Integrated Optics
- Sensors, Sensing Structures and Methods
IOS'2018

PROGRAMME
and
ABSTRACTS

Organizers of IOS 2018

Photonic Society of Poland,

Upper Silesian Devision of
the Polish Acoustical Society

and

Committee of Electronics and Telecommunication
at the Polish Academy of Sciences

26th February to 2nd March 2018,
Hotel "META"
Szczyrk - Beskidy Mountains, POLAND

http://ogpta.pl

Dear Participants

of 13th Conference INTEGRATED OPTICS - Sensors, Sensing Structures and Methods IOS'2018

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'2018 plenty of scientific satisfactions and many professional and social impressions.

Organizers

President of the Conference: Prof. Tadeusz Pustelny
Treasurer: Dr eng. Aneta Olszewska
Secretary: Dr eng. Marcin Procek
Members: Dr eng. Kamil Barczak
Dr eng. Przemysław Struk

This book includes the Program of IOS'2018 and Abstracts of presentations and posters sent by their Authors.

CONFERENCE PROGRAMME

26.02.2018 Monday	
13:00	***Dinner***
14:30-14:35	**OPENING CEREMONY of the conferences** **47th WSW&QA** **46th WSEA&V** **13th IOS'2018**
14:35-15:00	**Jubilee of the 45th anniversary** **scientific research and scientific activities** **Professor Tadeusz Pustelny**
15:00-18:30	**SESSIONS DEDICATED TO PROFESSOR** **TADEUSZ PUSTELNY** **ON THE OCASSION OF THE JUBILEE**
15:00-15:30	*Invited lecture* **Theoretical and numerical researches on the propagation of waves in the shallow sea** E. KOZACZKA, G. GRELOWSKA
15:30-16:00	*Invited lecture* **New trends in the development of radar technology** A. KAWALEC
16:00-16:30	*Invited lecture* **Roadmap on liquid-crystal fiber optics and photonics** T. WOLIŃSKI, S. ERTMAN, K. RUTKOWSKA
16:30-17:00	***Coffee break***
	Session shared with WSW&QA and WSEA&V
17:00-17:20	**System for the spatial visualization of hypodermic blood vessels** Z. OPLISKI
17:20-17:40	**Optical fiber current sensor with external conversion in high voltage environment** K.BARCZAK, K. MAŹNIEWSKI, D. DUDA
17:40-18:00	**Broad-band planar waveguide interferometers** K. GUT
18:00-18:30	**Nonlinear optics in gas-filled photonic crystal fibers** Sz. PUSTELNY, A. UMIŃSKA, M. GRABKA, C. PERRELLA, P. LIGHT, A. LUITEN
19:00	***Supper***
20:00	**MUSIC GLANCE – moment with string quartet**

27.02.2018 Tuesday	
13:00	***Dinner***
14:30-15:00	*Plenary lecture* **Bending optical beams in nematic liquid crystals** U. LAUDYN, M. KWASNY, I. OSTROMECKA, J. PIŁKA, B. KLUS, M. KARPIERZ
15:00-15:15	**Electro-optical properties of photo-aligned photonic ferroelectric liquid crystal fiber** D. BUDASZEWSKI, T. WOLIŃSKI
15:15-15:30	**Fabrication and characterization of an electric field directional sensor based on a photonic crystal fiber selectively filled with liquid crystals** O. JAWORSKA, S. ERTMAN
15:30-15:45	**Periodic phase separation in 5CB nematic liquid crystal doped with gold nanoparticles** P. LESIAK, K. BEDNARSKA, K. ORZECHOWSKI, M. WÓJCIK, W. LEWANDOWSKI, T. WOLIŃSKI
15:45-16:00	**Numerical modelling of pulse formation in Er3+-doped Q-switched fluoride glass fiber lasers** S. SUJECKI
16:00-16:15	**Experimental investigation of mid-infrared laser action from Dy3+ doped fluorozirconate fibre** L. SÓJKA, L. PAJEWSKI, E. BERES-PAWLIK, S. LAMRINI, K. MARKOWSKI, T. BENSON, A.SEDDON, S. SUJECKI,
16:15-16:30	**Side-polished optical fiber sensor** N. MALINOWSKA, M. POPENDA, E. BEREŚ-PAWLIK
16:30-17:00	***Coffee break***
17:00-17:30	*Plenary lecture* **T2SLs higher operating temperature detectors – where is the limit?** K. HACKIEWICZ, P. MARTYNIUK
17:30-17:45	**Higher operating temperature photoresponse of MWIR T2SLs InAs/InAsSb photodetector** K. MICHALCZEWSKI, T.Y. TSAI, P. MARTYNIUK, C. S. WU
17:45-18:00	**InAsSb photoluminescence in low temperatures** K. MURAWSKI, K. GRODECKI, P. MARTYNIUK

18:00-18:15	**Evolution of Low Level Radio Frequency Control Systems for Free Electron Lasers from short pulse to continuous wave operation.** W. CICHALEWSKI, A. NAPIERALSKI, J. SEKUTOWICZ, V. AYVAZYAN, J. BRANLARD
18:15:18:30	**Face re-identification across pose in thermal infrared spectrum based on local texture descriptors** A. GRUDZIEŃ, M. KOWALSKI, N. PAŁKA, M. SZUSTAKOWSKI
18:30-18:45	**Application of laser absorption spectroscopy to investigation of explosives chemical stability** B. RUTECKA, S. CHOJNOWSKI, A. KAMIEŃSKA-DUDA, J BORKOWSKI, J. WOJTAS
18:45-19:00	**Investigation of the nicotine infrared absorption spectrum** S. CHOJNOWSKI, B. RUTECKA, J. WOJTAS
18:30-19:00	**POSTER SESSION -mounting of posters**
19:00	***Supper***
20:00	**POSTER SESSION**
28.02.2018 Wednesday	
13:00	***Dinner***
14:30-15:00	*Plenary lecture* **Formation and steering of vortex spatial solitons in soft matter.** V. SHVEDOV, Y. IZDEBSKAYA, P. JUNG, K. CYPRYCH, W. KRÓLIKOWSKI
15:00-15:15	**Photonic sensors of the magnetic field using NV color centers in diamond** W. GAWLIK, A. KRUK, M. MRÓZEK, A. WOJCIECHOWSKI
15:15-15:30	**Boron-doped diamond nanosheets – A route towards transparent diamond-on-graphene heterojunction** M. FICEK, M. SOBASZEK, J. KARCZEWSKI, Ł. GOŁUŃSKI, A. NOSEK, M. BOCKRATH, A. Jaramillo-Botero, W. GODDARD, M. GNYBA, T. OSSOWSKI, R BOGDANOWICZ
15:30-15:45	**Nanodiamond films for optical fiber sensors** D. MAJCHROWICZ, M. JĘDRZEJEWSKA-SZCZERSKA
15:45-16:00	**Optical response and applications of selected azo polymers** A. KOZANECKA-SZMIGIEL, J. KONIECZKOWSKA, D. SZMIGIEL, J. ANTONOWICZ, K. RUTKOWSKA, E. SCHAB-BALCERZAK

