Integrated Optics
- Sensors, Sensing Structures and Methods
IOS'2016

PROGRAMME
and
ABSTRACTS

Organizers of IOS 2016

Photonic Society of Poland,

Upper Silesian Devision of
the Polish Acoustical Society

and

Committee of Electronics and Telecommunication
at the Polish Academy of Sciences

29th February to 4th March 2016,
Hotel "META"
Szczyrk - Beskidy Mountains, POLAND

http://ogpta.pl

Dear Participants

of 11th Conference INTEGRATED OPTICS - Sensors, Sensing Structures and Methods IOS'2016

Organizers welcome All of You very cordially in Szczyrk, in the beautiful scenery of the Beskidy Mountains.

We wish all Participants of the Conference IOS'2016 plenty of scientific satisfactions and many professional and social impressions.

Organizers

This book includes the Program of IOS'2016 and Abstracts of presentations and posters sent by their Authors.

CONFERENCE PROGRAMME

29.02.2016 Monday	
13:00	**DINNER**
14:15	**OPPENING CEREMONY of the 11th IOS'2016 and 45th WSW&QA Conferences**
14:30-15:50	**Common Session**
14:30-14:50	**THE SESSION DEDICATED TO THE MEMORY OF PROFESSOR JERZY KAPELEWSKI** T. PUSTELNY
14:50-15:10	**Electromagnetic Interference shielding vs surface modifications – the review** M. SZAFRAŃSKI, A. KAWALEC, A. DUKATA, M. OKOŃ-FĄFARA
15:10-15:30	**Analytical model of the acoustically loaded sandwich transducer** P. KOGUT, A. MILEWSKI, W. KARDYŚ, P. KLUK
15:30-15:50	**Surface Acoustic Waves in applications of semiconductor investigations** T. PUSTELNY, B. PUSTELNY
15:50-16:30	**Coffee break**
16:30-17:00	*Invited lecture* **Application of Microelectronics in High Energy Physics & Space Technology** W. CICHALEWSKI, M. JANKOWSKI, D. MAKOWSKI, M. ORLIKOWSKI, A. NAPIERALSKI
17:00-17:20	*Invited lecture* **Spectral properties of photonic crystal fibers infiltrated with nematic liquid crystals doped with metallic nanoparticles** T. WOLIŃSKI, A. SIARKOWSKA, M. CHYCHŁOWSKI, A. DYBKO
17:20-17:40	**Detection of the trace amounts of selected gas pollutants using cavity enhanced spectroscopy** J. WOJTAS, Z. BIELECKI, M. NOWAKOWSKI, J. MIKOŁAJCZYK, D. SZABRA, B. ZAKRZEWSKA, A. PROKOPIUK
17:40:17:55	**Novel comb polymers as a photonics and electronics sensing materials** E. MACIAK, M. PROCEK, A. STOLARCZYK, T. PUSTELNY

17:55-18:10	**Reliability of high temperature fiber optic sensors**. Tomasz STAŃCZYK, Dawid BUDNICKI, Karol WYSOKIŃSKI, Janusz FIDELUS, Agnieszka KOŁAKOWSKA,Małgorzata KUKLIŃSKA, Tadeusz TENDERENDA, Tomasz NASIŁOWSKI
18:10	**SUPPER**
20:00	**Theatrical performance**
01.03.2015 Tuesday	
13:00	**DINNER**
14:30-15:00	*Plenary lecture* **Polish optical atomic clock** W. GAWLIK
15:00-15:20	**Optical fibre technology as a creator of economy development** T. NASIŁOWSKI
15:20-15:35	**Multicore optical fibers for telecommunications and sensors** M. NAPIERALA, A. ZIOLOWICZ, Ł. SZOSTKIEWICZ, A. PYTEL, M. FILIPOWICZ, D. BUDNICKI, A. KOŁAKOWSKA, T. STANCZYK, T. TENDERENDA, B. BIEŃKOWSKA, Ł. OSTROWSKI, M, MURAWSKI, M. MAKARA, K. POTURAJ, G. WOJCIK, P. MERGO, T. NASILOWSKI
15:35-15:50	**A „colorful" polymers** P. MERGO, R. ŁYSZCZEK, M. GIL, L. CZYŻEWSKA, J. PĘDZISZ, A. JUSZA, R. PIRAMIDOWICZ
15:50-16:05	**Fiber optic displacement sensor with signal analysis in spectral domain** K. KARPIENKO, M. MARZEJON
16:05-16:30	**Coffee break**
16:30-17:00	*Plenary lecture* **Quasi-phase matching via femtosecond laser induced domain inversion in lithium niobate waveguides** X. CHEN, P. KARPINSKI, V. SHVEDOV, A. BOES, A. MITCHELL, Y. SHENG, W. KROLIKOWSKI
17:00-17:20	**Type II quantum wells with tensile-strained GaAsSb layers for interband cascade lasers** M. MOTYKA, Mateusz DYKSIK, Krzysztof RYCZKO, Grzegorz SĘK, Jan MISIEWICZ
17:20-17:35	**Multicolor emission in optical fibers doped with luminescent centers** P. MILUSKI, D. DOROSZ, M. KOCHANOWICZ, J. ŻMOJDA, J. DOROSZ

17:35-17:50	**Mid-infrared luminescence in HMO glass co-doped with Ho^{3+}/Yb^{3+} ions** T. RAGIŃ, M. KOCHANOWICZ, J. ŻMOJDA, P. MILUSKI, P. JELEŃ, M. SITARZ, D. DOROSZ
17:50-18:05	**New aspects of optical fibers attenuation** G.WOJCIK, K. POTURAJ, A. WALEWSKI, P. MERGO
18:05-18:20	**Dimethacrylate derivative of naphthalate-2,7-diol as a photoluminescent dopant useful in optical sensors** M. GIL, B. PODKOŃCIELNA, J. PĘDZISZ, P. MERGO
19:30	**Festive Supper (Banquet)**
02.03.2016 Wednesday	
13:00	**DINNER**
14:30-16:20	**Special Session-BioEngineering and MedicalEngineering**
14:30-15:00	*Plenary lecture* **World-smallest fiber-GRIN lens system for optofluidic applications** A. FILIPKOWSKI, B. PIECHAL, D. PYSZ, R. STEPIEN, J. CIMEK, A. WADDIE, M KLIMCZAK, M. R. TAGHIZADEH, R. BUCZYNSKI
15:00-15:15	**Laboratory stand and theory of measurement of blood chamber volume of mechanical prosthetic heart with use of image processing technique**. K. MURAWSKI, L. GRAD, T. PUSTELNY
15:15-15:30	**A comparison of impact of image feature extraction methods for measuring the volume of the chamber a mechanical prosthetic heart** L. GRAD K. MURAWSKI, T. PUSTELNY
15:30-15:45	**The enhanced micropump`s winding shape and its influence on the generated** S. BARTEL
15:45-16:05	**Doppler system of microembolus detection and blood flow measurement intended for ventricular assist device ReligaHeart EXT** M.GAWLIKOWSKI, M. LEWANDOWSKI, R. KUSTOSZ
16:05-16:30	Coffee break
16:30-17:00	*Plenary lecture* **Fiber-optic Fabry-Pérot sensors – modeling versus measurements results** J. PLUCINSKI, K. KARPIENKO

17:00-17:15	**Pulse interferometer in protection of telecommunication lines** M. KAROL, M. ŻYCZKOWSKI, M. SZOSTAKOWSKI, P. MARKOWSKI
17:15-17:30	**Label-free detection of drugs of abuse in whole blood with surface-enhanced Raman spectroscopy** M. WROBEL, S. SIDDHANTA, M. GNYBA, M. JĘDRZEJEWSKA-SZCZERSKA, I. BARMAN
17:30-17:45	**SS-OCT integrated probe for endomicroscopy application based on MOEMS Mirau micro-interferometer** P. STRUK, S. BARGIEL, Q. TANGUY, N. PASSILLY,C. GORECKI, L. FROEHLY, J.-J. BOY, C. ULYSSE, A. BILLARD
17:45-18:00	**Theoretical analysis of slab waveguides supporting SPP modes toward their sensitivity characteristics** C. TYSZKIEWICZ
18:00	**SUPPER**
19:00-21:00	**Poster Session**
03.03.2016 Thursday	
13:00	**DINNER**
14:30-15:00	*Plenary lecture* **Sensitivity of electrical properties of ZnO nanoparticles on action of various gaseous environments** T. PUSTELNY, M. PROCEK, A. STOLARCZYK, E. MACIAK
15:00-15:20	**Environmental sensing with multicore nonlinear coupling perturbation fiber system** A.ROMANIUK, M. KLIMCZAK, M. TRIPPENBACH, R. BUCZYŃSKI
15:20-15:40	**A new approach to measure the phase modulation introduced by flowing microobjects for an interferometric epi-mode imaging** P. OSSOWSKI, A. RAITER-SMILJANIC, A. SZKULMOWSKA, M. WOJTKOWSKI
15:40-16:00	**Investigations of optical current sensor in wide range of electric current values** K. BARCZAK
16:00-16:30	**Coffee break**
16:30-16:50	**Broadband common-path planar waveguide interferometer** K. GUT

16:50-17:10	**Waveguide SU8 polymer based on different substrates** T. HERZOG, K. GUT
17:10-17:30	**Different taper structure as functional element for sensor application** J. E. MUSIAŁ, K. A. STASIEWICZ, L. R. JAROSZEWICZ
17:30-17:50	**Fe_3O_4 NPs – filled microstructured fibers as sensor applications** N. PRZYBYSZ, L. R. JAROSZEWICZ
17:50	**Closing Ceremony of IOS'2016**
19:00	**SUPPER**
04.03.2016 Friday	
8:00	**BREAKFAST**

POSTER SESSION

Hybrid technology of multicore microstructured optical fibers
K. POTURAJ, G. WÓJCIK, A. WALEWSKI, J. KOPEĆ, M. MAKARA, T. NAZIŁOWSKI, P. MERGO

A low loss polymers
L. CZYŻEWSKA, M. GIL, J. PĘDZISZ, P. MERGO

Special protective coatings for sensor applications
A. WALEWSKI, J. KORYCIŃSKI, J. KOPEĆ, P. MERGO

Extruded polymer optical fibers
W. PODKOŚCIELNY, P. MERGO

High operating temperature long-wave HgCdTe detector for fast response operation - optimization approach
P. MARTYNIUK, M. KOPYTKO, K. GRODECKI, E. GOMUŁKA, K. MILCZAREK; W. GAWRON, K. JÓŹWIKOWSKI

Mechanical splicing of standard MMF and GI- POF
R. WONKO, P. PURA-PAWLIKOWSKA, P. MARĆ, J. MUSIAŁ, L. R. JAROSZEWICZ

Characterization of liquid crystalline materials for applications in integrated optic circuits
K. A. RUTKOWSKA, A. KOZAK, K. ORZECHOWSKI

Algorithm for detection and removal of discontinuity points on eigenvectors sets generated by FDM method
C. TYSZKIEWICZ

Thermo - optic properties of alkanes filled photonic crystal fibers
N. PRZYBYSZ, P. MARĆ, L. R. JAROSZEWICZ

Gas analysis software for selected techniques of laser absorption spectroscopy
M. PANEK, J. MIKOŁAJCZYK

Application of boron-doped diamond film and ZnO layer in Fabry-Pérot interferometer
D. MILEWSKA, W. DEN, M. JĘDRZEJEWSKA-SZCZERSKA

Broadband temperature sensor
J. E. MUSIAŁ, K. A. STASIEWICZ, R. K. WONKO, L. R. JAROSZEWICZ

Automated sampling system for human breath analyzing
A. PROKOPIUK, D. SZABRA, Z. BIELECKI, R. MĘDRZYCKI, J. MIKOŁAJCZYK

Properties of reduced graphene oxide and graphite oxide in the aspect of their possible application in gas sensors
S. DREWNIAK, T. PUSTELNY, R. MUZYKA

Single photon fiber optic sensor in detection of telecommunication line taping
Ł. OLSZEWSKI, K. BREWCZYŃSKI, M. SZUSTAKOWSKI, M. ŻYCZKOWSKI, M. KAROL, P. MARKOWSKI

Laboratory and field tests of the active composite fence
K. BREWCZYŃSKI, Ł. OLSZEWSKI, M. SZUSTAKOWSKI, M. ŻYCZKOWSKI, M. KAROL, P. MARKOWSKI

In vivo luminescence spectroscopy diagnosis system for skin cancer research
P. KAŁUŻYŃSKI, Z. OPILSKI

Fast chemoresistive NO_2 gas sensor based on the undoped ZnO nanostructures activated by temperature and UV radiation
M. PROCEK, T. PUSTELNY, A. STOLARCZYK

PRESENTATIONS ABSTRACTS

World-smallest fiber-GRIN lens system for optofluidic applications

Adam FILIPKOWSKI,[1] Bernard PIECHAL,[1] Dariusz PYSZ,[1] Ryszard STEPIEN,[1] Jarosław CIMEK[1,2], Andrew WADDIE,[3] Mariusz KLIMCZAK,[1] Mohammad R. TAGHIZADEH,[3] and Ryszard BUCZYNSKI.[1,2,3]

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We have developed a new type of optical fiber probe that integrates standard single mode fiber with gradient index (GRIN) microlens. The system is perfectly suited for optofluidic sensor applications since the diameter of the lens module is exactly the same as the diameter of the optical fiber. Moreover the performance of the GRIN lens is not degraded by low contrast of the refractive index between of the lens and the fluidic environment. The GRIN lens is made with novel technology of nanostructured optics. The principle of the operation of nanostructured elements can be described by the effective medium theory (EMT). The nanostructured elements were fabricated using the modified stack-and-draw technique, commonly used in the development of photonic crystal fibres. The fabricated GRIN lens is 11.9 µm long, which corresponds to 0.12 pitch length of the lens. Experimentally we verified focusing properties of the integrated fiber probe. We measured the focal plane at working distance of 80 µm, which is in agreement of the simulation results. At that distance, the full width at half maximum (FWHM) of the focal spot is equal to 8 µm.

The enhanced micropump`s winding shape and its influence on the generated electromagnetic torque

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In this article a short introduction describes the existing solutions of TAH (*Total Artificial Hearts*) and LVAD (*Left Ventricular Assist Device*) in terms of the type of drive and the possibility of blood transfusion will be shown. Next will be presented the principle of operation, the construction and the results of research of the pulsatile electromagnetically driven micropump. The simulation results of the electromagnetic drive will be done using the FEM method analysis for investigation the influence of the stator windings shape and its enhanced geometric, on the generated values of electromagnetic torque. The discussed existing solutions and the proposed concept of micropump in this article, are constructed for the minimal geometrical size, low energy consumption and effective human blood transfusion.

