflection from a covered substance (e.g. explosive material). In case of TDS setup, spectrum of the impulse is heavily deformed and the spectral features of substances are hard or impossible to identify. The proposed method based on the fact that the TDS signal reflected from a covered sample consists of two peaks and some "waves" after the second peak, which carry the spectral information about the sample. FFT analysis of this part of the signal reveals spectral features of the sample. The presented method is reference-free and bases only on analysis of the signal reflected from the sample. The method is restricted to frequencies in the range 0.4–1.8 THz and, therefore only some materials with characteristic features in this range, like RDX-based explosives, lactose, paraaminobenzoic acid and tartaric acid can be analyzed. We covered the materials with foils, paper and cotton and obtained good results for solid and powder samples. The method is sensitive to atmospheric water vapour.

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Terahertz spectra of materials measured by an Hot Electron Bolometer-based system

Palka N., Walczakowski M., Zagrajek P., Trzcinski T., Szustakowski M., Sypek M.

Development and implementation of terahertz (0.1–10 THz) technology in security area is connected with unique features in this part of electromagnetic spectrum. Many explosives (e.g., Hexogen, Penthrite, Trinitrotoluene, Octogen) and drugs have characteristic transmission/reflection features in the THz range, what is of great importance for security and defense related applications. We report on measurements of transmission spectra of chosen materials (Hexogen, Sucrose, Tartaric Acid) in the range 0.7–2.5 THz. The measurements were carried out by means of a setup, which bases on an Optical Parametric Oscillator (OPO) combined with a Hot Electron Beam (HEB) Bolometer. The setup consists of commercially available tunable OPO from MSquared working in the range 0.7–2.5 THz with repetition rate 53 Hz, duration of the impulse of about 10 ns and energy 10 nJ. The beam was detected by a HEB from Scontel (NEP$\sim 10^{-13}$ W/Hz$^{-1/2}$) in a Pulse Tube cryocooler. The spectra was compared to results obtained from a standard Time Domain Spectroscopy setup (Teraview TPS 3000). Only small discrepancies between spectra measured by both methods are observed. For the range 0.7–2 THz typical features can be identified using both methods.

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Laser photography – examples of processing of image information

Piszczek M.

Modern cameras working in various spectral bands can be successfully applied in many areas of our lives. Observational capabilities of modern cameras are widely utilized in the area of public security systems while measurement functionalities of cameras are the domain of Machine Vision Systems used mainly in industry applications. The development of vision techniques and data processing methods changed the perception of vision systems as a multifunction, observation and measurement systems. Laser photography device (LPD), developed in the Institute of Optoelectronics, Military University of Technology is an example of such imaging device. One of properties of time-spatial framing method is the ability to make complex spatial analysis

of observed scene thanks to proper control of acquisition parameters and metadata processing. This property can be very useful especially in real-time spatial and geographic information systems. The paper presents theoretical applications of time-spatial framing method and first experimental results.

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Laser photography system – selected functionalities

Piszczek M., Karol M., Kowalski M., Rutyna K., Zarzycki M., Szustakowski M.

The laser photograph is an advanced experimental system acquisition and distribution of spatial information. Its key element is a laser photograph device (UFL) use active illumination to observe the scene. The system also includes other information units such as VIS, IR, NIR cameras, and millimeter wave Radar. The study characterizes the individual components of the hardware and the system as a whole. Particular attention was given to the firmware so that it is possible to control system components as well as, a preliminary analysis of the results.. The presented system draws attention not only on the properties offered by the UFL but also the possibility of synergistic effects of the system as a whole through the fusion of data from different sensor units.

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Laser photography device – spatial parameters of imaging

Piszczek M., Kowalski M., Karol M., Rutyna K., Zarzycki M., Szustakowski M.

Laser photography device (LPD) is an imaging device developed in the Institute of Optoelectronics, Military University of Technology and it is an example of modern image acquisition device. The LPD allows to define a 3D observation scene thanks to short-time scene illumination and image acquisition method. This device works according to time-spatial framing method. In the paper, basics of time-spatial framing method are explained. Special attention is given to time parameters of device and their influence to spatial parameters of registered images. In this paper the laser photography device and results of chosen experiments are presented and described. Experimental results presented in the paper show the potential and possibilities of using the laser photography device as a camera for observation and measurement applications.

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Imaging with laser photography camera during limited visibility

Piszczek M., Zarzycki M., Rutyna K., Kowalski M., Karol M., Szustakowski M.