16:00-16:15	**Self-organizing, one-dimensional periodic structures in 5CB doped with gold nanoparticles** K. BEDNARSKA, P. LESIAK, K. ORZECHOWSKI, T. OSUCH, K. MARKOWSKI, M. WÓJCIK, W. LEWANDOWSKI, T. WOLIŃSKI
16:15-16:30	**Selected technological aspects of semiconductor samples preparation for Hall effect measurements** K. GORCZYCA, J. BOGUSKI, J. WRÓBEL, P. MARTYNIUK
16:30-17:00	***Coffee break***
17:00-17:30	*Plenary lecture* **Detection of single adsorbing nanoparticles by plasmon assisted microscopy** P. WRÓBEL, T. ŠPRINGER, J. HOMOLA
17:30-17:45	**Mobile biometric verification of passengers based on fingerprints** N. PAŁKA, M. SZUSTAKOWSKI, E. CZERWIŃSKA, J. MŁYŃCZAK, K. FIRMANTY, M. WALCZAKOWSKI, M. KOWALSKI, M. SOBCZAK, M. NAWROCKI, P. HOŁOWENKO, P. POŹNIAK, S. PACHLA, T. NISKI, M. KRASZEWSKI-CĄKAŁA, P. ŻYCKI, K. POPŁAWSKI
17:45-18:00	**Virtualization of the measurement system for the MIMO THz scanner** M. PISZCZEK, M. POMIANEK, M. MACIEJEWSKI, P. ZAGRAJEK
18:00-18:15	**A high-precision interferometric system for fast non-contact measurements of lens thickness** O. KARCZEWSKI, M. NAPIERAŁA, Z. HOŁDYŃSKI, K. WILCZYŃSKI, S. LIPIŃSKI, P. POLAK, T. STAŃCZYK, M. SZYMAŃSKI, T. NASIŁOWSKI
18:15-18:30	**Distributed Optical Fiber Sensors based on Photonic Crystal Fibers for Advanced Sensing Applications** A. DOMINGUEZ-LOPEZ, L. SZOSTKIEWICZ, M. NAPIERALA, T. NASILOWSKI
18:30-18:45	**Metal coated dual-core fiber for interferometric temperature measurement in high temperatures.** K. MARKIEWICZ A. MAKOWSKA (ZIOLOWICZ), L. SZOSTKIEWICZ, A. KOLAKOWSKA, J FIDELUS, T. STANCZYK, K. WYSOKINSKI, D. BUDNICKI, L. OSTROWSKI, M. SZYMANSKI, M. MAKARA, K. POTURAJ, T. TENDERENDA, P. MERGO, T. NASILOWSKI

18:45-19:00	**Distributed curvature measurements using C-OTDR and 7-core microstructured fiber** K. WILCZYŃSKI, Ł. SZOSTKIEWICZ, M. NAPIERAŁA, A. PYTEL, A. KOŁAKOWSKA, A. DOMINGUEZ-LOPEZ, T. NASIŁOWSKI
19:30	***Festive Supper (Banquet)***
1.03.2018 Thursday	
8:00	***Breakfast***
13:00	***Dinner***
14:15-14:35	*Plenary lecture* **Photonic integrated circuits – an emerging technology for optical sensing** R. PIRAMIDOWICZ, S. STOPIŃSKI, A. JUSZA, K. ANDERS, A. KAŹMIERCZAK, A. PAŚNIKOWSKA, M. SŁOWIKOWSKI, P. SZCZEPAŃSKI
14:35-14:50	**Interrogation of fiber optic sensor networks using integrated optics** A. KAŹMIERCZAK, S. STOPIŃSKI, A. JUSZA, K. ANDERS, M. SŁOWIKOWSKI, M. KREJ, Ł. DZIUDA, R. PIRAMIDOWICZ,
14:50-15:05	**WDM-PON access system based on integrated photonic devices** K. ANDERS, S. STOPIŃSKI, A. JUSZA, A. KAŹMIERCZAK, A. PAŚNIKOWSKA, M. TOMKIEWICZ, R. PIRAMIDOWICZ,
15:05-15:20	**Optical gyroscope systems using integrated optics** S. STOPIŃSKI, A. JUSZA, R. PIRAMIDOWICZ
15:20-15:35	**New single-mode condition for rib waveguide** C. TYSZKIEWICZ
15:35-15:50	**Optical fibers protective coatings in optical fibers sensors** L. CZYŻEWSKA, G. WÓJCIK, A. WALEWSKI, P. MERGO
15:50-16:05	**Microbendings loses in optical fibers with different cross-sections** G. WÓJCIK, K. POTURAJ, P. MERGO
16:05:16:20	**High precision aligning method for fiber-coupled single-photon sources based on semiconductor quantum dots** K. ŻOŁNACZ, W. URBAŃCZYK, N. SROCKA, T. HEUSER, D. QUANDT, A. STRITTMATTER, S. RODT, S. REITZENSTEIN, A. MUSIAŁ, P. MROWIŃSKI, G. SĘK, K. POTURAJ, G. WÓJCIK, P. MERGO, K. DYBKA, M. DYRKACZ, M. DŁUBEK
16:20-16:50	***Caffee break***