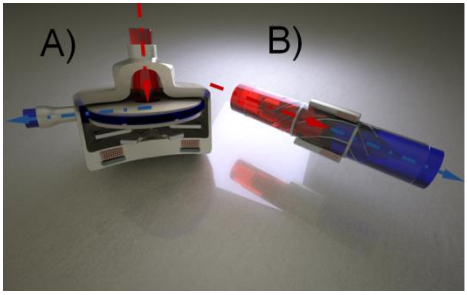

Fig. 1. A – DuraHeart 3G LVAD centrifugal rotary pump; B – DeBakey LVAD 2G axial flow rotary pump.

In Figure 1 are shown the two types of heart supporting devices of LVAD (*Left Ventricular Assist Device*) type for the different types of their pump drives. The first type of presented device is the Dura Heart 3G LVAD denoted as (A) and the second DeBakey LVAD 2G device denoted by (B). Dura Heart 3G is an third generation of centrifugal rotary pump designed by the Japanese corporation Terumo. For this kind of rotary pump the inlet and outlet are placed perpendicular to each, such a path of the blood flow is the result of centrifugal force of the rotating rotor.

The DeBakey 2G device is an second generation of axial flow rotary pump developed by MicroMed Technology from the United States. The axial rotary pump are the simplest devices for the human blood transfusion, where the inlet and outlet are placed on the same axis and the blood flow is forced by a screw-propeller shaped rotor blades. For both cases of rotating pumps the direction of blood flow is shown by arrows, where red determined the inlet and the blue arrow presents the blood outlet. Figure 2 shows the 3D computer visualisation of discussed in this article the electromagnetically driven pulse micropump. This type of pump design for the human blood transfusion is composed of two independent working artificial

blood chambers and their two electromagnetic drives.

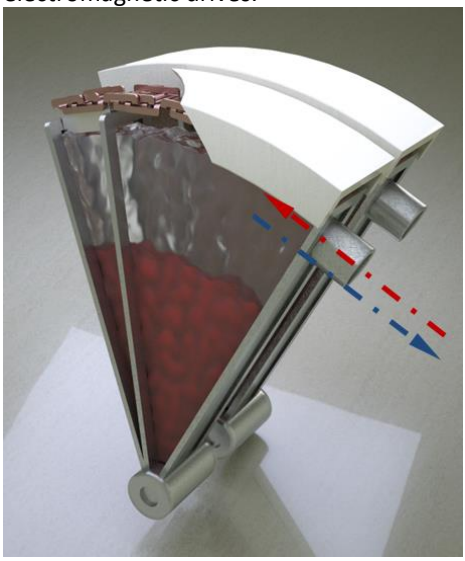

Fig. 2. 3D model of the electromagnetically driven pulse micropump.

Just as on the rotary pump example the inlet and outlet blood flow directions are determined by arrows. The blood flow for this construction is possible with the use of artificial heart valves, which they determine the right direction of flow for the pulsing cycles of the micropump. In contrast to the previously described existing LVAD devices, the pulsatile micropump is an TAH (*Total Artificial Hearts*) device which is designed for the orthotopic implantation in the human body.

References

[1] Trawiński T., Kluszczyński K., Kołton W.: Model obwodowy dwuuzwojeniowego silnika VCM dla systemów pozycjonowania głowic dysków twardych, Przegląd Elektrotechniczny, R. 87 NR 12b/2011, s.184-187.

[2] Trawiński T.: Verification of the mathematical model of Voice Coil Motor with high range of angular motion. Research and Education in Mechatronics KTH, Stockholm, Sweden June 15-16, 2006.

[3]Bartel S., Trawiński T.: Design issues of electromagnetic micropump. 15th International Workshop on Research and Education in Mechatronics (REM), 9-11 September 2014, El Gouna, Egypt. Piscataway: Institute of Electrical and Electronics Engineers, 2014, p. 1-7

Electromagnetic Interference shielding vs surface modifications – the review

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Even before Maxwell's equations were formed, humanity was exposed to numerous electromagnetic fields. However it was not until 20th century when manmade electromagnetic fields became more and more abundant. Many systems and platforms are sources of unintentional EM fields, which are potentially harmful to other electronic hardware. On top of that, at some point, these emissions may reach power levels that pose serious threat even to human health.

This issue required a new branch of electromagnetic devices to be designed to protect against adverse emissions. Nowadays this branch bears the name of EMI shielding (Electromagnetic Interference - EMI). It covers every possible aspect of modifying original materials in order to increase their shielding effectiveness against electromagnetic fields. Furthermore it applies to gaskets, physical layers, that cover desired circuits and even special paints that absorb EM energy.

This paper presents the review of theoretical and practical works describing EMI shielding among various frequency bands. Special attention has been paid to the methods regarding surface modifications.

Doppler system of microembolus detection and blood flow measurement intended for ventricular assist device ReligaHeart EXT

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Introduction and goal

In spite of advanced anticoagulation and antiplatelet therapy one of fundamental problem concerned the mechanical heart supporting is thromboembolic complications. In many cases it may cause multiorgan dysfunction or even death. To avoid this serious complication some of coagulation system indicators (like ApTT, INT, platelets function) are measured from blood samples. In fact, those parameters deliver knowledge about blocking of coagulation cascade, not about final effect, which is microembolus forming leading to larger clots growing.

Material and methods

In order to non-invasive monitoring of microembolus in flowing blood the ultrasound, PW Doppler system has been developed and tested on laboratory stands, in-vitro on porcine blood and in-vivo, during 26 day animal trial. Blood flow was calculated basing of integration of velocity profile (on the assumption spatial symmetry of flow). The best estimator of mean Doppler frequency in gates was chose experimentally. In order to emboli detection two methods were developed: auto-regression and power spectrum analyze. Optimal thresholds were chose to obtain the best sensitivity and specificity of emboli counts. The reference was optical recognition of microspheres (90um-260um) by means of fast camera (360FPS) and telecentric lens. The preliminary investigation on embolus size estimation by means of calculation Emboli-to-Blood-Ratio (EBR) were carried out. In order to understand relations between Doppler echo character and microembolus structure numerous in-vitro blood circulation were carried out. Blood samples were filtered on hemocompatible, cascade filter (porosity: 170um, 105um and 40um) and next – immunohistohemical assessment of filtered microclots were performed. Final stage of project were animal trials. 8 pigs were supported by means of ReligaHeart PED extracorporeal system. During experiment the correlation between Doppler echo and clinical status of animal were being searched.

Results

After calibration the accuracy of continuous and pulsating blood flow measurement was 10% and 15%, respectively. Resolution of microparticles recognition was between 106um and 150um (the middle-size particles should be used to more accuracy estimate of resolution). Developed methods of microembolus counting got following results: true positive counts: 92%, false

positive counts: 23%, false negative counts: 2%. Estimation of microembolus size by means of EBR appeared inaccurate and variance of series obtained for two sizes of particles was high. Animal trials revealed, that Doppler ultrasound methods allowed to observe many clinical events, like backflow through tilting-disc valve, double or triple counting of microembolus, differences between echo registered in inlet and outlet cannula.

Conclusions

It was experimentally proved that developed ultrasound Doppler system and methods are useful to monitoring microembolus in blood especially during mechanical heart supporting by means of rotary and pulsatile blood pumps.

Acknowledgements

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References

[1] G. B. Wright, Ed., September 1968, New York, Springer-Verlag 1969, 739.

A comparison of impact of image feature extraction methods for measuring the volume of the chamber a mechanical prosthetic heart

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The paper presents a comparison of impact of image feature extraction methods for measuring the volume of chamber a mechanical prosthetic heart. Research was performed on the developed model of artificial prosthetic heart. In the considered task the volume of chamber was estimated with use of artificial neural network (ANN). Artificial neural network was used to determine the relationship between the views of membrane and measured chamber volume. The membrane was observed by a camera that works in the near-infrared band.

Broadband common-path planar waveguide interferometer

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Thanks to researches and the development of integrated optics devices for optical applications in the telecommunications, relatively cheap sources and detectors of optical radiation that can be used in the design of planar optical sensors [1, 2]. One of the commonly used sensor systems is the differential interferometer, based on planar waveguides [3]. In the analyzed system propagates a mode for wavelengths from 450 nm to 600 nm. This type of arrangement is shown in [4-6] and called "frequency-resolved", "broad-band" or "wavelength interrogation" Mach-Zehnder interferometer. This abstract presents the idea of a spectropolarimetric differential interferometer in which the recorded signal indicates the spectral distribution recorded at the output of the structure. Any change in the condition of propagation results in the case in a change of the recorded spectral distribution. In the case of an interference of the modes TE0 and TM0 and the same optical power density I0 is transmitted in both modes, the signal recorded by the detector I (t) can be expressed by the formula [3]:

$I(\lambda,t)=Io\{1+\cos[\Delta\phi(\lambda,t)]\}$ (1)

where $\Delta\phi(\lambda,t)$ is the phase difference between the modes at the output of waveguide.

In the course of propagation the difference of the phases between the modes is attained, which is a function of the length of the path of propagation L, the difference of the effective refractive index (NTM-NTE) and the wavelength.

$$\Delta\phi(\lambda) = \frac{2\pi}{\lambda} \mathrm{L}\,(\mathrm{N}(\lambda)_{\mathrm{TM}} - \mathrm{N}(\lambda)_{\mathrm{TE}}) \quad (2)$$

The second polarizer placed before the spectrometer provides light from both orthogonal modes to one plane of polarization, permitting the recording of the signal of interference.

Figure 1 presents the normalized light intensity distribution concerning the refractive indices of the cover nC= nH2O and nCi= nH2O +i× 0.001 (i=1,2,3).

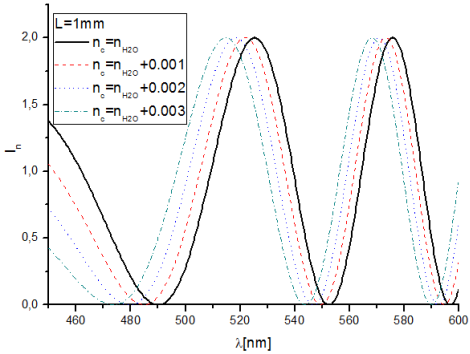

Fig. 1. In (λ) for different indices of refraction of the coating layer

A change of the refractive index of the cover of the waveguide in a spectropolarimetric interferometer results in a change of the distribution of power in the spectrum transmitted by the considered system.

References

[1] P. Lambeck, *Integrated optical sensors for the chemical domain*, Meas. Sci. Technol. vol.17, pp. R93-R116, 2006

[2] P. Kozma, et ol., *Integrated planar optical waveguide interferometer biosensors*, Biosensors and Bioelectronics, vol. 58, pp. 287-307, 2014

[3] W. Lukosz, *Integrated optical chemical and direct biochemical sensors*, Sensors and Actuators B, vol. 29, no. 1, pp. 37–50, 1995

[4] K. Misakos, et ol., Broad-band Mach-Zehnder interferometers as high performance refractive index sensors: *Theory and monolithic implementation*, Optics Express vol. 22, no.8, pp. 8856-8870, 2014

[5] M. Kitasara et al*., Integrated optical frequency-resolved Mach-Zehnder interferometers for label-free affinity sensing*, Optics Express, vol. 18 no.8, pp.8193-8206, 2010

[6] M. La Notte, V. Passaro, *Ultra high sensitivity chemical photonic sensing by Mach-Zhender interferometer enhanced Vernier-effect*, Sensors and Actuators B, vol. 176, pp. 994-1007, 2013

SU8 polymer based waveguides on different substrates

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Polymers are nowadays commonly used in many fields of engineering. In this paper optical and waveguide parameters of SU8 polymer on different substrates will be presented. SU-8 polymer is commonly used in integrated optics because of high and uniform transmission in visible spectrum of light up to near infra-red. Additionally this polymer is very chemicaly resistant, especially for commonly used in photolitography acids and bases. SU-8 polymer is also bio-compatible which is great advantage in designing of LOC (Lab On Chip) and microfludics devices[1-3].

During experiments polymer based waveguide on different substrates were made. As polymer layer Gerseltec SU8 GM1040 and Microchem SU8 2000.5 were used. By using Gerseltec SU8 GM1040 we obtained layer with thickness 950 nm which gave us bimodal structure for λ=633nm [4-5]. By using Microchem SU8 2000.5 we obtained layer thickness 450 nm which gave us single mode structure for λ=633nm. As substrate we used 2µm of SiO_2 on Si and standard microscope glass.

Additionally we performed measurements for characterization of optical and physical properties of obtained layers. We measured layer thickness with AFM (Fig.1) and elipsometer. Elipsometric measurement also gave us refractive indices of waveguide layer and substrate. We also performed measurement of effective refractive index and attenuation of waveguide layers. Additionally we performed SEM measurement for checking layers adhesion.

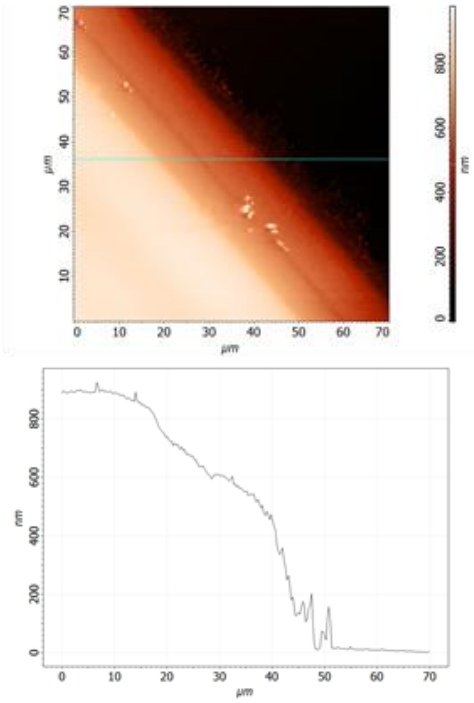

Fig. 1. Measurement of layer thickness with AFM (Atomic Force Microscopy).