Present systems for vision monitoring very often employ many different imaging devices working in various spectral ranges e.g. visible (VIS), near infrared (NIR), infrared (IR). Every single spectral range deliver slightly different relevant information for process of threats detection, recognition and identification. However, technology progress still does not satisfy every need. Finding new vision solutions, capable for imaging in very difficult conditions (adverse weather conditions, partial occultation of observed scene) is still one of the most urgent and demanding task for researchers. One of the possible solutions is using a camera working with time-spatial framing method. This method is able to minimize the impact of adverse factors on image acquisition process. Laser photography device (LPD) is a camera developed in the Institute of Optoelectronics, Military University of Technology working according to the time-spatial framing method. The paper presents theoretical basics and initial results of the laser photography device tests.

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Optical sensor to monitor pupillary light reflex (PLR)

Różanowski K., Murawski K.

This paper describes the design of an optical sensor intended to analyze pupillary light reflex (PLR). It also presents the results of physiological adaptation mechanisms in human eye, i.e. response of the iris to changes in the intensity of light that falls on the retina of the eye under conditions of sensory deprivation. PLR is a closed loop nerve reflex. It controls the amount of light that reaches the retina. Based on the test results, an optical sensor was designed, fabricated and correctly calibrated. In comparative tests with the use of F^2D Fit-For-Duty, a commercial system by AMTech, selected pupillographic parameters were primarily evaluated (baseline pupil diameter, oscillations, reflex latency, maximum reaction time, pupil constriction time, pupil dilation time, and constriction amplitude) under conditions of diminished alertness, reduced ability to concentrate, increasing fatigue, and drowsiness.

The solution comes as part of a mobile pupillography device intended to be assembled in cars and airplanes to identify conditions of lower alertness, reduced ability to concentrate, increasing fatigue and drowsiness in drivers, pilots and traffic controllers, and to trigger alarm and preventive measures, if necessary.

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Design of a Multisensor System for a High Integrated Driver Fatigue Monitoring Technology

Różanowski K., Sondej T., Murawski K.

This paper describes the architecture and use of the multisensor system for estimating the driver's fatigue. These sensors are an element of the integrated system of monitoring driver behaviour, also including the measurement of environmental conditions and driving technique. Sensors described in the article are designed to work under simulated and real conditions (during driving a vehicle). To estimate driver's fatigue we used the subsystem for measurement of eye closing frequency and oculomotor activity (Eye Activity Research Subsystem - EYEARS), personal medical packet (PMP) and non-contact electrocardiography signal measurement module. In addition, for comparison purposes, we used commercial solutions called faceLAB (system for tracking and testing the activity of the eyes)

and FlexComp (system for physiological activities measurement). The article presents a description of the sensors, the way they communicate with the master device Logger Box and their location in the car. It also presents a typical test procedure and sample signals recorded during driving.

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Tunability of discrete diffraction in photonic liquid crystal fibers

Rutkowska K., Laudyn U., Jung P.

Recently, photonic liquid crystal fibers, PLCFs [i.e. photonic crystal fibers (PCFs) infiltrated with liquid crystals (LCs)] have gained significant amount of scientific attention. Their uniqueness results from the specificity of the PCF-host structures, as well as from the special optical properties of LCs. The latter can be dynamically adjusted by: (i) external fields and factors (including electric and magnetic fields, temperature, strain and pressure) and (ii) optical beam itself (i.e. when nonlinear effects take place in LCs).

In this work, the results of theoretical analyses and experimental tests on the light propagation in PLCFs are presented. While refractive index of the inclusion is higher than that of silica glass, analyzed photonic structure can be considered as a matrix of mutually parallel waveguide channels. This connotes discrete light propagation to be observed in PLCF, with the output beam profile strongly dependent on geometrical and optical properties of both the beam (e.g. wavelength and beam size) and the fiber (e.g. periodicity and index contrast). Importantly, changes in discrete propagation can be obtained dynamically (by varying optical power and/or by applying external fields and factors). In nonlinear case, under specific conditions, discrete spatial soliton can be obtained, paving thus the way for all-optical switching to be developed in PLCFs.

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Efficiency of diamond thin-film sensor on an Si-based integrated Mach-Zehnder interferometer

Sobaszek M., Jędrzejewska-Szczerska M., Bogdanowicz R., Płotka P.