16:50 –17:10	*Plenary lecture* **Fused silica optical fibers with graded index nanostructured core** R. BUCZYNSKI, A. ANUSZKIEWICZ, R. KASZTELANIC, G. STEPNIEWSKI A. FILIPKOWSKI, B. SIWICKI, D. PYSZ, M. KLIMCZAK
17:10-17:25	**Optimization of the light source design for the sensor to measure the stroke volume of the artificial heart** K. MURAWSKI, M. MURAWSKA, T. PUSTELNY
17:25-17:40	**Measurement of the stroke volume of artificial ventricle model in conditions close to real.** W. SULEJ, K. MURAWSKI, T. PUSTELNY
17:40-17:55	**Optimization of the markers system on a flaccid membrane with the use of evolutionary strategy.** T. MALINOWSKI, K. MURAWSKI, W. SULEJ
17:55-18:10	**Examination of the possibility of using a neural network to determine the stroke volume of a new model of a pneumatic heart prosthesis** L. GRAD, W. SULEJ
18:10-18:25	**Study of the influence of the object location in relation to the camera optical axis on the result of distance measurement by DFD technique** T. PAŁYS, A. ARCIUCH
18:25-18:40	**Studying the influence of markers arrangement on the membrane shape mapping accuracy in the new Depth From Defocus method** W. SULEJ
18:40-18:55	**Vision sensor for a filament positioning in the optical fiber tapering system** W. SULEJ
18:55	***Closing ceremony***
19:00	***Supper***
2.03.2018 Friday	
8:00	***Breakfast***

POSTER SESSION

Resistive humidity sensors based on ITD transducers featured Nafion® as sensing component.
G. ADAMSKI, R. KRZYSZKOWSKI, E. MACIAK, P. KAŁUŻYŃSKI

Investigation of optical fiber current sensor with external conversion in unstable stands
K. BARCZAK, M. SZABLICKI

Application of polysulfones for the synthesis of polymeric blends as a new materials in optical fiber technology
A. BARTNICKI, M. GARGOL, B. PODKOŚCIELNA, J. NOWAK, B. GAWDZIK

LC stabilization for planar devices
M. CHYCHŁOWSKI, K. RUTKOWSKA, T. WOLIŃSKI

Single and multimode optical fibers with numerical aperture larger than 0.3
K. POTURAJ, G. WÓJCIK, L. CZYŻEWSKA, A. WALEWSKI, J. KOPEĆ, P. MERGO

The influence of the oxidation method on the properties of graphite oxide and graphene oxide
S. DREWNIAK, R. MUZYKA, T. PUSTELNY

Enhanced fluorescence of NV color centre nanodiamond pretreated by sonication
M. FICEK, M. GŁOWACKI, K. SYCZ, M. MRÓZEK, W. GAWLIK, R. BOGDANOWICZ

Study of physico-chemical properties of the new potential optical polymers based on 2-hydroxyethyl methacrylate
B. GAWDZIK, B. PODKOŚCIELNA, A. BARTNICKI, M. GIL, P. MERGO

Coordination complexes useful for active polymers – theoretical approach
M. GIL, J. PĘDZISZ, W. PODKOŚCIELNY, R. ŁYSZCZEK, P. MERGO

Theoretical investigation of properties of InAsSb mid-wave infrared detectors
E. GOMÓŁKA, M. KOPYTKO, P. MARTYNIUK

The use of laser printers for obtaining masks for the photolithography process
K. GUT, S. STDENT

ALD films in fiber-optics sensors
M. HIRSCH, M. JĘDRZEJEWSKA-SZCZERSKA

Luminescence spectroscopy diagnosis system for non-invasive in vivo skin cancer research
P. KAŁUŻYŃSKI, Z. OPILSKI, D. KOGUT, I. NIEDZIELSKA, N. SITEK-IGNAC

Spectroscopic ellipsometry measurements and nanocharacterization of conducting graft copolymers thin films
P. KAŁUŻYŃSKI, M. PROCEK, E, MACIAK, Z. OPILSKI, A. STOLARCZYK

Optical fiber sensor with nitrogen-doped diamond film
M. KOSOWSKA, D. MAJCHROWICZ, M. JĘDRZEJEWSKA-SZCZERSKA

Field application of optical fiber sensor for rotation and tilt registration
A. KURZYCH, L. R. JAROSZEWICZ, R. ZAWISZA

Investigation of physicochemical properties of hybrid combcopolymers graft P3HT/transverse metal oxides (TMO) composites
E. MACIAK, A. STOLARCZYK

Long term stability study of InAsSb mid-wave infrared HOT detectors passivated through two step passivation technique
K. MICHALCZEWSKI, Ł KUBISZYN, D. BENYAHIA, A. KĘBŁOWSKI, P. MARTYNIUK

Signal correlation methods for photodetector noise characterization
M. PANEK, K. ACHTENBERG, J. MIKOŁAJCZYK

Design and characterization of integrated transceivers for fiber-optic access systems
A. PAŚNIKOWSKA, A. KAŹMIERCZAK, S. STOPIŃSKI, M. TOMKIEWICZ, R. PIRAMIDOWICZ

Thermal and optical study of the new methacrylic copolymers useful in POF technology
B. PODKOŚCIELNA, K. FILA, M. GOLISZEK, M. GARGOL, A. BARTNICKI, B. GAWDZIK, M. GIL, P. MERGO

Testing the SteamVR trackers operation correctness with the OptiTrack system.
M. MACIEJEWSKI, M. PISZCZEK, M. POMIANEK

Virtual 3D object manipulation with graphics tags and AR technology.
M. PISZCZEK, M. POMIANEK, M. MACIEJEWSKI

Influence of near UV irradiation on ZnO nanomaterials gas sensing poperties
M. PROCEK, A. STOLARCZYK

Problems of Quantum Fields Theory QFT within the Standard Model of fundamental particles
T. PUSTELNY

Intense mid-infrared luminescence in bismuth-germanate glass co-doped with lanthanide ions
T. RAGIŃ

Hybrid radio-optical data link
J. MIKOŁAJCZYK, D. SZABRA, B. RUTECKA, Z. BIELECKI

Optical properties of monomer-doped liquid crystalline materials for waveguiding structures
K. RUTKOWSKA, M. CHYCHŁOWSKI, B. TUROWSKI, A. KOZAK