REFERENCES

[1] Hamid, Qudus, et al.: Surface modification of SU-8 for enhanced cell attachment and

proliferation within microfluidic chips. Journal of Biomedical Materials Research Part B: Applied Biomaterials (2015) vol. 103, no.2, pp.473–484.

[2] Robin, Vishnoi, et al.: Mechanical Behavior and Anisotropy of Spin-Coated SU-8 Thin Films for MEMS, Journal of Microelectromechanical Systems (2013), vol.23, no.1, pp.168-180

[3] Joshi, Manoj, et al.: A novel dry method for surface modification of SU-8 for immobilization of biomolecules in Bio-MEMS.Biosensors and Bioelectronics (2007)vol. 22, no: 11, pp.2429-243

[4] Gut, Herzog : Analysis and investigations of differential interferometer based on a polymer optical bimodal waveguide, Photonics Letters of Poland, Vol 7, No 2 (2015)

[5] Herzog , Gut : Near field light intensity distribution analysis in bimodal polymer waveguide. Proc. SPIE 9816, Optical Fibers and Their Applications 2015

Pulse interferometer in protection of telecommunication lines

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The development of fiber optic sensor technology allows more and more reliable detection of alarm signals, but the effective protection of critical infrastructure requires the implementation of ever newer and more sophisticated solutions. In the era of information society the data sent between users or organizations is critical to safety. The protection of this data needs protection of communication lines which are considered as elements of critical infrastructure.

At the moment, ensuring adequate procedures are maintained, quantum cryptography systems can increase the security of data transmitted via the transmission line. However, due to loopholes in the system carried out by proven effective attacks, they prevent their use to protect sensitive information in full. Another possibility for protection of transmission lines is the use of sensor systems for monitoring the integrity of the link. Currently used solutions provide the ability to detect the location and place of the violation of the line. In the case of detection of attempts to interfere in protected line is followed by transmission of alarm signal and pause of data transmission

One of the approach to the subject of security is the protection of transmission lines by sensing devices. But in this case protection is limited by detection properties of used sensors. Ideal solution providing completely safe transmission would be a combination of sensing signal with transmitted data. Unfortunately, pulse sensor solutions are not widely used in fiber optic protection.

In this paper authors presents solution that can provide higher level of security in data transmission. Team of authors conducted a study on use of pulse interferometer system for transmission line protection and a combination of sensing signal with encoded transmitted data. Analysis of pulse interferometer properties in terms of information security and ability to readout of transmitted data. There is also consideration of using the sensor in areas other than transmission lines protection.

Keywords: fiber optics, fiber optics sensors, pulse interferometer

Fiber optic displacement sensor with signal analysis in spectral domain

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Optical fiber sensors are often used for measurements of various physical quantities, such as temperature or strain, especially in the applications where their small size, all-dielectric construction of the sensing part or immunity to electromagnetic interference (EMI) are needed. In some instances, the transducer has to be placed remotely from the source and the detection setup, with the length of lead-in and lead-out fibers reaching several hundred meters. With increasing length of these fibers the changes in their attenuation, induced by environmental factors, such as vibrations, adversely affect the operation of these sensors. While accuracy of most fiber optic sensors, especially intensity-modulated ones, is degraded by changes in attenuation of lead-in and lead-out fibers, a few classes of fiber optic sensors are immune to attenuation changes. These include sensors in which the measurand changes phase, fluorescence lifetime, or optical spectrum. An important class of sensors using changes in optical spectrum are low-coherence optical fiber sensors. They are used, among others, for the measurement of the refractive index dispersion, temperature or displacement [1, 2].

In this paper, a preliminary study of a low-coherence fiber optic displacement sensor is presented. The sensor consisted of a broadband source whose central wavelength was either at 1310 nm or 1550 nm, a sensing Fabry-Pérot interferometer operating in reflective mode and an optical spectrum analyzer acting as the detection setup. All these components were connected by a single-mode fiber coupler. Metrological parameters of the sensor were investigated for different lengths of the fiber connecting the sensing Fabry-Pérot interferometer (1 m, 10 m and 1000 m). For each length of the fiber, displacement in the range of 0 μm to 500 μm, in increments of 50 μm were measured. Representative measurement results of displacement of 200 μm are shown in Fig. 1.

Obtained results indicate that the developed sensor is not sensitive to changes in attenuation in the optical path, thus enabling remote measurement of the displacement on long distances while maintaining a satisfactory accuracy.

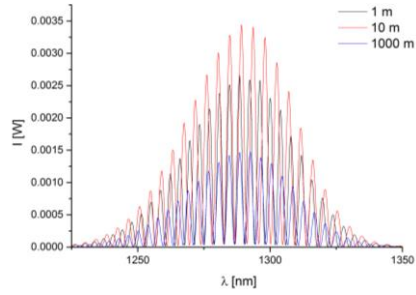

Fig. 1. Representative measurement results of displacement of 200 μm. Central wavelength was 1310 nm

Acknowledgements

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References

[1] K. Karpienko, M. S. Wróbel, R. Urniaż, *Reliability and validity of optoelectronic method for biophotonical measurements*, Proc. of SPIE, vol. 9032 (2013), pp. 90320Q-1 - 90320Q-9

[2] D. Milewska, K. Karpienko, *The use of thin diamond films in fiber-optic low-coherence interferometers*, IOP Conference Series: Materials Science and Engineering, vol. 104 (1) (2016), pp. 012023

Analytical model of the acoustically loaded sandwich transducer

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Ultrasonic transducers used in a high power applications such as ultrasonic welding or cleaning systems are mostly constructed as a piezoelectric stack systems known as sandwich transducers. Explicit formulation of the sandwich transducer parameters is well known and documented but only in reference to unloaded conditions and in parallel resonance working regime only. To overcome those difficulties many authors have been using lumped models such as Mason model or T-network model of the acoustic transmission lines as well as the finite element modeling. This approach takes time and obviously is less transparent than explicit formulation of the basic transducer parameters. This article provide an extent to the existing explicit formulations of the sandwich transducer parameters such as resonant frequencies, electromechanical coupling factor, mechanical amplitude gain factor and power gain factor. Authors derived explicit relations for those parameters taking into consideration acoustic loading conditions and both series and parallel resonant frequencies working regime. Designated formulas can be use to optimize transducer geometry dimensions such as piezoceramic stack length and position in order to maximize the transducer acoustic power capabilities under certain acoustic loading medium. Obtained results have shown that acoustic loading and resonant frequency working regime have strong influence on the transducer parameters.

Quasi-phase matching via femtosecond laser induced domain inversionin lithium niobate waveguides

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We demonstrate an all-optical fabrication method of quasi-phase matching [1] structures in lithium niobate ($LiNbO_3$) waveguides using tightly focused femtosecond near-infrared laser (wavelength 800 nm). In contrast to other all-optical schemes that utilize a periodic lowering of the nonlinear coefficient χ modification, here the illumination of femtosecond pulses directly reverses the sign of χ of ferroelectric domain inversion [3]. The resulting quasi-phase matching structures, therefore, lead to more efficient nonlinear interactions. For an example we fabricate a structure with the period of 2.74 μm to frequency double 815 nm light. A maximum conversion efficiency of 17.45% is obtained for a 10 mm long waveguide

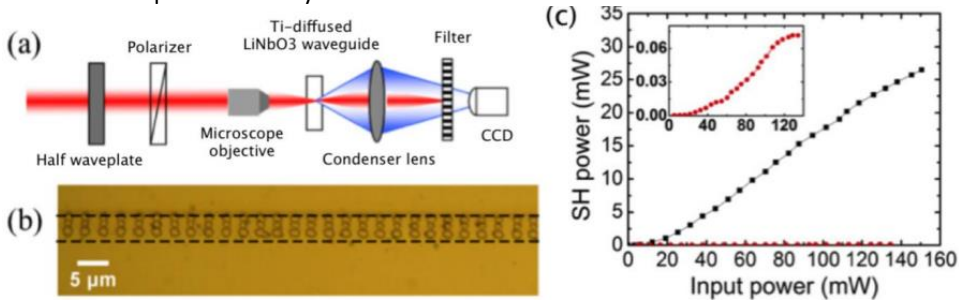

Fig.1. (a) Experimental setup for femtosecond laser optical poling and in situ monitoring of ferroelectric domain inversion via Čerenkov-type second harmonic scanning microscopy. (b) The optical microscopic image of the optically poled domain pattern in the Ti-indiffused LiNbO3 waveguide. The circles represent inverted domains. Waveguide boundaries are indicated with dashed lines. To obtain the image the waveguide is etched for 5 minutes in HF solution. (c) The second harmonic power versus input power at the quasiphase matching temperature 62.5℃. The inset depicts details of the SH generation without domain structure.

Acknowledgement

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References

[1] D. S. Hum, M. Fejer, "Quasi phase matching," C.R. Physique 8, 180 (2007).

[2] C. Y. J. Ying, A. C. Muir, C. E. Vakduvuam G. H. Steigerwald, C. L. Sones, R. W. Eason, E. Soergel, and S. Mailis, "Light-mediated ferroelectric domain engineering and micro-structuring of lithium niobate crystals," Laser Photonics Rev. 6, 526 (2012).

[3] X. Chen, P. Karpinski, V. Shvedov, K. Koynov, B. Wang, J. Trull, C. Cojocaru, W. Krolikowski, and Y. Sheng, "Ferroelectric domain engineering by focused infrared femtosecond pulses," Appl. Phys. Lett. 107, 141102 (2015).

Novel comb polymers as a photonics and electronics sensing materials

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Sensors based on semiconductor oxides are generally low in cost and show high stability [1]. At present market offers sensors enabling measuring and detection NO2 in relative high temperatures and concentration in ppm levels [1]. It is related with using semiconductor oxides as receptors because for them chemisorption takes place at relatively high temperatures (hundreds of Celsius degree), and it is important in context sensors power consumption. Therefore, it would be necessary to develop and fabrication practical, small, and low-cost sensor devices that can detect low gas concentrations. This leads to search new materials, provides considerable growing up sensitivity, speed and accuracy of measure, thus, in consequence safety. Gas sensors based on organic receptor as like phthalocyanines (Pc) or conducting polymer layers (including poly(3-hexylotiophene) - P3HT) become increasingly popular [2-5].

Grafting, in our case, involve reaction of functional groups (Pc or P3HT and PEG) located at chain ends of one kind of polymer with another functional groups which distributed randomly on the main chain of the poly(metyl-hydro-siloxane) (PMHS) polymer backbone. This work presents an investigation on novel graft comb copolymer of polymethylsiloxane (PMS) with phthalocyanine (Pc) side group and polymethylsiloxane (PMS) with poly(3-hexylotiophene) (P3HT) and poly(ethylene) glycol (PEG) as functional side groups. Those segmented copolymers were investigated as gas sensing materials. Gas sensing, optical and electrical properties of thin films of graft polymers are tested and compared. Thin films of investigated materials obtained by spin coating method on interdigital transducers and surface plasmon resonance (SPR) sensor structure are characterized using AFM method and Raman spectroscopy.

Chemosensors obtained by spin coating of comb copolymer-based films reveal good sensing characteristics and general good stability. In addition, it is worth noting that it has been demonstrated that the simple and low cost of the sensor fabrication technique provide to development in the field of novel sensing material.

Acknowledgements

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Science Centre (NCN) within Grant no. 2012/ 07/B/ST7/01 471.

References

[1] Fine, G.F.; Cavanagh, L.M.; Afonja, A.; Binions, R. Metal oxide semi-conductor gas sensors in environmental monitoring. Sensors 2010, 10, 5469–5502.

[2] J. F. Van der Pol, E. Neeleman, R. J. M. Nolte, J. W. Zwikker, and W. Drenth, "Asymmetrically substituted liquid-crystalline phthalocyanines and side-chain polymers derived from them", Makromol. Chem., 190, pp. 2727-2745, 1989.

[3] E. Maciak, and T. Pustelny "An optical ammonia (NH3) gas sensing by means of Pd/CuPc interferometric nanostructures based on white light" Sensors and Actuators B, 189, pp. 230-239, 2013.

[4] N.B. McKeown, "Phthalocyanine-containing polymers" Journal of Materials Chemistry, 10, pp. 1979–1995, 2000.

[5] R. S. Dudhe, J. Sinha, D.S. Sutar, A. Kumar, V. R. Rao "Poly(3-hexylthiophene) and hexafluoro-2-propanol-substituted polysiloxane based OFETs as a sensor for explosive vapor detection" Sensors and Actuators A: Physical 171, 12-18 (2011).

Multicolor emission in optical fibers doped with luminescent centers

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Nowadays, the high impact in new constructions of light sources is noticeable. The new multicolor emission materials are attractive as their spectra can be optimized for specific applications. One of the possibility to obtain the required light spectrum is using co-doped matrices. The energy transfer or conversion phenomena can be used for emission spectrum modification. The interesting spectroscopic properties can be obtained in optical fibres. The long interaction distance inside light guiding structure allows to observe interesting phenomena which can be used for spectrum modification (reabsorption, energy transfer, host attenuation). The efficient multicolor luminescence can be obtained by using co-doped luminescent centers in glass and polymeric matrices. The luminescence can be caused by lanthanides ions or organic dyes. The properties of antimony-germanate and tellurite glasses doped by Yb3+, Tm3+, Ho3+ ions will be presented. The up-conversion mechanism in co-doped glasses will be investigated as it assure attractive luminescent properties. Moreover, the white light emission in glass host is possible by using specific concentrations of proposed lanthanides. The CIE1931 chromaticity diagram coordinates of obtained luminescence spectra will be shown. The properties of optical fibres doped by chosen lanthanides will investigated. The energy transfer in optical fiber co-doped by Yb3+/Tm3+ and Yb3+/Ho3+ ions will be also shown. The organic luminescent dyes are interesting alternatives to presented glass hosts materials. The excellent optical properties of PMMA in visible spectrum range and good processability makes it good candidate for numerous applications. The multicolor emission fluorescence spectra of PMMA co-doped by chosen organic dyes will be shown. The Perylene and Rhodamine 6G co-doped polymeric fibre will be shown as it assure efficient multicolor emission. The white light fluorescence of PMMA fibre at color temperature 3350K will be presented.

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Type II quantum wells with tensile-strained GaAsSb layers for interband cascade lasers

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Optical properties of modified type II W-shaped quantum wells have been investigated with the aim to be utilized in interband cascade lasers [1]. The results show that introducing a tensely strained GaAsSb (see Fig. 1c) layer, instead of a commonly used compressively strained GaInSb, allows employing the active transition involving valence band states with a significant admixture of the light holes. Theoretical predictions [2] of multiband k•p theory have been experimentally verified by using photoluminescence and polarization dependent photoreflectance measurements.