Mach-Zehnder is one of the commonly used two-beam interferometer in fiber-optic technology. This is because this interferometer can be easily elaborated with the use of conventional couplers or as an integrated optic device. Mach-Zehnder interferometer has measurement and reference arms and the output signal is the sum of optical signals from those two arms. By the use of special designed construction of measurement arm it is possible to determine many physical or chemical quantities. In this article, authors will present the result of theoretical investigation upon the new design of measurement arm in Mach-Zehnder interferometer. Authors will compare and contrast parameters of two devices. The first, which consists of SiO_2 and diamnod layer and the second made from Si and diamond. The technology of devices made from SiO_2 and diamond is known but still verypromising, on the other hand the technology of silicon optics is quite knew. Therefore the comparing and contrasting parameters of Mach-Zehdner interferometer made with the use of those two technology is very interesting. In this article, authors will present preliminary research which will be the base for constructing fiber optic sensor with the use of Mach-Zehnder interferometer.

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The possibility of using functional optical coherence tomography for scattering materials with nanoparticles evaluation and testing

Strąkowski M., Kraszewski M., Sobaszek M., Antoniuk P.

The optical coherence tomography is a non-invasive and non-destructive method for scattering materials evaluation and testing. It produces tomography images of the devices inner structure with micrometer resolution. The functional OCT covers a number of different additional techniques of measurement signal analysis, which expand the range of OCT applications. The main OCT extensions are the Doppler analysis, polarization sensitive analysis and spectroscopic analysis. All these methods enable a better characterization of the tested materials and investigation the phenomena occurs inside the sample. Our research interests are focused on polarization sensitive (PS-OCT) and spectroscopic OCT (Sc-OCT). The PS-OCT delivers the information about the local changes of the devices optical anisotropy. However, the Sc-OCT gives the local spectral scattering characteristic of the tested sample. The combination of those two methods can be very useful for examination of scattering materials with nanoparticles. The size, the shape and the concentration of the nanoparticle dopants change the scattering features, which can be investigated by the use of functional OCT. In this paper we present our preliminary studies on the OCT application for nano-composite materials examination. Also the experimental results have been shown.

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Hybrid input-output systems of light for applications in integrated optics devices

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The paper presents the results of investigations concerning input-output systems of light for applications in structures of integrated optics. The input-output system used in described planar waveguides are in the form of prism couplers and photonics structures with grating couplers. The first part of the paper contains numerical analyses of photonics structures with grating couplers aiming at an optimization of their geometrical parameters. The second part presents the practical realization as well as experimental tests of the planar optical waveguide with the hybrid input-output system. As the input system of the light a prism coupler was applied, and in the case of the output system – a photonic structure with grating coupler was used. The investigated planar wave guides with the input-output structures were made of a wide energy band gap semiconductor – zinc oxide (ZnO).

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Comparison of standard and polymer polarimetric fiber sensors for stress monitoring in composite materials

Szeląg M., Lesiak P., Awietjan S., Boczkowska A., Kuczkowski M., Ertman S., Budaszewski D., Domański A., Woliński T.

In this work, we present results of our research on optical fiber sensors based on standard and plastic polarimetric fibers embedded into composite material samples. We manufactured two composite samples. In each sample six fibers were embedded: four plastic fibers made by Kiriama Pty Ltd, one Blaze-photonic fiber and one standard fiber HB1500 made by Nufern. Both ends of the composite plate were support articulated, so we could observe only bending effect. The composite plate was deformed up to 10 mm. In this paper, influence of bending effect on light polarization parameters such as: the Stokes vector, azimuth, ellipticity, degree of polarization, phase difference, power on standard and polymer polarimetric fiber sensors placed in composite material has been investigated.

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Analyzing of transmission properties in birefringent gradient index MMI structures with absorbing layer

Szewczuk A., Błahut M.

The aim of this study is to examine the possibility of the use in optical sensors technology polarization effects occurring in ion exchanged waveguides. The investigated gradient index MMI structures are produced in the K+-Na+ ion exchange process. Investigation was carried out for both polarizations TE and TM. This distinction into two polarizations is necessary because for the gradient index MMI structures produced in the K^+–Na^+ ion exchange process, propagation condition of light are different for each of the polarization. We have stated that birefringence of these waveguides manifests itself in different modal fields distributions and in particular in the different input field image position. Furthermore, the wave of TE and TM polarization will react differently with the sensing layer. This results in different operating characteristics for each of polarization.

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Investigations of MMI structures covered by bromocresol purple for ammonia detection

Szewczuk A., Błahut M.

The basis of the presented research is a gradient index MMI structure (Fig. 1) with multimode section length relating to the length of the input field image formation. Multimode section is covered with material which changes its optical parameters (refractive index and extinction coefficient) when is exposed to appropriate gaseous environments. The coating parameters changes have an effect on light propagation condition in structure and can be seen as the output signal variation. In this configuration, there are several factors responsible for changes in the registered output signal. Variation of coating layer refractive index influence the mode properties of the multimode waveguide, which result in the input field image position and the output signal value. In the case of the absorption layer the refractive index changes have also influence on the modal attenuation value by changing the shape of the modal field distribution, which leads to a reduction or increase of the amount of light penetrating the absorbing sensing layer. This effect is different for different modes. Depending on the properties of a sensor layer – its refractive index and extinction coefficient – there is observed the predominance of the first (phase) or second (absorbing) effect. In this paper, we focus on the absorbing effect occurring in bromocresol purple sensing layers used to measure the gas concentrations.