Critical technical aspects of manufacturing photonics integrated circuits on a silicon platform
M. SŁOWIKOWSKI, R. MROCZYŃSKI, A. KAŹMIERCZAK, S. STOPIŃSKI, R. PIRAMIDOWICZ

CEZAMAT Environment - Polish Center of Excellence as a bridge between science and industry
P. SOBOTKA, K. RUTKOWSKA, T. WOLIŃSKI

Numerical analysis of integrated optics structures based on wide band-gap oxide semiconductors ZnO and TiO_2
P. STRUK

Investigation of physical properties of ZnO semiconductor material for sensor applications
P. STRUK, M. A. BORYSIEWICZ

Review of blood transfusion devices.
T. TRAWIŃSKI, S. BARTEL

PRESENTATIONS ABSTRACTS

WDM-PON access system based on integrated photonic devices

K. ANDERS[1], S. STOPIŃSKI[1], A. JUSZA[1], A. KAŹMIERCZAK[1], A. PAŚNIKOWSKA[1], M. TOMKIEWICZ[2] , R. PIRAMIDOWICZ[1]
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Last few decades observed dynamic growth of the telecommunication market, stimulated by continuous introducing and development of completely new services, typically requiring enormously high data rates. All-optical solutions, known under a common name Fiber To The Home (FTTH), are the only which can come up to telecom market's expectations, and specifically the concept of a passive optical network (PON) seems to provide the optimal architecture for implementing broadband services in next-generation networks. According to the current ITU standards, the PON-based systems use three wavelengths only – 1490 nm and 1310 nm for downstream and upstream transmission, respectively, and 1550 nm for optional CATV broadcasting, which is definitely not enough for present requirements. The detailed technical specifications for WDM-PON (wavelength division multiplexing PON), considered as the future of optical access, are still under discussion.

In this work we propose a new solution for WDM-PON systems, based on the concept of introducing photonic integrated circuits (PICs) instead of discrete components in transmitter/receiver modules, which allows not only reduction of size, energy consumption and costs but also significant increase of the reliability factor. In particular, several concepts of integrated multichannel transmitters and receivers in generic technologies, will be presented and discussed with respect of applicability in WDM-PON systems.

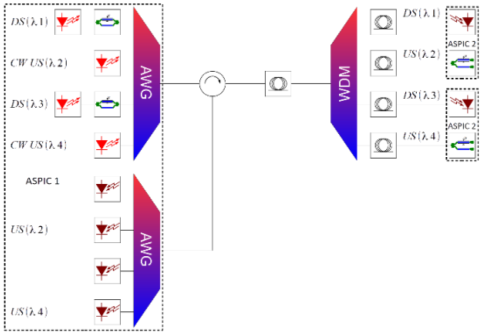

Fig. 1. Operational scheme of an experimental WDM-PON system based on photonic integrated circuits

The proposed experimental WDM-PON system (see Fig. 1) uses two different transceiver circuits. The first is a multi-wavelength device for application in the optical line terminal of the WDM-PON system. The second is a single wavelength transceiver to be implemented in the optical network unit (ONU). The circuits were designed using DBR lasers, electro-optic Mach-Zehnder modulators, multi-mode interference couplers/splitters (MMI), arrayed waveguide grating (AWG) and PIN photodiodes.

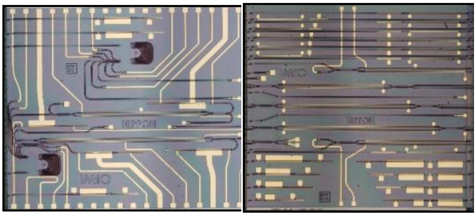

Fig. 2. Microscope pictures of the fabricated devices – optical transceivers for OLT (left) and ONU (right)

The circuits were fabricated in multi-project wafer runs (MPW) which allows to share mask and wafer costs to produce prototypes designs in low quantities. Microscope pictures of fabricated PICs are shown in Fig. 2. All unpackaged photonics integrated chips were carefully characterized in IMiO WUT laboratories with special regard to spectral and power parameters of the DBR lasers, as well as performance of the amplitude modulators. Detailed examination of these parameters enabled to select the best device to be packaged and tested in a real telecom system.

Acknowledgments: This work was supported by the National Centre for Research and Development (project of the third Applied Research Programme NIPPON, grant agreement PBS3/A3/21/2015).

References:

[1] M.K. Smit et al., Semicond. Sci. Technol. 29, 8, (2014) SMART Photonics website, http://smartphotonics.nl/

Optical fiber current sensor with external conversion in high voltage environment

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The presented work is concentrated on investigation of electric properties of optical fiber current sensor with external conversion [1]. The sensor was examined in the presence of high voltage (up to 30 kV). Moreover, there was one high voltage trial at 70 kV for 1 min. [2].

High voltage tests showed very good insulating properties of the sensor. A leakage current was estimated. It's value was lower than for high-voltage ceramic insulator (Fig. 1 and Fig. 2).

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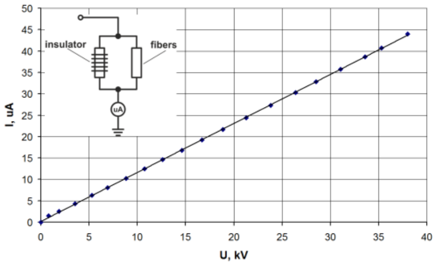

Fig. 1. Leakage current as a function of voltage for an insulator and fibers grounded.

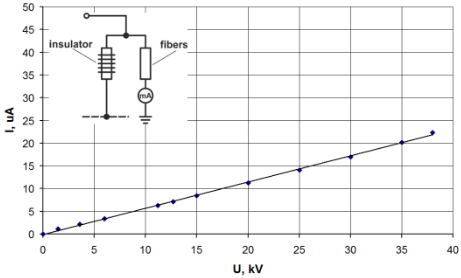

Fig. 2. Leakage current as a function of voltage if only fiber grounded.

References:

[1] K. Barczak, K. Maźniewski, *Investigation of optical fiber current sensor with external conversion in AC magnetic field*, Proceedings of SPIE ; vol. 10325 0277-786X, (2017).

[2] D. Duda, K. Maźniewski, M. Szadkowski, *Electro-insulating covers of rigid busducts 110 kV as part of the additional shock protection*, Przegląd Elektrotechniczny. No 10/2016, pp. 116-119, (2016).