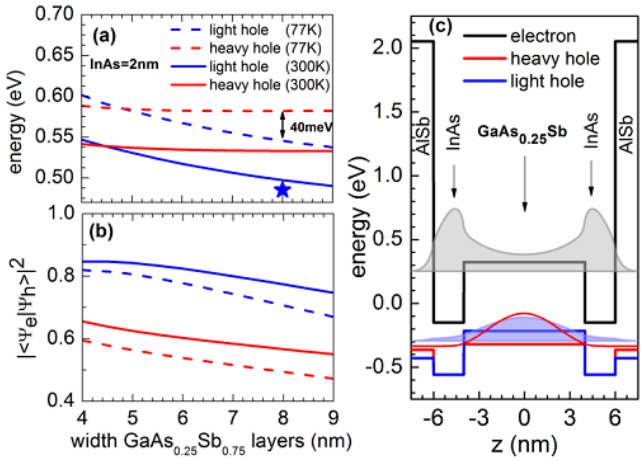

Fig. 1. The calculated energy (panel a) and squared wave function overlap (panel b) for fundamental transition involving heavy (red curves) and light holes (blue curves) in investigated quantum wells with $GaAs_{0.25}Sb_{0.75}$ layer as a function of layer thickness. Blue star denotes fundamental transition energy measured (by PL) for sample with 8nm $GaAs_{0.25}Sb_{0.75}$ layers width. Panel c shows band structure together with confining levels and density probabilities of electrons (grey line), light holes (blue line) and heavy holes (red line) for one of the investigated QW.

In Figure 1, there are shown the calculated fundamental transition energy (panel a) and the squared wave function overlap (panel b) for the type-II AlSb/InAs/GaAsSb/InAs/AlSb QW as a function of GaAsSb layer thickness for a value of As content of 25% (with respect to the InAs substrate). The calculations were performed for 77 K (dashed lines) and 300 K (solid lines). One can see in Fig. 1a that when the well width is less than ~5 nm the fundamental optical transition is of heavy hole character, whereas for the well width greater than 6 nm the fundamental transition becomes a light hole transition, when only transitions for k_II=0 are considered. It is worth noting, that such a situation is a result of the tensile strain in GaAsSb material affecting (via the shear component) the separation of heavy and light hole valence band edges. Such strain shifts the heavy and light hole states in opposite directions on energy scale, causing their crossing and final position exchange as a function of the GaAsSb well thickness. Additionally, there are also shown the calculated squared overlaps of the electron and heavy or light hole wave functions for particular transitions showing that the latter is larger for the entire range of the considered GaAsSb layer thicknesses and for the two temperatures considered. These results open a pathway for practical realization of mid-infrared lasing devices with uncommon polarization properties including, for instance, polarization independent mid infrared light emitters [3].

References

[1] R. Q. Yang, Superlattices Microstruct., 17, 77 (1995)

[2] K. Ryczko, G. Sęk, J. Misiewicz, Applied Physics Express 8, 121201 (2015)

[3] M. Motyka, M. Dyksik, K. Ryczko et al, Applied Physics Letters (2016) under review

Laboratory stand and theory of measurement of blood chamber volume of mechanical prosthetic heart with use of image processing technique

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The paper presents in details the method of measuring the shape of flexible membrane based on digital image processing. The solution is characterized in that the simultaneous multi-point distance measurements to the objects are performed by a motionless camera with established and unchanged parameters during measurement. The camera is equipped with a one non-stereoscopic lens. The membrane shape is determined on the basis of one objects view presented on one image. We were also shown the construction and technology used to build of computer system and laboratory stand for measurement volume of prosthetic heart chamber.

Different taper structure as functional element for sensor application

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In this presentation, unique physical and optical properties of tapered fibers will be shown. Optical fiber taper offers a number of favorable properties for sensing application, including physical, chemical and biological sensors. The theoretical part of presentation describes propagation of a light in tapered optic fibers. The different structure of tapers used in optical sensing will be introduced. Results of simulations performed with MODE Solutions software by Lumerical for selected structures as well as different application of it will be demonstrated.

Optical fibre technology as a creator of economy development

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In order to accelerate the development of the Polish economy, it is absolutely necessary to build up a solid base of strong hi-tech industries using indigenous, innovative technologies. As early as the 1970s, Polish scientists had already established the early foundations for research in optical fibre technology, quite independently of research centres in the West. This resulted in a number of patents which must be respected internationally, thus giving rise to a native specialty in the field of advanced technology. Years of research have built up a unique wealth of knowledge and experience, giving rise to tremendous opportunities for developing practical solutions. So far in Poland, we have developed and manufactured many different types of fibre, from classical solutions to highly specialized applications using microstructures or photonics. Polish scientific development is on-going, and now our advanced research and development, combined with close cooperation between science and industry is beginning to deliver tangible results in the form of new applications. Recently a world class plant has been established in Poland, using innovative methods to produce fibre optic cables and microstructural fibres. The unique technology of microstructured optical fibres could revolutionize areas such as: the new generation of telecommunications, precision fibre optic sensors, and innovative light sources. These innovations are capable of modernizing almost all branches of Polish industry, and could thus have considerable influence on the development of the whole economy. Creating a strong sector for applications of photonics based on optical fibre technology will not only provide accelerated development for Poland, but will also enable us to compete effectively with the more technologically developed countries around the world.

Application of Microelectronics in High Energy Physics & Space Technology

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The paper presents achievements of TUL DMCS electronic design team, related to circuitry designed for operation in tough environments and for control of extreme environments.TUL DMCS has participated and participates in design of electronic circuitry for High energy physics projects. One set of projects results from cooperation with Deutsches Elektronen-Synchrotron (DESY) in Hamburg [1]. This cooperation resulted in design of electronic control systems for several accelerators like European X-ray Free Electron Laser (XFEL) accelerator, for example. Another large entertainment is International Thermonuclear Experimental Reactor (ITER) [2]. This long-term project aims at building experimental thermonuclear fusion reactor based on tokamak concept, first in the world to produce net energy.ITER Members are China, the European Union, India, Japan, Korea, Russia and the United States (35 counties in total).

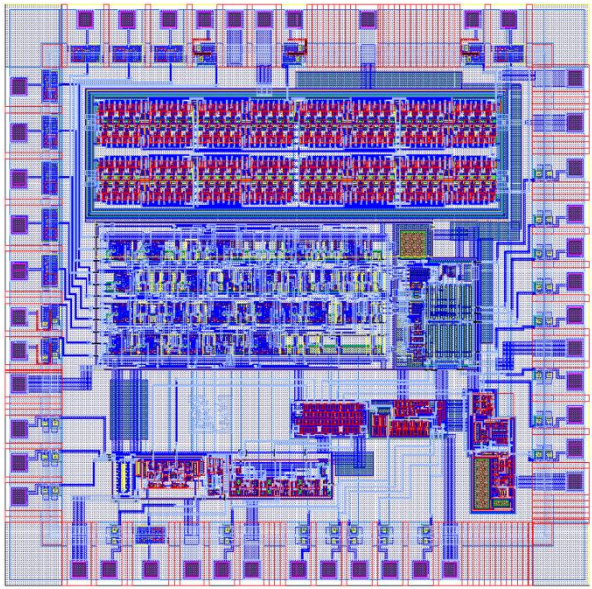

Fig. 1. Layout of an ASIC circuit containing a register optimized for detecting particle hits (upper part)

Apart from large scale projects, also smaller designs related to high energy physics are carried out in TUL DMCS. For example, a specialized design of digital register, intentionally designed to be susceptible to particle hits. The circuit was fabricated with use of only available Polish technology line in Piaseczno.

Microelectronic designs of small complication scale are now followed by project of DC/DC converter for space applications. This project is realized in cooperation with Astri Polska Company and Center of Space Research of Polish Academy of Sciences and is funded by European Space Agency.

This project is the first of its kind in Poland. It is focused on design and full space qualification of the designed ASIC, so the outcome is intended to be fully mature product applicable for wide range of applications in which electronics are exposed to thermal and radiative influences.

The circuit under design is expected to be applicable in both carriers/rockets (short term missions) and satellites (long term missions with no possibility of maintenance).

Market for space grade DC/DC converters may be considered limited, so other applications are possible, like military equipment, for example.

References

[1] D. Makowski, et al, Standardized Solution for Management Controller for MTCA.4, IEEE TRANSACTIONS ON NUCLEAR SCIENCE, 2015, vol. 62, no. 3, p. 932-939,

[2] A. Napieralski et al., Recent research in VLSI, MEMS and Power Devices with practical application to the ITER and DREAM projects, Facta Universitatis, 2014, vol. 27, no. 4, p. 561-588, ISSN: 0353-3670,

[3] K. Skup et. al., Mixed Signal ASIC Controller for Satellite Medium Power DC/DC Converters, Proc. Conf. "Mixed Design of Integrated Circuits and Systems". Poland, Toruń, 25-27.06.2015, pp. 359-363.

Multicore optical fibers for telecommunications and sensors

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There are several challenges in terms of multicore fiber (MCF) design, which are different from the point of view of final application of MCFs: whether they are intended for the use in telecommunications [1] or for sensing applications [2].In telecommunications, MCFs are used to increase the link capacity, so fiber designs are mainly oriented on assuring low core-to-core crosstalk (XT), since each core is treated as independent transmission channel. When one wants to combine MCF with mode division multiplexing (MDM), there is a need to take into account additional aspect of crosstalk which can occur between modes, which play in this case a role of the transmission channels. On the other hand the core-to-core power transfer may be considered as a beneficial effect in other applications, such as sensors. To take advantage of the MCF design flexibility we performed a research, which was aimed at investigating the XT phenomenon in MCFs. The research allowed us to form a theoretical model of the XT (based on supermode theory) and its consequences on signal transmission in MCFs.

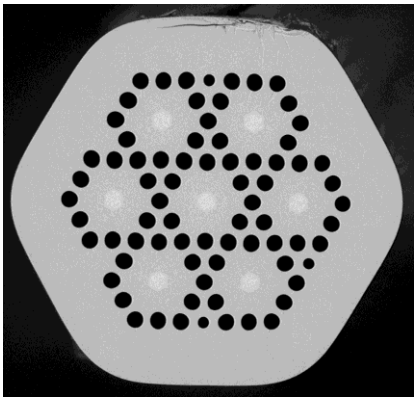

Fig. 1. Cross-section of manufactured seven-core hole-assisted fiber

The studies on the XT let us to optimize a structure of seven core fiber for telecommunications, which is presented in Fig. 1 and allowed to investigate multicore fibers also for sensing applications.

We examined the series of dual-core hole-assisted fibers [3] (see Fig.2) to verify the compatibility of the model with experimental results and to check whether the fibers can be used as sensors. The research was conducted on fiber elements based on post-processed dual-core fibers,

whereas post-processing relied on air hole collapse.

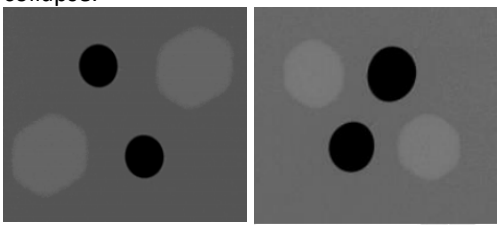

Fig. 2. Dual-core hole assisted fibers under test.

In this way, we created an area with increased level of core-to-core XT. The application of such element is twofold: it can be used as optical fiber coupler or it can serve as the strain sensor (with low cross-sensitivity to temperature). The experiments showed that such fiber element is very sensitive to strain, which was manifested with switching of the signal between the cores at the fiber output together with fiber elongation. The power detected at the output of one of the cores reflects therefore the strain applied to the fiber.

Measurements of sample series proved that the XT, which is regarded as undesirable effect in telecommunications, can be used as operation principle of new type of sensors. Similar approach of changing the conditions of interference of supermodes in multicore fibers was also used to create all-fiber power splitter.

References

[1] D. J. Richardson, J. M. Fini, L. E. Nelson, *Space-division multiplexing in optical fibres*, Nat. Photonics 7, pp. 354–362 (2013).

[2] A. Van Newkirk, J.E. Antonio-Lopez, G. Salceda-Delgado, M.U. Piracha, R. Amezcua-Correa, A. Schulzgen, *Multicore Fiber Sensors for Simultaneous Measurement of Force and Temperature*, IEEE Photonics Technology Letters 17, 1523 – 1526 (2015)

[3] A. Ziolowicz et al., *Supermode interference in dual-core hole-assisted fiber for sensing*, Proc. SPIE 9816 (2015)

A new approach to measure the phase modulation introduced by flowing microobjects using optical low-coherence interferometry

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Biological microobjects can introduce significant phase modulation with considerable scattering anisotropy and dominant forward-scattered light [1]. Such physical properties may favor the use of a trans-illumination imaging method. However, an epi-mode may be more practical and robust in many applications. This study describes a new way of measuring the phase modulation introduced by flowing microobjects. The novel part of this invention is that it uses the backscattered signal from the substrate located below the flowing/moving objects [2].

In this study we attempt to differentiate objects using light that is initially disturbed by the object and secondarily scattered by a material of known optical properties (Fig. 1). In our approach the backscattered light is registered by low-coherence interferometry, in particular by Fourier-domain optical coherence tomography (Fd-OCT). In the configuration presented in Fig. 1, the phase modulation introduced by the object flowing in a channel will also contribute to the electromagnetic field scattered later from the base. For a stationary location of an illuminating beam (M-scan mode) and with no object flowing in the channel, the registered OCT signal from the scattering base will be static. An additional contribution to the phase modulation induced by the object will be clearly visible on this static background as a new speckle field and will be observable in both the intensity and the phase-sensitive OCT images.

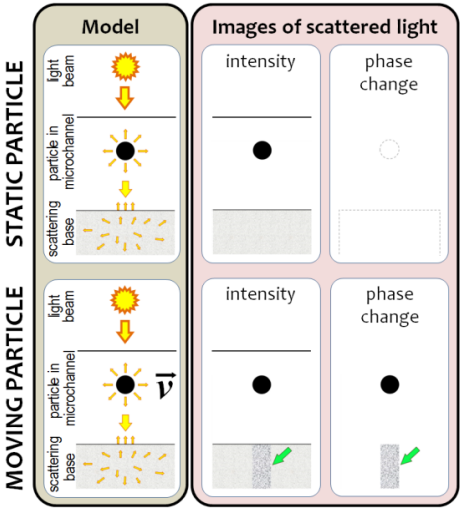

Fig. 1. Intensity and phase change images of scattered light for static and moving objects. Signal enhancement (green arrows) in the static scattering base appears only for moving objects.