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Photonic liquid crystal fibers with polymers

Tefelska M., Mileńko K., Budaszewski D., Domański A. W., Ertman S., Orzechowski K., Rutkowska K., Siarkowska A., Sierakowski M., Nowinowski-Kruszelnicki E., Dąbrowski R., Mergo P.

Photonic liquid crystal fibers with polymers constitute a new solution based on liquid crystals and microstructured polymer optical fibers (mPOFs) opening up new areas in innovative sensing and photonic devices applications. Compared with their silica-based microstructured fibers, it is easier to fabricate exotic mPOFs by extrusion or drilling at low temperature; their nonlinearity is potentially stronger, the range of available polymers that may be drawn is more diverse and the biocompatibility of polymers is often better. Liquid crystals due to their attractive properties i.e., the high birefringence, high electro-optic and thermo-optic effects are a very good candidate for mPOF infiltration to obtain tunable all-in-fiber innovative photonic devices. The paper will discuss basic properties and possible applications of the polymer photonic liquid crystal fibers that will arise from their high optical tunability with external and internal factors. Current research effort is directed towards two main solutions: photonic crystal fibers and mPOF-based structures, both infiltrated with liquid crystals of tailored optical properties.

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Processing of measured data from integrated optics low-coherent sensors

Wróbel M., Karpienko K., Jędrzejewska-Szczerska M.

In this article authors present data processing techniques of measured signal from integrated optical sensors. We propose the use of dedicated software to support data analysis. It is shown that the use of such data processing can improve metrological parameters of the low-coherent sensor. The results of theoretical investigation and experimental work confirm that described techniques can be an effective method for improving the signal processing in low-coherent measurement sensors.

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White upconversion in Yb3+/Tm3+/Ho3+ – doped antimony-germanate glasses

Żmojda J., Dorosz D., Kochanowicz M., Miluski P., Dorosz J.

Glasses from the system $SiO_2 – Sb_2O_3 – GeO_2 – Na_2O$ triply doped with Yb3+/Tm3+/Ho3+ ions were melted and characterized. Fabricated glasses was exhibiting simultaneous multicolour upconversion luminescence. Strong blue 1G4→3H6 (Tm3+), green 5F4→5I8 (Ho3+) and red 5F5→5I8 (Ho3+) upconversion emission bands have been measured under 980 nm excitation at room temperature. The dipole-dipole interaction between Yb3+/Tm3+ and Yb3+/Ho3+ ions have a non-resonant character hence, the phonon-assisted energy transfer has been investigated. Ytterbium ions plays important role in enhancing of upconversion emission efficiency. Colour coordinates (CIE-1931) and correlated colour temperature CCT of different molar ratio of active ions were calculated.

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Modalmetric fiber optic sensor for security of collections

Życzkowski M.

The main aim of the work is the integration of modalmetric sensor in one arm. The proposed sensor is a classical fiber optic cable which measuring arm is upgraded with multimode sensor. The theme of research is to assess the impact of modal changes to detection of mechanical disturbances and comparative assessment of detection capabilities interferometer sensor, modalmetric sensor and hybrid sensor for different types of excitations. The described tests, concerned area of basic research. The results can be used in the construction sensors with corresponding characteristics and properties to the appropriate applications as specially to protect of collection.

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Quantum key as fiber optic security sensor

Życzkowski M.

he paper describes the methodology of identification interference in optical fiber, it also presents the technology known as "QKD" Quantum Key Distribution. It is based on the technology of constant comparison the input quantum characteristics of light source with its characteristics at the end of fiber optic. Methodology of presented work includes the evaluation of the functional objectives through assumptions to develop laboratory models. The paper presents the model of a system based on the comparison of polarization states of light quanta using two asymmetric Mach-Zender interferometers as transmitting and receiving systems to enable compensation of polarization state changes at the input and output of fiber optic sensing cable. On the base of continuous monitoring the state of the reference signal, the specific changes natural or ambient effects on the fiber, will attempt to identify interference in the optical waveguide as a change in the polarization of the quantum states of the light. The authors indicate the possibility of using such a fiber optic sensor as a security sensor to protect of wide critical infrastructure facilities.