Self-organizing, one-dimensional periodic structures in 5CB doped with gold nanoparticles

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We have investigated the use of gold nanoparticles and nematic liquid crystal (5CB) composites to create a network in a form of one-dimensional (1D) photonic structure. We show that by heating the composite to the isotropic phase, gold nanoparticles reversibly self-assemble into highly regular structures. The morphologies and associated LC patterns are controlled by the heating rate, concentration, and elastic properties of the LC. Those effects emerge from the phase separation process which is known in literature [1-5]. In this work, we are demonstrating an influence of the capillary internal diameter on the period of such structures. Our experimental results show that doubling the capillary diameter increases twice the period of the structure.

References:

[1] V. J. Anderson, E. M. Terentjev, S. P. Meeker, J. Crain, and W. C. K. Poon, Eur. Phys. J. E 4, 11 2001

[2] J. Cleaver and W. C. K. Poon, J. Phys.: Condens. Matter 16, S1901 2004

[3] D. Vollmer, G. Hinze, W. C. K. Poon, J. Cleaver, and M. E. Cates, J. Phys.: Condens. Matter 16, L227 2004

[4] J. C. Loudet, P. Barois, P. Auroy, P. Keller, H. Richard, and P. Pouling, Langmuir 20, 11336 2004

[5] J. Milette, et al, Soft Matter 8, 173 2012

Side-polished optical fiber sensor

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This paper presents theoretical analysis and experimental verification of a side polished, large sensing area optical fiber senor destined for the fluorescence detection purposes. Authors believe that this type of sensor may become useful in the integrated sensor networks or as a stand-alone fiber optic elements, used to examine thin and hard to reach cavities, so the sensor constructed in this way can be used in industry and in medicine. A half-polished core on one side of the optical fiber, emitting rays of light outside the optical fiber core, will give information about the concentrated power outside it, e.g. in a fluorescent substance and power returning to the optical fiber. Fiber with the polished region was then straightened. By employing the ray tracing method, it was possible to analyze clutch parameters, such as the depth of polishing and fiber bending radius. These parameters influence the amount of excitation light emitted out of the polished region, and hence determine the total amount of fluorescence induced in the sample medium.

Before the implementation of the side sensor project, a computer simulation was carried out in the Matlab® environment. To check whether these simulations are correct, samples sensors were prepared and their efficiency in inducing and collecting fluorescence was examined. In the simulation were optimized optical fiber parameters such as: - core diameter;
- diameter of the coat;
- depth of polishing;
- fiber bending radius.

The next step in the implementation of the side sensor simulation was to simulate its operation, based on the Ray Tracing method. The Ray Tracing method gives the opportunity to analyze fiber optic elements. The algorithm allows you to specify thousands of radius traces simultaneously in a desired 3D area with an arbitrarily determined refractive index. The application of this method in the study of the light rays inside the optical fiber allowed to obtain information about the amount of light emitted by the ground part of the core out of the optical fiber. Then, we examined how many percent of the light returned to the fiber. After the simulation side-polished optical fiber sensor with optimal parameters was made. The results from the simulations and results obtained during the experiment were compiled and compared.

Boron doped diamond nanosheets – A route towards transparent diamond-on-graphene heterojunction

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arious carbon layered materials are of considerable interest as potential electronic materials for future diverse electronic and optoelectronic devices, including transistors, photodetectors or optical modulators. To overcome that drawbacks, the freestanding diamond foils and thin diamond nanosheets could be utilized. The boron-doped diamond nanosheets were synthetized in the MW PA CVD system (SEKI Technotron AX5400S). The diamond foils were synthesized on mirror polished molybdenum substrates. Substrate temperature was kept at 500°C during the deposition process. The growth time was 2h, producing film of a thickness ca. 500 nm[1–3]. The large area (up to 5 mm x 5 mm) diamond sheets have been exfoliated from the substrate using mechanical techniques.

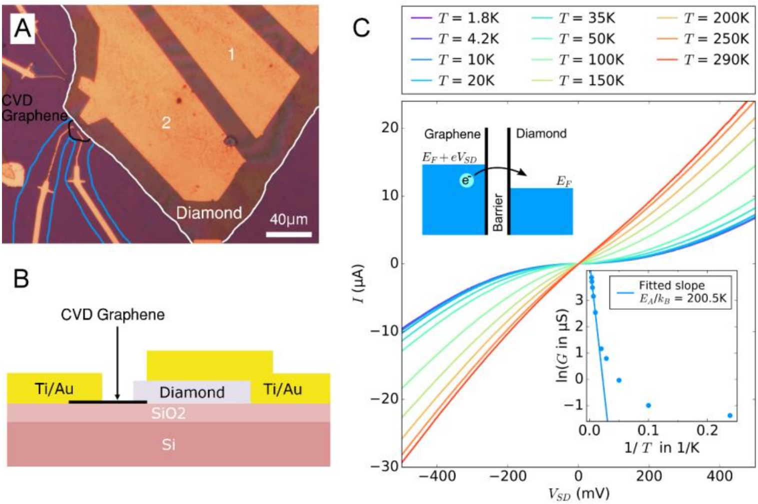

Fig. 1 Electronic properties of diamond-graphene heterojunction (diamond nanosheets are marked by a white line, the CVD graphene islands by a black line, and evaporated contacts by a blue line).

Our atomistic simulations of thermal deformations of Ta(110) – Diamond (111) interface reveal the mechanism behind the observed phenomenon. We established that the main factor responsible for CVD diamond delamination is thermally induced interfacial stress and lattice mismatch. The lattice mismatch between the two materials and differing thermal expansion coefficients enabled mechanical isolation and transfer of large-area diamond nanosheets to various secondary substrates.

We have investigated how the electronic properties depended upon the free-standing diamond growth, the mechanical transfer process, and the composition of large-area diamond sheets. We have designed a prototypical diamond nanosheet – graphene FET transistor and studied its electronic transport properties as a function of temperature. We show that these systems lead to thermally activated transport over a barrier, which is dominated by quantum tunneling at T below 20 K. These findings prove that hydrogen termination of diamond dangling bonds leads to efficient carrier transfer at the diamond-graphene interface.