Therefore, the scattering medium can be considered to be a kind of “intensifier” of

the phase modulation introduced by the object.

In order to demonstrate the applicability of the method we conducted an experiment to differentiate erythrocytes (RBC) from leukocytes (WBC). It is well known that WBC and RBC have diverse scattering properties due to their differences in size and internal structure [3]. Therefore, we expect to see a qualitative difference between these cells by observing the modulation signals in the phase-sensitive images and a quantitative difference by calculating the statistical differential parameters [2].

A two-dimensional scatter plot presented in Fig. 2 shows that we are able to distinguish between cells considering only the phase information provided by OCT (two phase-based differential parameters obtained from phase-sensitive OCT images).

References

[1] V. Maltsev, K. Semyanov, *Characterisation of Bio-Particles from Light Scattering*, Utrecht, VSP, Boston 2004.

[2] P. Ossowski et al., Opt. Express **23**, 27724 (2015).

[3]A. Dyrnaev, J. Opt. Technol. **79**, 708 (2012).

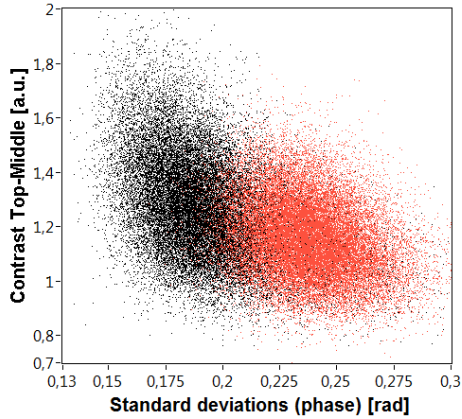

Fig. 2. 2D scatter plot for two phase-based parameters: OX-axis: *standard deviations (phase)* [rad] vs. *contrast top-middle* [a.u.] (OY-axis). This plot contains ~70,000 points, and each point corresponds to a registered modulation signal coming from a single flowing cell (~35,000 red dots for RBCs and ~35,000 black dots for WBCs).

Fiber-optic Fabry-Pérot sensors – modeling versus measurements results

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Fiber-optic Fabry-Pérot sensors represent an important class of sensors for measuring several physical quantities. They are particularly promising if they are stimulated by broadband radiation and a spectrum analyzer is used as the detector. Since the detection in this sensor configuration is based on the measurement and location of spectral bands, measurement systems using these sensors can be highly resistant to disturbances of the optical path, e.g. accidental and inevitable changes in attenuation of fiber-optic path. Principle of operation of these sensors is based on interference of optical radiation occurring inside the cavity forming a Fabry-Pérot interferometer. As a result of the interference, changes of spectrum of an optical signal reflected or transmitted by the cavity can be observed. The nature of these changes depends on geometric and optical parameters of the cavity; by changing these parameters due to external factors, it is possible to measure several physical parameters. For example, pressure or temperature can change the dimensions of the cavity or change the refractive index of the substance inside the cavity. Also, it is possible to measure the concentration of various substances on the basis of the measurement of refractive index, dispersion, or even changes in attenuation or scattering. These phenomena change the spectrum of the reflected optical radiation, in particular the position of the maxima and minima of the spectrum and their relation.

In order to measure the parameters of optical medium inside the Fabry-Pérot interferometer on the basis of spectra of the optical signal from the sensor, it is necessary to know how the spectrum depends on all relevant parameters of the interferometer and the medium [1-3]. Neglecting some dependencies can lead to significant errors in the measurement.

This paper describes how parameters of investigated substances and the fiber-optic Fabry-Pérot sensing interferometer affect the output spectrum in the sensor. First, modeling of the operation of the sensing interferometer was conducted. Most important parameters and effects that were taken into account are: changes in the parameters of an optical beam inside the interferometer, including the mode field diameter of a single mode fiber, dependence of the diameter of the laser beam from the Gouy effect, the curvature of the wavefront, the refractive index and the absorption of the medium inside the cavity of the interferometer. Impact of these parameters and dimensions on the spectrum at the output of the sensor was subsequently investigated. Following, spectra from selected Fabry-Pérot optical sensors, applied to measurement of refractive index were presented. Measurement results were compared with the spectra obtained by modeling.

Acknowledgements

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References

[1] B.E.A. Saleh, M.C. Teich, *Fundamentals of Photonic*, 2nd Ed, A John Wiley & Sons, Inc., Publication, Hoboken, New Jersey 2007,

[2] P.F. Goldsmith, *Quasioptical Systems - Gaussian Beam Quasioptical Propagation and Applications*, IEEE Press, New York 1998,

[3] D. Marcuse, *Loss analysis of single-mode fiber splices*, Bell. Syst. Tech. J., vol. 56 (1977), pp. 703-718.

Sensitivity of electrical properties of ZnO nanoparticles on action of various gaseous environments

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The work deals with experimental investigations of ZnO nanostructures obtained chemically. The influence of both oxidizing and reducing gases on the physic-chemical properties of ZnO nanostructures have been tested. Extensive investigations concerning the effect of the atmosphere of air and the atmosphere of nitrogen (without oxygen) on the values of electrical resistance have been performed. The investigations concerned also sensitivity of ZnO nanostructers on the effect of tested gases in wide ranges of their concentrations at room temperature and at temperature of 200^{o}C as well as without optical excitation of ZnO nanostructures and in conditions caused by UV radiation. These investigations indicated a high sensitivity of electrical properties of ZnO nanostructures to the effect of NO2, even a concentration on the level of 1ppm. It may be assumed that the results of our experimental investigations of ZnO nanostructures provide an essential value and they will be also valuable in an aspect of their utilization – the ZnO nanostructures of this kind ought to be applied for practical detecting NO_2 with extremely low concentrations of the order of several 1ppb in the atmosphere.

Changes in the resistance of the nano-ZnO structure on the effect of NO_2 are relatively large (of the order of hundreds %) even at a concentration of NO_2 at the level of some ppm. It may be expected that ZnO nanostructures will detect extremely low concentrations of NO_2 at concentration of few tens ppb. The nano-ZnO structures present a high selectivity to NO_2 and as these gas sensing structures should be practically used, e.g. for environmental monitoring. Such a high sensitivity of nano-ZnO particles exposed to NO_2 provides an opportunity to apply this type ZnO nanostructures in order to detect vapors of explosives. It seems that nano-ZnO structures may allow to construct a sensor of vapors of explosives without using preconcentration methods. These investigations may therefore also to have an important utilitarian value.

Fe_3O_4 NPs – filled microstructured fibers as sensor applications

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At this stage of the project we were able to develop manufacturing methods of the proposed materials in order to design transducers. We have prepared stable citrate with PVP-capped Fe_3O_4 NPs soluble in water by using a facile one step method. Based on these material we have prepared optical fiber transducers with partially filled LMA 10 PCF by prepared ferrofluids. We have tested temperature and magnetic properties of prepared samples. Spectral characteristics of the samples under temperature changes have shown two specific wavelength regions. Calculated optical losses at the wavelength of 1310 nm grow with temperature, and the sensitivity is at a level of 0.045 dB/^{o}C and for the wavelength of 1600 nm these losses decrease, and the sensitivity is of 0.071 dB/^{o}C. We have started measurements of magnetic properties of prepared samples and this work will be continued to have possibility to use it as the magnetic field sensor.

Surface Acoustic Waves in applications of semiconductor investigations

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Among the methods of investigations of semiconductor surfaces, there are no methods of investigating the kinetic properties of electrical carries in fast and very fast surface states. The existing methods allow only investigations of the surface sates with a carrier life-time τ of above 10^{-8}s. In the case of extrinsic semiconductors the surface states may, however, be considerably faster (the carrier life-time in surface traps is usually less than 10^{-8}s). In such cases the existing methods of determining the parameters of fast surface states allow only to estimate these parameters, since the obtained results exhibit a considerable uncertainty. For this reason, investigations of the kinetic properties of fast surface states are not popular and there are not any new results concerning their determination.

For some years attention has been paid to the influence of the physical state of the near-surface region of a semiconductor on the results of investigations of the acoustoelectric effects in piezoelectric-semiconductor systems. Also recently attention has been paid to the possibility of applying Rayleigh's surface acoustic waves SAWs for investigations of various parameters of solid states.

The theoretical and experimental results of the application of acoustoelectric effects (longitudinal and transverse) for the determination of carrier properties in near surface region (e.g. the surface electrical potential, carrier concentration, electrical conductivities,…) have been presented. Problems connected with the determination of the chemical and mechanical means of surface treatments in the first step of preparation of semiconductor plates for technology on their kinetic properties have analysed

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Mid-infrared luminescence in HMO glass co-doped with Ho^{3+}/Yb^{3+} ions

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Infrared light sources operating in the 3 µm range are current research topic due to their wide applications in both civilian and military field including remote sensing, eye-safe laser radar, air pollution monitoring or medical diagnostics and surgery [1-4].

In this work, emission properties of Bi_2O_3-GeO_2-Ga_2O_3-Na_2O glass co-doped with holmium and ytterbium have been investigated. Composition of host has been developed in terms of low phonon energy (724 cm^{-1}), low absorption coefficient in the infrared region (< 0.5 cm^{-1}) as well as good mechanical and chemical properties. Glass samples has been synthesized under a low vacuum condition which reduced absorption band at about 3 µm due to concentration decrease of OH^- ions to 50 ppm.

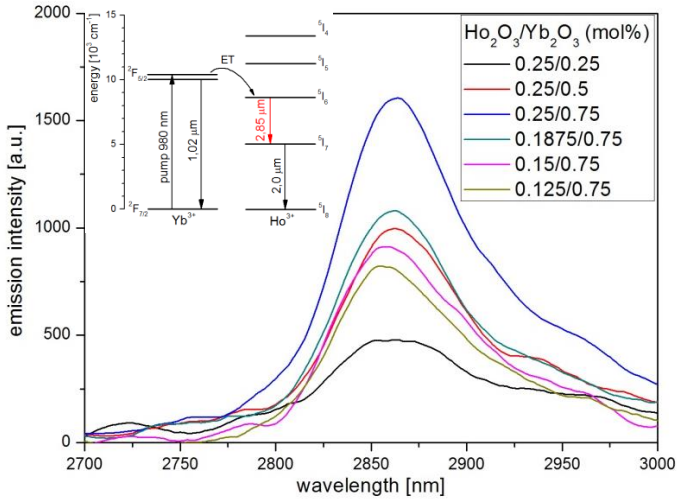

Fig.1. The luminescence spectra of synthesized active glasses in the 2.85 µm region. The inset presents simplified energy diagram od holmium and ytterbium ions with indicated energy transfer

Energy level structure of holmium doesn't allow pumping holmium to upper energy levels with commercial NIR high power laser diodes. Therefore, Ho^{3+}/Yb^{3+} system has been incorporated into the glass host. Ytterbium ions in glass matrix enable

indirect exciting of holmium in course of $Yb^{3+} \rightarrow Ho^{3+}$ energy transfer (inset of Figure 1).

Glass matrix has been co-doped with different molar concentration of rare earth ions. Luminescence has been investigated at the wavelength of 2.85 µm associated with the radiative transition between excited levels $^5I_6 \rightarrow {}^5I_7$ in holmium ions (Figure 1). The maximum emission intensity has been observed in the glass doped with molar concentration 0.25 Ho_2O_3 and 0.75 Yb_2O_3 (ratio 1:3).

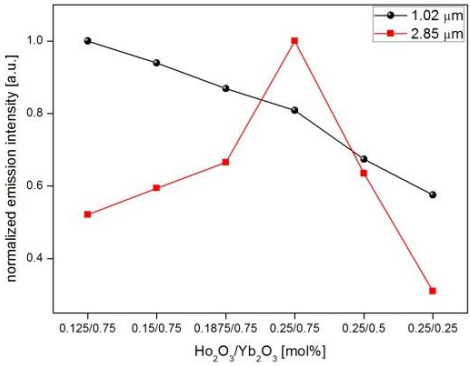

Fig.2. Normalized emission intensity in synthesized glasses at band of 1.02 µm and 2.85 µm

Analysis of normalized luminescence intensity connected with radiative transition between excited levels $^2F_{5/2} \rightarrow {}^2F_{7/2}$ in ytterbium ions has been conducted. It was indicated that emission value at 1.02 µm increases linearly with ytterbium growth and holmium concentration decrease. This phenomenon confirms an increase of energy transfer probability in samples with higher Ho^{3+}:Yb^{3+} ratio (from 1:1 to 1:6, respectively).

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Environmental sensing with multicore nonlinear coupling perturbation fiber system

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Nonlinear phenomena in optical fibers are very sensitive to the external perturbations. They can be efficiently used as a sensing device for detection of small changes in external electromagnetic field or thermomechanical conditions.

We present numerical study of the nonlinear coupling in "2+1" multicore structure (two strongly coupled cores, which are weakly coupled with third one). This structure is simulated using Coupled Generalized Nonlinear Schrodinger Equations (CGNSE). We study nonlinear processes (like soliton propagation, dispersive waves and supercontinuum generation) in the fiber and and investigate how sensitive they are to the perturbations. The results of our simulations show the strong dependence on the selected geometry of photonic crystal fiber (PCF). Change of PCF geometry (f.e. squeezing and bending) modifies not only dispersion relations for propagation modes, but also coupling conditions between modes. The considered system suggests that it is possible to build environmental sensor which is very sensitive not only to the amplitude of perturbation, but also to its distribution over the fiber.

SS-OCT integrated probe for endomicroscopy application based on MOEMS Mirau micro-interferometer

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The detection of neoplastic lesion in its incipient stage allows to increase significantly treatment efficiency and survival rate of patient. Stomach cancer, for example, belongs to the most common cancers worldwide and it can be effectively treated in about 90% of cases (5-years survival rate) when it is diagnosed at the initial stage of development, i.e. when only innermost mucosa layer of stomach is affected [1]. Currently biopsy followed by histological examination is the gold standard for cancer detection used by clinicians. However, this procedure is invasive, painful for patient and time consuming. In addition diagnosis by surgical biopsy of small (a few mm size), pre-malignant changes is often difficult, leading to negative biopsy result. More invasive procedure, requiring several sample of tissue, would be necessary to detect such pathology at the expense of increased risk of complication for the patients and higher therapy cost [2].