Acknowledgements:

This work was supported by the Polish National Science Centre (NCN) under the Grants No. 2014/14/M/ST5/00715 and 2014/14/E/ST7/00104. The DS funds of Faculty of Electronics, Telecommunications and Informatics of the Gdansk University of Technology are also acknowledged.

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Fused silica optical fibers with graded index nanostructured core

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The ability in shaping the index profile of optical fibers holds a key to fully play with its optical properties and future application [1]. Optical fibers with engineered sub-wavelength features forming the core, have evolved into a distinct field in structured fiber optics. Depending on the involved technology, different structures have been demonstrated, including fiber tapers and sub-micron scale wires, with either solid core or air core.

Recently normal dispersion multimode GRIN fibers were used to show self-organization of nonlinear waves, where intermodal interactions are mediated by disorder, nonlinearity and dissipation [2]. Graded index distribution in core of optical fibers is typically achieved with use of MCVD techniques [3]. In this fabrication processes the diversity of materials and dopant levels of silica glass are very narrow and, in consequence, obtaining of arbitrary refractive index profile [4] is limited. Because of the technology limitation the single-mode silica GRIN optical fibers haven't been considered as a dispersion engineered medium for telecommunication or nonlinear optics medium.

We present a new approach for the development of graded index fused silica fiber based on core nanostructurization. The structure of the fiber core has been designed for a parabolic refractive index profile with a symmetry axis along the fiber's optical axis. A graded index core is obtained by means of distribution of two types of subwavelength glass rods according to calculated pattern. The effective refractive index profile of the core in this structure has a parabolic profile. The effective medium Maxwell-Garnett theory is applied to describe performance of the fiber [5]. A standard stack-and-draw technology commonly used for photonic crystal fibers development is used for development of fibers with nanostructured core [6]. The proposed method allows to obtain arbitrary graded distribution not limited to the circular or any other symmetry as in the standard graded index fibers.

We have developed a proof of concept fiber with parabolic refractive index core and showed a perfect match between predicted, designed and its measured properties. The fiber has a core composed of 2107 rods of 190 nm of diameter made of both, pure fused silica and Ge-doped fused silica with 8.5 %mol concentration (Fig. 1). Several fibers with various core and cladding sizes were fabricated. A single mode performance for wavelengths above 1.310 µm was verified experimentally in a fiber with the core radius of around 4 µm and cladding diameter of 125.7 µm.

Proposed method breaks the limits of standard fabrication methods used for fused silica fibers.

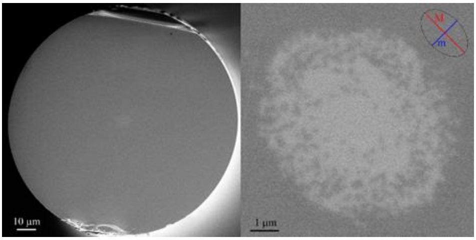

Fig. 1. SEM image of cross-section and geometrical parameters of drawn fibers. a SEM image of fiber #4 with an elliptical core b. Dark areas correspond to fused silica glass, bright ones are the Ge-doped silica rods.

Acknowledgements

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Electro-optical properties of photo-aligned photonic ferroelectric liquid crystal fibers

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In the following paper, electro-optical response times of photo-aligned photonic ferroelectric liquid crystal fibers under an influence of an external electric field have been investigated.

Photonic crystal fibers (PCFs) play a predominant role in development of modern photonics and sensing technology. By infiltrating PCFs' internal structure with different substances those physical properties can be manipulated by external factors, it becomes possible to design a new type of photonic in-fiber devices. One of the most suitable materials for this purpose are liquid crystals (LCs) which are sensitive for electric or magnetic field and temperature.

The combinations of host PCFs and guest LCs, known as photonic liquid crystal fibers (PLCFs), are in the field of interest of many researchers since 2003 [1, 2]. Recently, an increasing interest has been devoted to application of chiral smectic C (SmC*) LCs also known as ferroelectric liquid crystals (FLCs) in PCFs [3, 4]. These group of LC materials possess faster electro-optical response times for electric fields than commonly used nematic LCs, what makes them a promising material for combining with PCFs.

One of the important factors in designing PLCF-based devices is a proper alignment of LC molecules inside PCF micro-capillaries. For this reason, different

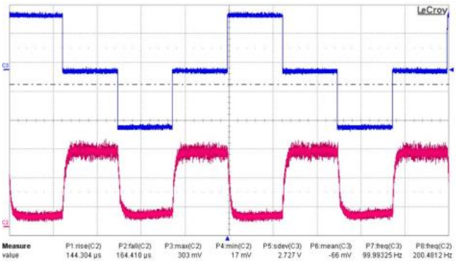

Fig. 1. Electro-optical response of the PLCF LMA-10 infiltrated with the photo-aligned FLC FD4004N (red signal) under an influence of the square-shaped electric field (blue signal) for frequency of 100 Hz and the electric field intensity 11 V/µm.

aligning techniques are utilized as photo- or thermo-alignment. In our research we have covered the inner structure of isotropic PCF LMA-10 (NKT Photonics) with the photosensitive sulfonic azo dye SD1 [5] and then infiltrated the PCF with FLC FD4004N (DIC, Japan) on a distance of 10 mm. As it was previously reported [6], the SD1 agent can interact with FLCs providing good and stable alignment of FLC molecules inside cylindrical structures. A good FLC alignment can be observed when anchoring energy normalized to the micro-capillary diameter is lower than the elastic energy of the FLC helix. In order to investigate electro-optical response times of the PLCF infiltrated with the photo-aligned FLC, a square-shaped electrical signal (Fig. 1) was applied to the infiltrated part. The electric field intensity was in the range of 4.6 to 12.3 V/μm. For the signal frequency 100 Hz and the electric field intensity 11 V/μm, we have registered the rise time and fall time of 144.3μs and 164μs, respectively. However, for higher frequencies of 1kHz, these values can decrease to 29.3μs and 41μs.