Research are being conducted towards the development of fast and non-invasive methods for early cancer detection in human upper human digestive tract with particular emphasis on stomach mucosa tissue. One of the most attractive methods combine endomicroscopy and a Swept Source Optical Coherence Tomography (SS-OCT). The SS-OCT technique permits real-time 3-dimensional (3D) optical biopsy of biological tissue with high resolution - at the subcellular level ~5□m and with relatively big penetration depth in tissue (stomach mucosa) at the level of ~1.5mm @ □ = 840 nm. The authors presents the concept of the new generation SS-OCT fiber-based endomicroscopy with integrated probe based on Micro-Opto-Electro-Mechanical Systems (MOEMS) technology for early diagnosis of stomach cancer. The MOEMS integrated probe consists of a fiber-GRIN lens collimator and a monolithic integrated Mirau micro-interferometer. The Mirau micro-interferometer (which is a key part of the SS-OCT endoscopic system) is manufactured by use of wafer-level vertical integration of batch fabricated silicon/glass components i.e. silicon base, focusing glass lens with focal length fL=10mm, reference micro-mirror, separator and beam splitter. The investigation are focused on the design, technological development and

characterization of the Mirau micro-interferometer components and its vertical integration on wafer 4" level. In particular, we focus on a fabrication and optical characterization of a key component of the micro-interferometer which has a direct impact on OCT imaging quality i.e. monolithic focusing glass lens, fabricated by a non-contact, thermal glass reflow process. In addition the authors shows the preliminary results of SS-OCT measurements obtained by fabricated MOEMS integrated probe. It should be noted the MOEMS integrated probe thanks to small external dimensions (4x4x20mm3) will be connected to a continuum robotic arm and placed on the extremity of an endomicroscope, allowing the 3D positioning of the probe [3].

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References

[1] H. Onodera, A. Tokunaga, T. Yoshiyuki, T. Kiyama, S. Kato, N. Matsukura, G. Masuda, T. Tajiri, Surgical Outcome of 483 Patients with Early Gastric Cancer: Prognosis, Postoperative Morbidity and Mortality, and Gastric Remnant Cancer, Hepatogastroenterology, vol. 51, no. 55, pp. 82-85, Jan-Feb. 2004

[2] W. Jung, D. T McCormick, Y. Ahn, A. Sepehr, M. Brenner, B. Wong, N. C Tien, Z. Chen, "In vivo three-dimensional spectral domain endoscopic optical coherence tomography using a microelectromechanical system mirror," Optics Letters, vol. 32, no. 22, pp. 3239-3241, Nov. 2007.

[3] P. Struk, S. Bargiel, L. Froehly, M. Baranski, N. Passilly, J. Albero, and C. Gorecki, Swept Source Optical Coherence Tomography Endomicroscope Based on Vertically Integrated Mirau Micro Interferometer: Concept and Technology, IEEE Sensors Journal, Vol. 15, no. 12, December 2015.

Reliability of high temperature fiber optic sensors

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In this work, authors describe and analyze the problem of fiber optics sensors' reliability at high temperatures. As an example we use InPhoTech's high temperature fiber optic sensor based on the MachZehnder interferometer principle. Well-developed fiber optics technology allows to produce sensors that are able to work at extremely high temperatures (up to 900 ˚C [1]). However, from the industrial point of view, not only the maximum working temperature of the sensor is important, but also its reliability and long term operation. As reliability is an essential aspect of overall product quality, it is important to remember that fiber optics sensors introduced into the market should remain functional after operating in target environment (e.g. ammonia [2]) for particular period of time. Authors describe the methodology of reliability investigation and experimental test results. By performing the accelerated life tests of the sensors, and analyzing the samples infant mortality effects, authors were able to identify potential week points of the sensors and eliminate them in order to provide fully functional product to the customer. What is more, performed accelerated life tests, allowed to calculate mean life of the sensors in order to provide more detailed i nformation about developed sensors' durability.

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References

[1] L. V. Nguyen, D. Hwang, S. Moon, D. S. Moon, and Y. Chung, "High temperature fiber sensor with high sensitivity based on core diameter mismatch," Opt. Express, vol. 16, no. 15, p. 11369, Jul. 2008.

[2] J. D. Fidelus, T. Stańczyk, K. Wysokiński, S. Lipiński, T. Tenderenda, J. Rodriguez Garcia, I. Canadas Martinez, and T. Nasiłowski, "Solar cyclic tests of optical fiber components working in ammonia and high temperatures," 2015, p. 98160I

Theoretical analysis of slab waveguides supporting SPP modes toward their sensitivity characteristics

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This work is devoted to studying the dielectric/metal multilayer planar waveguide structure that is composed of a high-refractive index (~1.81 for λ=677 nm), single mode, silica-titania film deposited on a BK7 glass substrate. The silica-titania waveguide film is loaded with a thin gold film through a thin silica buffer film. It is assumed that water is a cover layer. The following naming convention is taken: a TM_0 mode, supported by this structure with the metallic film thickness reduced to zero is called unloaded, whereas this mode in the structure with the metallic film of non-zero thickness is called loaded. It is shown that beside the TM_0 mode, there are two types of surface plasmon polariton (SPP) modes in the this structure if the metallic film is present. Each of them have its maximum value of a fundamental magnetic field component distribution on different interface of the metallic film. The so called SPP-t mode have it on a water/gold interface, whereas the second, SPP-b mode, on a gold/silica interface or gold/silica-titania interface if the thickness of the silica film is reduced to zero. For such structure there are presented and analyzed spectral characteristics of effective indexes of TM_0 waveguide modes and SPP modes. The analysis of these characteristics is aimed at finding the best conditions for exciting the loaded TM_0 mode and SPP modes, taking assumption that the exciting is done by the field distribution of the unloaded TM_0 mode. There are three conditions that must be met for successfully excitement of the loaded structure this way: polarization, phase and wavelength matching. The analysis was carried out in a wavelength ranging from λ=400 nm to 800 nm. A thickness of silica titania film was assumed to be constant and equal to 180 nm, which is slightly higher than a cut-off thickness. At this thickness, an optical power density is maximized on the silica-titania film interface. A thickness of the silica film was changed from d_b=0 nm to d_b=100 nm with a 10 nm step. Finally, analysis was carried for three values of gold film thickness: d_m=50 nm, 60 nm and 70 nm. The FDM method implemented in the FIMMWAVE solver was used. It was shown that the presence of silica film is indispensable for reduction of a difference between effective indexes of unloaded and loaded TM_0 modes. Conditions for matching effective indexes of loaded TM_0 modes and SPP-t modes are met in a broad range of silica film thickness only for a gold film having thickness d_m=50 nm. Increasing a thickness of the gold film requires increasing the silica film thickness in order to reduce the difference between effective indexes of loaded and unloaded TM_0 modes. However it's possible only in

a range of wavelengths in which SPP-t modes have effective indexes lower than BK7 refractive index, rendering their excitement impossible. For d_m=60 nm and 70 nm there are conditions for matching loaded TM_0 modes with SPP-b modes, however effective refractive index characteristics of loaded and unloaded TM_0 modes are strongly separated. Moreover, in order to characterize this structure from the sensory point of view, there were calculated spectral characteristics of its sensitivity toward changes of cover refractive index. This sensitivity is defined as a derivative of attenuation coefficient in respect to cover refractive index for a given wavelength. This definition was derived by analogous to homogeneous sensitivity, that characterizes sensitive properties of planar evanescent wave transducers with phase-to-intensity conversion. It was shown that for structure with gold film thickness d_m=50 nm there is a single maximum which initially is moving toward longer wavelengths along with an increase of the silica film thickness and after that moves back toward shorter wavelengths. Within a range of change of above defined parameters, only for SPP-t modes there is a range of silica film thickness allowing excitation of the loaded TM_0 mode that is matching the SPP-t mode whose sensitivity is close to maximum on its spectral characteristic.

Detection of the trace amounts of selected gas pollutants using cavity enhanced spectroscopy

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Sensors providing the detection of trace amounts of various compounds are essential in the effort to minimize the level of the environment contamination, control very costly and complex technological processes in industry, support medical diagnosis, ensure a higher level of security and find use in many other applications. During the last decades, many methods have been applied for in-situ detection and concentration measurement of volatile substances. The most common are mass spectrometry, gas chromatography, chemiluminescence, semiconductor gas sensors or electrochemical devices. Their main inconveniences are the size and cost of the apparatus, complicated maintenance, drifts and cross-response issues, e.g. to humidity, high detection limit and limited lifetimes.

We demonstrated optoelectronic sensors employing cavity enhanced spectroscopy (CES) in detection of the trace amounts of selected gas pollutants. The sensors use the phenomenon of optical radiation absorption to detect and measure the concentrations of the molecules, provide achieving low detection limits and high selectivity [1]. For this purpose, it is necessary to apply radiation, the wavelength of which is matched to the spectral range characterized by strong absorption of the tested molecules. In our experimental setups, we applied visible and mid-IR semiconductor lasers [2]. Initially, the research were focused on the development of nitrogen oxides sensors. Nitrogen oxides together with sulphur dioxide are the main gas air pollution. They cause strong acidification of precipitation, the formation of photochemical smog and highly toxic secondary pollutants (ozone, aromatic hydrocarbons). They also rapidly accelerate corrosion of stone buildings and metal structures, threaten human health, irritate the respiratory system and general weaken the body's resistance to infectious diseases. We developed portable NO_2 sensor that is characterized by a low detection limit (1 ppb) and a short measurement time (~ 3 sec). This sensor was applied in outdoor tests consisting in determination its applicability for measuring NO_2 concentrations in the atmosphere. The sensor uses a blue-violet semiconductor laser (414 nm) developed at the Institute of High Pressure of the Polish Academy of Sciences. The mid-IR lasers were applied to investigate gases, the absorptions lines of which are located in the infrared region of spectrum. There were applied quantum cascade lasers (4.53 μm and 5.27 μm) from Alpes Lasers SA and the prototype

quantum cascade laser (4.78 μm) from the Institute of Electron Technology [3]. The developed setups enabling a detection such gases like: nitric oxide (NO), nitric dioxide (N_2O) and carbon monoxide (CO) in laboratory conditions. Carbon monoxide is a highly poisonous, colorless, odorless and tasteless gas. It causes irreversible damage to the central nervous system, coronary insufficiency and myocardial infarction. In preliminary experiments of CO sensors, the tunable laser system PG711-DFG-SH from the Ekspla company was applied. Results of the sensors tests were summarized in Tab. 1.

Tab. 1. The test results of our sensors

Type of sensor	Operation wavelength	Detection limit	Measurement uncertainty	Comments
NO_2	414 nm	1 ppb	5%	Outdoor tests
N_2O	4.53 μm	45 ppb	13%	Laboratory tests
NO	5.27 μm	30 ppb	12%	Laboratory tests
CO	4.78 μm	Approx. 150ppb	-	Laboratory tests
CO	4.78 μm	10 ppb	10%	Tests using PG711

The experiments showed that CES sensors are more sensitive and selective than many other detection techniques. They offer fast and continues concentration measurements. For that reason, such sensors can be very useful tools the effort to minimize the level of the environment contamination.

Acknowledgement

The presented works were supported by The National Centre for Research and Development and National Science Centre in the scope of Projects: ID: 179616.

References

[1] T. Stacewicz, et al. Opto−Electron. Rev. 20(1). pp. 34-41, (2012).

[2] J. Wojtas, J. Mikolajczyk, Z. Bielecki. Sensors, 13(6), 7570-7598, doi:10.3390/s130607570, (2013).

[3] K. Pierscinski, et al. J. Appl. Phys., 112(4), 043112, (2012).

Spectral properties of photonic crystal fibers infiltrated with nematic liquid crystals doped with metallic nanoparticles

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Over the last years, research efforts have been made to improve properties of liquid crystals (LCs) by doping them with different materials as: polymers, dyes, or carbon nanotubes. Recently, there has been a growing interest in dispersing nanopatricles (NPs) in LCs. Even a small amount of metallic NPs should be sufficient to influence the dielectric anisotropy and threshold voltage of LCs. The most common dopants are gold and silver NPs. Both have been shown to improve electro-optical properties and increased thermal stability of LC. Combining the ease of tuning of physical properties of LCs and structure of a photonic crystal fiber, a new type of a fiber, i.e. Photonic Liquid Crystal Fiber (PLCF) with an improved control of spectral, polarization, and guiding properties was proposed more than 10 years ago.

In this paper, preliminary results of PCFs infiltrated with nematic LCs doped with metallic NPs are reported. Two types of NPs: Titanium NPs and Gold NPs and two types of LCs: 6CHBT and 5CB LCs were used to compare an influence of the doping on propagation parameters of the PLCFs and their electro-optical response to external electric field.

POSTERS ABSTRACTS

Laboratory and field tests of the Active Composite Fence

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This paper presents tests of the active composite fence with razor tape module. Due to application of electro-magnetic and optical fiber sensors the fence becomes actively protected.

This type of solution may be used to detect violations of peripheral areas [1]. Due to using composite materials the fence is lighter, cheaper and resistant to environmental conditions (including corrosion). What is the most important the composite fence system is transparent to electromagnetic waves.

a).

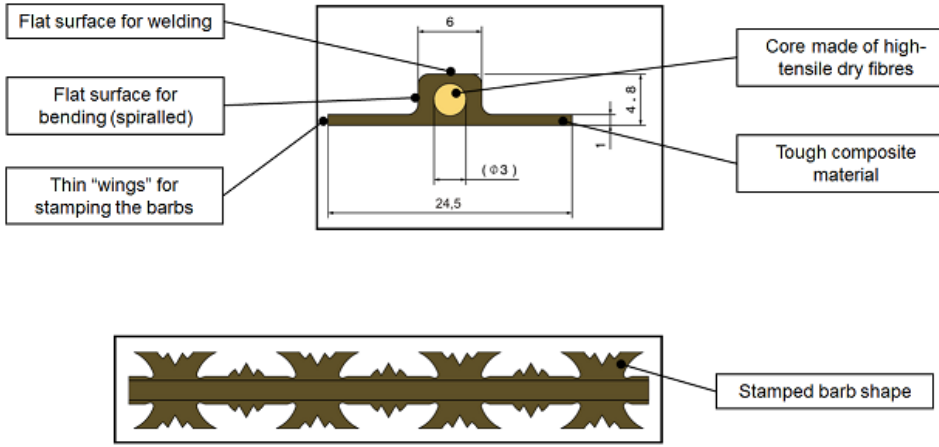

Fig. 1. Active Composite Fence structure: a). picture, b). scheme

Another advantage of using composite material is the possibility of integration the fiber optic and electro-magnetic cable in the structure of the fence [2]. The durability of a composite is comparable to a standard metal fence. The paper presents test results of the sensors placed on the composite fence. This type of the

fence system protection with alarm sensors integrated in its structure is unique in the world scale(Fig. 2).