The results obtained confirm faster electro-optical responses of the PLCFs infiltrated with FLCs under a influence of the external electric field, even one order of magnitude faster than for commonly used nematic LCs

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Investigation of the nicotine infrared absorption spectrum

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A tobacco products smuggling is still a challenging problem causing adverse financial and health consequences. Complex imaging systems [1] and dogs [2] are most frequently techniques applied to their detection. Using other method is limited because of very low markers concentration resulting from sophisticated smuggling ways. Gas chromatographic, mass spectroscopy as well as fluorescence spectroscopy are usually used to trace matter detection [3]. Comparable sensitivity and selectivity but much faster response offer laser absorption spectroscopy (LAS) techniques [4]. LAS can be effective tool of tobacco products detection but requires knowledge of the characteristic absorption spectrum of the gaseous compounds emitted by them. One of the main substances that occurs in the atmosphere of tobacco is the nicotine. The article presents the investigation results of the nicotine absorption spectrum in the infrared range. For this purpose a high resolution FT-IR spectrometer (Nicolet iS50) was applied. The obtained spectrum was also combined with selected atmospheric gases (according to HITRAN database) that may interfere with this measurement. The calculations of the optimal range of nicotine absorption in environments with different air quality will be presented as well.

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Evolution of Low Level Radio Frequency Control Systems for Free Electron Lasers from short pulse to continuous wave operation

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Nowadays Free Electron Laser (FEL) light sources are becoming popular tools for scientist and researchers various industry branches that need to explore the matter in the atomic resolution. The initiative called European X-Ray Free Electron Laser have been build in Hamburg (Germany) and commissioned last year (2017). Currently the E-XFEL start its operation phase.

One of the key component in this laser accelerator part is Low Level Radio Frequency (LLRF) control system. This electronic, digital system main responsibility is to provide optimal energy transfer between accelerating superconducting cavities and accelerated electron beam. Precise regulation of the accelerating field parameters (like amplitude and phase) is essential in laser light generation process in the undulators, at the end of the facility linac. E-XFEL (as well as other FEL facility – FLASH) have been designed and build to work in pulse mode operation scenario (10 pulses per second, ~1,5ms each pulse). Since almost a decade an effort of future FEL upgrades possibility that would provide constant laser burst is being investigated. The continuous wave operation scenario and its impact to the LLRF system structure and functionality have been studied.

This paper summarizes the work on the short pulse LLRF system modifications and extensions proposed, developed and evaluated in the accelerator environment. All this work have been dedicated to proof LLRF system capabilities in precise accelerating field (down to 0.01% in amplitude and 0.01 deg in phase) control for various operation scenarios.

Distributed Optical Fiber Sensors based on Photonic Crystal Fibers for Advanced Sensing Applications

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In order to properly satisfy the societal needs of today in terms of energy, communications, transportation or housing, a great number of civil infrastructures is required. Dykes, bridges, highways or railroads should all guarantee a correct and continuous working, and hence, solutions to preserve and control the integrity of these installations are strongly needed. Distributed Optical Fiber Sensors (DOFS) are particularly suitable for these kinds of applications, for they can provide measurements of strain, temperature and/or vibrations (or any other magnitude dependent on these) along thousands of sensing points over tens of kilometers of fiber.

The foundation of all distributed sensors is the analysis of the scattered light within the optical fiber, due to either Rayleigh, Brillouin or Raman effects. Among them, Rayleigh scattering turns out to be the most intense of all, which arises due to the interaction between the light and the inhomogeneity of the material the fibers are made of. Since there is no exchange of energy between the incident light and the scattered photons (no change in frequency/wavelength), Rayleigh scattering is classified as an elastic process [1]. On the other hand, Brillouin and Raman effects are two inelastic scattering phenomena, i.e. the incident light and the scattered photons are not at the same frequency/wavelength [1].

The first and most widely-spread DOFS is the Optical Time Domain Reflectometer (OTDR), which was proposed in the late 1970s [2]. Its working principle is based on sending a pulsed light into the fiber, and analyzing the backscattered signal in the time domain. This features a very interesting tool which allows for characterizing long fiber hauls (in the range of several tens of kilometers) with a spatial resolution (minimum detectable distance between two sensing points) in the order of meters. However, due to the use of non-coherent light sources, this approach only permits analyzing changes in the intensity of the backscattered wave. On the contrary, if a coherent light source is utilized (with a coherent length at least as long as the pulse width), the backscattering light coming from several scattering centers within the fiber will interfere with each other. This is the fundamental principle of the so-called phase-sensitive Optical Time Domain Reflectometry (φ-OTDR) [3]. This sensing scheme allows for detecting fast changes in the phase of the backscattered signal, which enables the capability of sensing acoustic waves or vibrations [3]. On top of that, φ-OTDR sensors also permit retrieving relative changes in the local strain or temperature along kilometers of fiber [4].

Among the sensing techniques based on Brillouin scattering, the most popular turns out to be the so-called Brillouin Optical Time Domain Analysis (BOTDA) [5], which, in this case, maps the Brillouin Frequency Shift (BFS) along the entire measuring range, in a time-wise manner. This approach permits obtaining absolute strain or temperature variations.

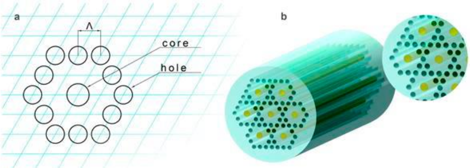

Fig. 1. Novel seven-hole Multi-Core Fiber (MCF) proposed: (a) Basic cell of proposed hole-assisted MCF with marked lattice constant Λ. (b) Composition of seven cells with three additional holes as markers [6].

All of the above-mentioned sensing approaches, although well established and widely-spread, fail when addressing the issue of cross-sensitivity of the sensor, as well as in determining other interesting magnitudes, such as pressure or curvature of the fibers utilized. To overcome such limitations, the so-called Photonic Crystal Fibers (PCF) [7] play a key role. By changing the inner structure of the fibers utilized, in terms of geometry, number of cores, or air-holes, a vast amount of new magnitudes can be effectively measured by DOFS. In this work, we will address the interesting possibilities the PCF bring into the world of DOFS and the smart infrastructures

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Fabrication and characterization of an electric field directional sensor based on a photonic crystal fiber selectively filled with liquid crystals

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It was recently demonstrated that photonic crystal fibers infiltrated with liquid crystals can be used as fiber optic sensors to detect the intensity of external electric fields [1,2]. Measuring the direction of a field is possible after infiltrating the fiber selectively, due to its initial birefringence [3]. The most common approach to selective filling of PCFs involves the blocking of selected holes using a UV-curable optical adhesive. One way to accomplish this is to apply the adhesive manually to selected areas using an applicator or injector [4, 5]. If the amount of adhesive is small enough and is positioned with great precision, single PCF holes can be blocked. However, this method is usually used for gluing groups of holes. Selected holes can also be blocked after applying the adhesive evenly over the whole tip of the PCF using selective photopolymerization [6].