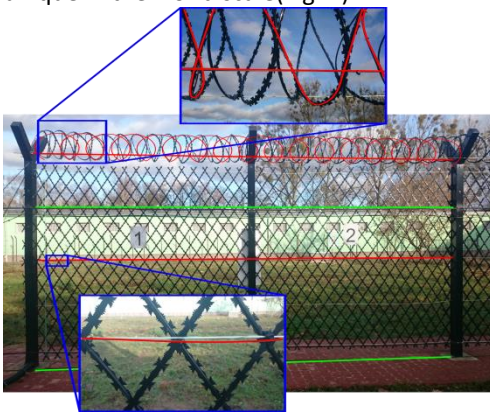

Fig. 3. Active Composite Fense – modalmetric sensor (red line) and electro-magnetic sensor (green line) placement on a fence

Performed tests consisted of laboratory and field tests of modalmetric fiber optic sensor itself, laboratory and field tests of electro-magnetic sensor itself and field tests of both sensors combined.

During the laboratory tests an electrodynamic shaker was used to excite the modalmetric sensor to an alarm state. Its excitation distance decreases with the frequency growth. The tests were made for different frequencies and different forces to imitate different fence violation e.g. climbing on it, cutting it or walking along it.

Keywords: active composite fence, fiber optic sensor, modalmetric sensor, electro-magnetic sensor, security system

References:

[1] M. Szustakowski, P. Markowski, W. Ciurapiński, M. Życzkowski, M. Karol, The use of composite fence with integrated sensors in security system, Proceedings of SPIE, vol. 9647, 2015

[2] M. Życzkowski, M. Szustakowski, P. Markowski, New properties of a fiber optic sensor in application of a composite fence for critical infrastructure protection, Proceedings of SPIE, vol. 9634, 2015

Properties of reduced graphene oxide and graphite oxide in the aspect of their possible application in gas sensors

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The carbon materials were often used as a sensor layer. We present the results of our experiments on graphite oxide (GRO) and graphene oxide (rGO). For characterization of the materials we used such techniques as: Atomic Force Microscopy (AFM); Scanning Electron Microscopy (SEM- Fig. 1) and Raman Spectroscopy (RS). We also used X-ray Photoelectron Microscopy (XPS) and Fourier Transform Infrared Spectroscopy (FT-IR). The composition of examined materials was confirm using elementary analyser. The experiments were perform before and after exposition of GRO and rGO on selected gases (nitrogen dioxide, hydrogen).The properties of graphite oxide and graphene oxide as a function of temperature were investigated by the following techniques: Thermogravimetric (TG) and Differential Thermogravimetric (DTG). The obtained data have made it possible to interpret the physicochemical changes occurring in analyzed materials.

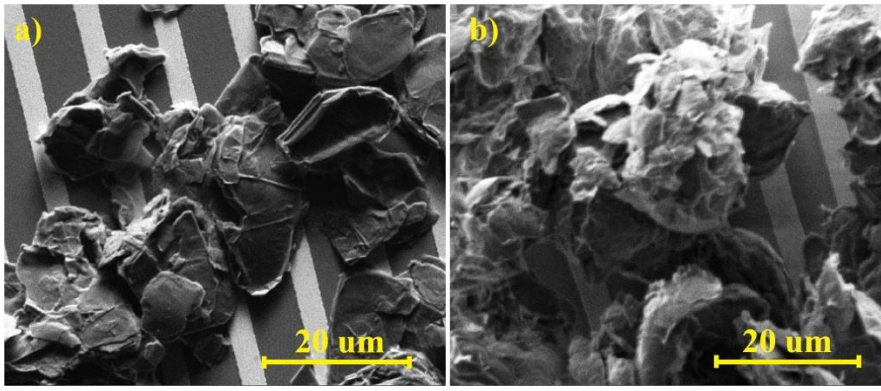

Fig. 1. The SEM image of: a) graphite oxide and b) graphene oxide

In vivo luminescence spectroscopy diagnosis system for skin cancer research

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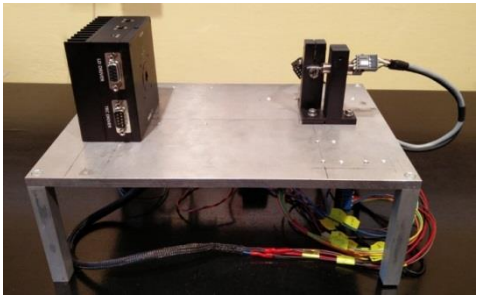
Non-invasive methods and techniques for the diagnosis of skin cancers are nowadays main trends for biologists, optoelectronic engineers and many scientist, focused in early disease detection.

In this paper we propose the novel design of non-invasive skin cancer optical diagnostic system which will be used in imaging of malignancies using the augmented reality, by identifying cancerous tissues, based on luminescence spectroscopy analysis of given tissues.

The study shows that fluorescence spectra of cancer tissues excited by near UV 405nm light gives specific peaks of emitted spectrum between 620nm and 680nm, which do not appear in the emitted spectra of the healthy skin tissues (characteristic peaks between 500nm and 550nm). There is also difference in fluorescence intensity in emitted spectra between different types of skin cancer (e.g. SCC, BCC). By using well known marker agents e.g. HpD (hematoporphyrin derivatives), it is possible to significantly increase spectroscopy signals. By using differential analysis by comparing red and green peaks in spectra, the system will be able to increase the sensitivity of detection of cancerous tissues.

Our proposal of that “optical biopsy” method and given fluorescence spectra shows that it could be used as one of the criteria for early skin cancer diagnosis and can be used in imaging of malignancies as the augmented reality by using VR goggles.



Rys. 1. Prototype of laboratory stand

REFERENCES

[1]. Kałużyński P., Opilski Z.: In vivo luminescence spectroscopy by use of a 405nm laser excited autofluorescence diagnosis system for skin cancer research, Integrated optics - sensors, sensing structures and methods. IOS'2015, 2nd to 6th March 2015, Szczyrk - Beskidy Mountains, Poland. Programme and abstracts, 2015

[2]. Kałużyński P., Opilski Z.: Cancer imaging by detecting laser induced photoluminescence, Integrated optics - sensors, sensing structures and methods. IOS'2014, Szczyrk - Beskidy Mountains, Poland, 3rd to 7th March 2014. Programme and abstracts, 2014

High operating temperature long-wave HgCdTe detector for fast response operation - optimization approach

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It is fully confirmed that the development of the new HgCdTe long-wave (8−12 micrometer) infrared radiation (LWIR) detector has been driven by applications requiring high frequency response and operation at higher temperature (HOT - hot operating temperature). Both, time response and detectivity of the HOT HgCdTe detector should be optimized. The HOT HgCdTe's performance is limited by Auger processes and to circumvent that issue the $N^+/\pi/P^+n^+$ device's designs has been proposed to suppress that generation - recombination mechanism, i.e. combination of exclusion and extraction heterojunctions (π is a p-type doping region) The nominally sharp interfaces in $N^+/\pi/P^+n^+$ (especially $N^+\pi$) layered HgCdTe heterostructures are affected by interdiffusion during technological process leading to significant composition and doping grading occurring during HgCdTe growth by MOCVD. Mentioned composition and doping grading should be controlled to optimize frequency performance of the devices. In this paper we present short analysis of the time response depending on type and doping grading of $N^+/\pi/P^+n^+$ HOT HgCdTe structure. The voltage and structural dependence of the time response were simulated. The time response of the LWIR HgCdTe detector with 50% cut-off wavelength ≈ 10.6 μm at T = 230 K was estimated at the level of ≈ 52 ps.

Application of boron-doped diamond film and ZnO layer in Fabry-Pérot interferometer

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In this article the use of boron-doped diamond films for sensor applications have been presented. The low-finesse Fabry-Pérot interferometer working in reflective mode has been implemented [1]. Two kinds of reflective layers have been elaborated: boron-doped diamond thin films and zinc-oxide (ZnO) layer. Thin ZnO layers were deposited by Atomic Layer Deposition (ALD) [2] on the face of a standard telecommunication single-mode optical fiber (SMF-28). Interference signal was measured for 200 nm thickness of ZnO layer. Boron-doped diamond films were deposited using Microwave Plasma Enhanced Chemical Vapour Deposition (µPE CVD) system [3]. The diamond films were synthesized with the use of MW PA CVD system (SEKI Technotron AX6200S, Japan).

The metrological properties of Fabry-Pérot interferometer have been examined with the use of two broadband light sources (SLD type S1550-G-I-10 with central wavelength λ_0 = 1560 nm, $\Delta\lambda_{FWHM}$ = 45 nm, produced by SUPERLUM and SLD type S1300-G-I-20 with central wavelength λ_0= 1290 nm, $\Delta\lambda_{FWHM}$ = 50 nm, produced by SUPERLUM). Detection of the measured signal was performed using an optical spectrum analyzer (Ando AQ6319). All devices were connected with a single-mode commercially available, telecommunications coupler (SMF-28 fiber). Measurements were performed for Fabry-Pérot interferometer in reflective mode, as shown in Fig.1.

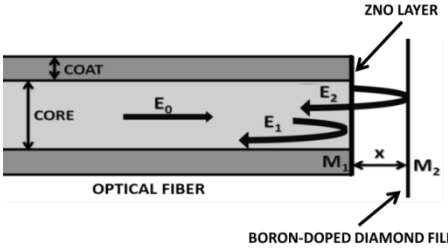

Fig. 1. Extrinsic Fabry-Pérot interferometer working in reflective mode: M1 (ZnO layer), M2 (boron-doped diamond film) – cavity mirrors, x – length of the Fabry-Pérot cavity, E0 – the amplitude of an electric vector of an incident wave; E1, E2 – the amplitude of an electric vector of wave reflected of the first and second mirror, respectively

Measurements were performed for various lengths of the air cavity. The cavity length was varied from 0 µm to 600 µm in increments of 50 µm. Representative measured spectra obtained with a cavity length of 100 µm are presented in Fig. 2.
The preliminary investigation of elaborated the low-coherence interferometers Fabry-Pérot have shown their ability for their application in sensors.

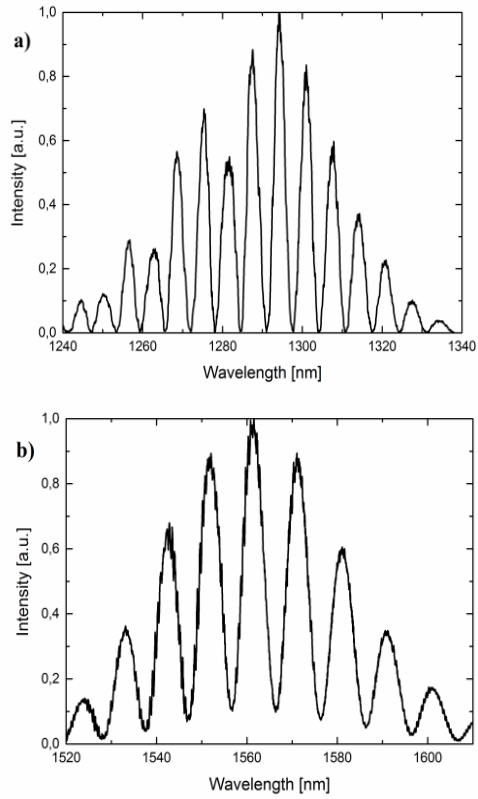

Fig. 2. Representative measured spectra from the low-coherence fiber-optic Fabry-Pérot interferometer with a cavity length of 100 µm a) light source 1300 nm; b) light source 1550 nm.

Acknowledgements

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References

[1] K. Karpienko, M. Wróbel, M. Jędrzejewska-Szczerska, "Determination of Refractive Index Dispersion Using Fiber-Optic Low-Coherence Fabry-Perot Interferometer: Implementation and Validation," Optical Engineering, 53(7), 077103(2014).

[2] M. Jędrzejewska-Szczerska, P. Wierzba, A. Abou Chaaya, M. Bechelany, P. Miele, R. Viter, A. Mazikowski, K. Karpienko, M. Wróbel, "ALD thin ZnO layer as an active medium in a fiber-optic Fabry-Perot Interferometer," Sensors and Actuators A – Physical 221, 88-94 (2015).

[3] R. Bogdanowicz, M. Gnyba, P. Wroczynski, B. B. Kosmowski, "Optoelectronic system for monitoring of thin diamond layers growth," Journal of Optoelectronics and Advanced Materials, 12, 1660-1665 (2010).

Broadband temperature sensor

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The paper consists of two parts. The first part comprises computer simulations on light propagation in a taper fiber with a different reflective index of the surrounding medium. Simulations were prepared for different dimensions of the taper. Results show that the taper waist is a sensitive area to changing boundary conditions. It was basic for realization of the second part of experiments with a taper fiber and some materials with modification of the state depending on temperature changing. This combination provided a possibility to build a broadband temperature sensor. That sensor's characterizations, low cost and low loss technology, provide a possibility to create a sensor for different rangeof temperature, which is smart enough to work as an in-line element and its working range is of 800-1700nm.

Single photon fiber optic sensor in detection of telecommunication line taping

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This article presents the single photon fiber optic sensor for detecting disorders of the transmission line. With the growing popularity of the use of fiber optic communication systems, there is a need to protect transmission lines against unauthorized interference and data interception. Classical Quantum Key Distribution (QKD) allows to transfer quantum key and interrupt transmission when it detects interference. The use of proven as safe protocols BB84 in conjunction with currently used encryption techniques provide better data safety. However, due to lack of evidence on the safety of transmission using commercial QKD systems, their apply to the protection of classified information is currently impossible. Support these assumptions are carried out so far successful attacks on QKD system. These statements do not mean impossibility of implementing these systems for the protection of classified information in the future. Our team proposes a solution consisting in transmitting information in fiber optic track with simultaneous implementation of a single photon sensor, developmentally impaired with the location of the interference place. The greatest yield of this method is to detect the intruder, who is unaware of its detection. To optimize and accelerate the testing, a simulation program that allows you to adjust the operating parameters of the sensor system and verification of performance of laboratory systems has been developed. Execution of simulation, helps in the selection of appropriate elements of the actual configuration and in comparison to obtained results. This work contains the results of the test operation of the system for disorders of mechanical and manual as well as performed simulations.

Keywords: fiber optics, fiber optics sensors, single photon, interferometer

Gas analysis software for selected techniques of laser absorption spectroscopy

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The article presents a software dedicated to spectral analysis of gas absorption. The analysis takes into consideration impact of other gases so-called performances of two laser absorption interferents. For this purpose, the spectroscopy techniques i.e. cavity program gives the possibility to enter data enhanced absorption spectroscopy (CEAS) of several gases and to determine that gas and wavelength modulation spectroscopy is being analysed in parallel. The (WMS). It basis on data imported from the implemented procedures indicate HITRAN database. The main task is to influence of the absorption spectrum of determine a wavelength range of interferents on the absorbance of tested operation providing effective results of gas. This operation is particularly these gas detection techniques. The important for CEAS technique, where the software is not only able to identify main importance is to indicate both spectral lines characterized by the highest characteristic and strictly defined absorbance values of the defined gas but absorption line also to indicate a line with the least

Fig.1. View of user panel

The developed software was tested for the identification of selected gases, which are so-called disease biomarkers in the exhaled air. That test was performed in the frame of the project “Sensormed” taking into consideration detection of nitrous oxide, methane and carbon monoxide. It provided to define the wavelength ranges in which the least impact of water vapor and carbon dioxide (the most important interfering gases in human breath) on the measurements is observed. Correct operation of the program was also identified comparing results of absorption lines analysis for other gases and literature ones.

Acknowledgements

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References

[1]J. Reid, D. Labrie, *Second-Harmonic Detection with Tunable Diode Lasers – Comparision of Experiment and Theory*, Applied Physics, Springer-Werlag 1981A. Name, Phys. Rev. B33, 55234 (2001),

[2] *Metrologia w medycynie*, editing Andrzej Michalski, Warsaw, WAT Publishing, 2011, ISBN 978-83-62954-00-1.

Fast chemoresistive NO_2 gas sensor based on the undoped ZnO nanostructures activated by temperature and UV radiation

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Gas sensors which are able to detect and measure small concentrations of nitrogen dioxide are very important in the field of automotive industry, environmental monitoring, medicine and explosives detection [1]. The most popular gas sensors are chemoresistive ones which are mainly based on wide band gap semiconductors. Such sensors are very sensitive but also unselective and requires relatively high temperatures of operation (even in the range of 300-700˚C). Instead the high temperature, wide band gap gas sensors can be activate by electromagnetic irradiation from the range of near ultraviolet [2].

In this work resistance gas sensor based on zinc oxide (ZnO) nanostructures is presented. Sensor operation at different temperatures (room temperature RT = 23 ˚C, and 200˚C) and under different lighting conditions (dark conditions and UV irradiation – LED λ = 390 nm) are compared and discussed. Tests of action of ZnO nanostructures with NO_2 were also carried out at different atmospheres (at nitrogen and synthetic air).

Results proves that sensor can operate at room temperature when it is activated by UV light. Sensor reaction to NO_2 under UV conditions at room temperature is comparable to its operation at 200˚C in dark conditions. Sensor reactions at under these conditions are very high (hundreds of % to single ppms) but sensor responds relatively slow (response times at the level of hundreds of seconds). Sensor response and recovery times under different conditions are collected in Fig. 1.

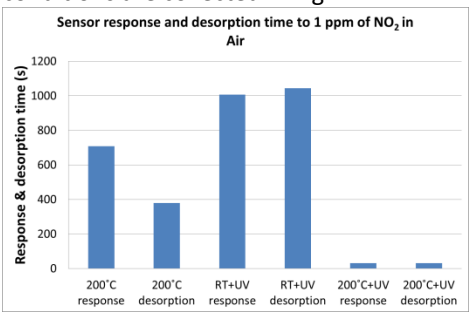

Fig. 1. Sensor response and recovery time (for 1 ppm of NO_2 in air) under different conditions of operation

When sensor operates at elevated temperature and under UV irradiation simultaneously it response and recovery time are greatly reduced (to about 30 s to 1 ppm of NO_2) but response increased. This shows that clean undoped ZnO nanostructures can operate in different conditions depending on user's needs.

Acknowledgements

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and by the Silesian University of Technology, Faculty of Electrical Engineering within the projects: BKM/514/RE4/2014 and BKM/534/RE4/2015.

References

[1] M. Procek, A. Stolarczyk, T. Pustelny, E. Maciak, A Study of a QCM Sensor Based on TiO_2 Nanostructures for the Detection of NO_2 and Explosives Vapours in Air., Sensors (Basel). 15 (2015) 9563–81.

[2] M. Procek, T. Pustelny, A study of gas sensing properties of ZnO nanostructures activated by UV light, Photonics Lett. Pol. 7 (2015) 50–52.

Automated sampling system for human breath analyzing

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Screening patients and diagnostic tests are the fundamental tools supporting the modern medicine. Human breath analysis is very attractive technology which could be applied in clinical diagnosis, as well as in the disease monitoring and in identification of the environmental influence on the human body. An important feature of such instruments is not only concentration measurement of defined volatile organic compounds (VOC's) present in the exhaled air (biomarkers), but also an effective breath sampling. This difficulty often results from the low concentration of VOC's at the level of the detection limit of the sensors [1]. In addition, the sampling procedure should provide test time as short as possible to minimize result of VOC's chemical reactions, the minimum patient stress, elimination of possibility of the infectious diseases while meeting ATS/ERS standards [2]. Due to the temporary distribution of gases in the breath, gas sampling should also take place in a strictly defined moment of exhalation. In practice, the exhaled air filling so-called dead space of the human lung has been not exchanged, therefore, this breath part should not be analyzed.

Literature analyses has shown, the VOC's concentration in the human breath can vary depending on the sampling technique [3]. Therefore, it is very important to develop standardized methods for collecting samples, which will be fully controlled both quantitatively and qualitatively.

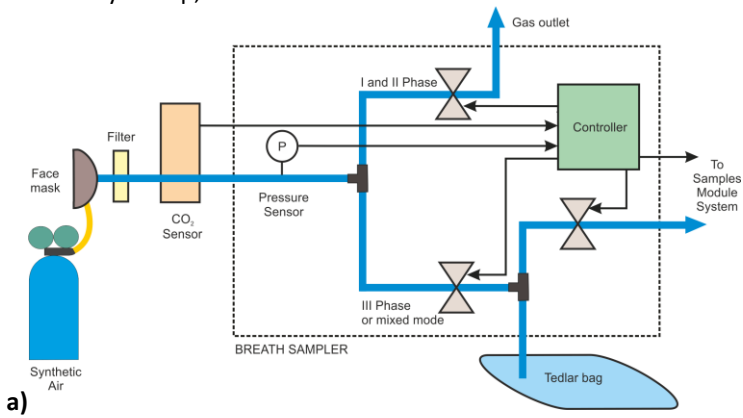
The paper presents a designed prototype of fully automated breath sampling system. The system provides to monitor exhalation phases and to identify the air flow from the upper and lower parts of human lungs basing on carbon dioxide (CO_2) measurement. View of the block diagram of the device is shown in the Fig. 1. The system consists of single-use face mask and antibacterial filter, CO_2 infrared sensor, pressure sensor, solenoid valves and Arduino based controller.

Tab. 1. Main parameters of breath sampling system

Operating modes	*off-line, on-line*
Breath phases	*I/II, III based on CO_2 monitoring*
Patient's interface	*single-use mask, filter and valves*
Collecting time	*2 minutes (max) for 5l Tedlar® bag*
Visualization panel	*color LED pressure bar, timer LED*
Operator's panel	*color LCD touch screen, USB*

The system construction also includes the possibility to use synthetic air to reduce the impact of ambient conditions. It is able to operate in two modes, i.e.: on-line or

off-line, significantly increasing its functionality. The practical features of the sampling system have been verified using a special laboratory setup, Tab. 1. This setup can be used as a breath sampler for different sensors and techniques of laser absorption spectroscopy.



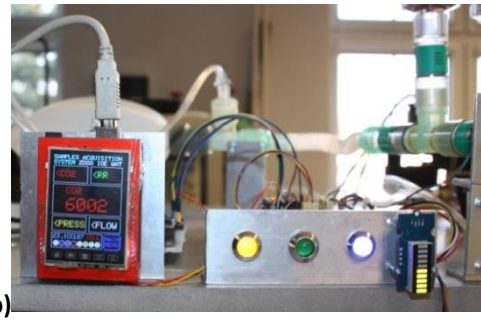


Fig 1. Block diagram of the breath sampling system a) and view of operator's control panel with visualization panel b)

Acknowledgement

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References

[1] J. Wojtas, Z. Bielecki, T. Stacewicz, J. Mikolajczyk, M. Nowakowski, *Ultrasensitive laser spectroscopy for breath analysis*, Opto−Electron. Rev. 20, no. 1, 2012.

[2] Raed A. Dweik, et al., *An Official ATS Clinical Practice Guideline: Interpretation of Exhaled Nitric Oxide Levels (FeNO) for Clinical Applications*, American Journal of Respiratory and Critical Care Medicine VOLUME 184, ISSUE 5

[3] B. Buszewski, M. Kesy, T. Ligor, A. Amann, *Human exhaled air analytics: Biomarkers of diseases*, Biomed. Chromatogr. 2007, 21, 553–566.

Thermo - optic properties of alkanes filled photonic crystal fibers

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In this paper we have been experimentally investigated thermo-optic properties of fiber optic transducers based on a partially filled LMA 10. We have prepared PCFs samples based on pure higher alkanes: pentadecane, hexadecane, heptadecane and octadecane. These materials have different melting points i.e.: pentadecane (MP 9-10°C), hexadecane (MP 18°C), heptadecane (MP 20-22°C), and octadecane (MP 26-29°C) and we have measured temperature spectral characteristics within the range of 0°C – 60°C.

By analyzing their thermo-optic properties, we observed that for all samples the melting points (MP) are close to product information. For all samples we have had hysteresis between melting and crystallization points which makes us believe that a high purity grade of the used materials and a small number of crystallization centers are the major problems in this case. This class of materials are very good candidates for manufacturing a multistage temperature threshold sensor on which we will report in future work.

Characterization of liquid crystalline materials for applications in integrated optic circuits

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Liquid crystal (LC) technology is a subject to many advanced areas of science and engineering. Apart to LCD applications, liquid crystals are commonly applied in modern photonic devices, including these for integrated optic systems (IOS) [1]. Advantages brought to IOS by LC-based waveguiding structures and devices stems mainly from: (i) their large diversity; (ii) much broader range of optical properties and much easier reconfiguration than offered by solid-state photonic structures; and (iv) significant optical nonlinearities [2]. Moreover, the fluid nature of LC and theirs compatibility with most optoelectronic materials, polymers and organic materials allow them to be easily incorporated with other elements in various configurations, forms and geometries, and thus enhance possibilities of potential applications in novel photonic networks. Taking the above into account, optically active and easily reconfigurable liquid crystalline structures and materials can be considered as a promising medium for the functional optical circuits [3]. In this communication we present our results on characterization of selected liquid crystalline materials and structures in terms of their optical properties and their prospective applications as waveguiding layers in IOS. Specifically, refractive indices and birefringence (with their dependence on external fields and factors), as well as propagation losses within specific spectral range will be measured and reported.

References

[1] G.V. Tkachenko, New Developments in Liquid Crystals, InTech 2009.

[2] I.C. Khoo, N.T. Wu, Optics and Nonlinear Optics of Liquid Crystals, World Scientific 1993.

[3] J.R. Whinnery, C. Hu, Y.S. Kwon, Liquid-Crystal Waveguides for Integrated Optics, IEEE J. Quantum Electron. QE-13, 262-267 (1977).

Algorithm for detection and removal of discontinuity points on eigenvalue sets generated by FDM method

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The Finite Difference Method (FDM) is particularly well suited to model optical waveguides characterized by high-step refractive index profiles and optical waveguides including metallic structures. The implementation of the FDM method in the commercial mode solver FIMMWAVE 6.2 was used to calculate series of complex effective index characteristics, in a spectral domain, for the dielectric/metal multilayer planar waveguide structure composed of a high-refractive index (~1.81 for λ=677 nm), single mode, silica-titania film deposited on a BK7 glass substrate. The silica-titania waveguide film is loaded with a thin gold film through a thin silica buffer film. For that structure, two types of solution to Helmholtz wave equation were searched for: a TM_0 mode and two Surface Plasmon Polariton (SPP) modes. With each of them there is corresponding a specific distribution of magnetic field component that is tangent to planes separating films, the modeled structure is composed of. It turned out that in order to obtain complete spectral characteristics of a real and complex part of the effective index one must calculate a number of eigenvalues significantly exceeding a number of modes which are looked for. Moreover the solver labels the eigenvalues (effective indexes) at variance with the character of a spatial distribution of its eigenvectors (distribution of mode profiles). In order to reconstruct continuous spectral characteristics of effective indexes and attenuation coefficients for modes supported by that structure, an algorithm is being proposed. At the input there is a set of one-dimensional arrays labeled with eigenvalue number containing values of attenuation coefficient for given label. The assumption is taken that if at a given position in a given array a discontinuity is encountered, there is another array in which there is also discontinuity at the same position

Mechanical splicing of standard MMF and GI- POF

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Polymer optical fibers (POF) made from perfluorinated polymethyl methacrylate offer width scope of applications, including telecommunication and sensors. POFs sensors and telecommunications systems are receiving a huge interest due to their mechanical and thermal properties. The FTTx ("Fiber To The x") systems required the development of passive connection between SOF and POF because releasable connectors commercially available on the market result in high losses. Hence, alternative method for MMF and POF splicing is to perform optical adhesive connection. This work presents optimization of matching geometry of connected structure and the method of application optical adhesive glue. Experiment showed that joint made of NOA has given loss of less than 0,2 dB. As a confirmation of the effectiveness adhesive connection we conducted a thermal and a mechanical tests. Parameters of the study were selected according to working conditions of the optical fiber infrastructure. Modal characteristics of near- field was also observed.

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