We report an effective method for the selective infiltration of photonic crystal fibers, using a two two-step procedure consisting of precise application of a microdroplet of UV-curable optical adhesive followed by selective photopolymerization. Fiber holes were filled with adhesive microdroplets formed on a Kevlar fiber. A semiconductor laser and a video projector were used to photopolymerize the adhesive on selected parts of the fiber tip.

In method utilizing video projector and microscope the size of a pixel displayed on the fiber end-face was slightly larger than the diameter of a single PCF hole, thus it was easy to change the pattern of infiltration via simple adjustment of the displayed video. In this approach, a red light can be used as illumination during position adjustments and a blue/white pattern can be used for selective curing.

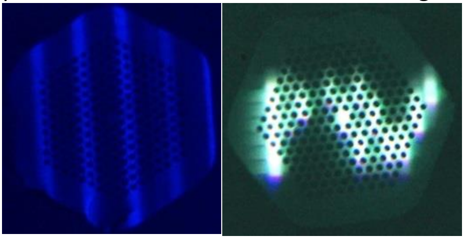

Fig. 1. Images displayed on a tip of a PCF: periodic blue lines and exemplary color image demonstrating the performance of the setup

The method was applied to build a sensor to detect the direction of an external electric field. The sensor was based on photonic crystal fiber with a central row of holes filled with liquid crystals. Measurements of transmission spectra were performed at various fiber positions relative to the direction of the field. At high values of field intensity, the fiber transmits light when the filling axis is aligned with the direction of the field and of light polarization.

Changes of spectrum with increasing external electric field intensity for orthogonal polarizations of outgoing light were investigated and compared for different fiber positions. It appeared that only for polarization matching the direction of the external electric field and the filling axis of the fiber (fiber at position a in 2) was the transmission at a high intensity of the external electric field comparable to the transmission measured prior to applying the field. In all other cases, the transmission decreased with increasing external electric field intensity.

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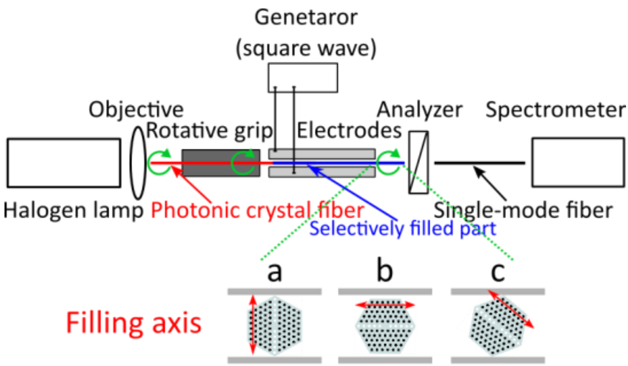

Fig. 2. Schema and photo of the setup for characterizing a selectively filled PCF as a directional sensor of electric field

Selected technological aspects of semiconductor samples preparation for Hall effect measurements

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Quantitative mobility spectrum analysis (QMSA) is currently one of the most useful tool for semiconductor-carrier-transport characterization [1]. Basically, it relies on a data processing of the Hall-effect measurements being gathered versus magnetic-field. Despite of many advantages, that technique has one inconvenient feature - it requires very high symmetry and uniformity of the samples. In this report we present comparison of the results for “standard Hall sample” – SHS (used for a rough estimation of the Hall carrier concentration in the single magnetic field) and the “full processed” – FP one.

Preparation of SHS basically consists of cutting 0.5×0.5 cm^2 piece of wafer, scratching of the sample corners surface and deposition in this area a small volume of chloroauric acid, providing (after decomposition) golden electrical contact into each measured layer. Electrical connections between sample and holder are realized by gluing golden wires on a silver paste. Such procedure allows to process Hall sample in a very fast manner. However, due to difficulties with repeatability of the sample and contact geometry, those requirements were found not to be sufficient enough for QMSA characterization.

For the precise measurement of the Hall effect versus magnetic field, the careful fulfilling of the van der Pauw method assumptions are critical [2]. In our case the high symmetry and uniformity of the sample are realized by cloverleaf geometry made in FP mode. Using InAs, Be -doped samples, we have performed multi-photolithography using the AZ 4533 photoresist and NaOH solution developer, chemical etching using the orthophosphoric/citric acid water solution plus 30% hydrogen peroxide and hydrochloric acid [3].

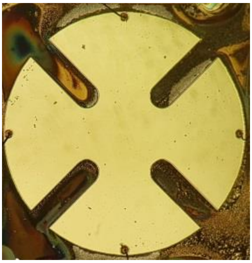

Fig. 1. Example of Hall sample in cloverleaf geometry via optical microscopy

Moreover, the electrolytic anodization in $Au(CN)_3$ water solution in order to process golden contacts, and semi-automatic wire bonding between these contact and sample holder have been performed. The example of Hall sample has been presented on the Fig. 1.

It this report we are focused on quantitative quality comparison between described two methods of sample preparation. As a quality criterion the minimum of the sample resistivity versus magnetic field has been used. Namely, the expected “ideal” value should be as close zero magnetic field as possible. Our results proves that only high symmetry samples should be used for detailed QMSA analysis.

Acknowledgments:
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Examination of the possibility of using a neural network to determine the stroke volume of a new model of a pneumatic heart prosthesis

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The article presents research aimed at investigating the possibility of using a neural network to determine the ejection volume of a new model of a pneumatic heart prosthesis. The study used artificial neural networks to determine the relationship between the actual membrane view and the ejection volume of the mechanical cardiac chamber. The research was carried out using the best network model developed and presented in the literature as well as the best technique for extracting image features.

Face re-identification across pose in thermal infrared spectrum based on local texture descriptors

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Physical appearances can now verify payments, grant access and improve existing security systems. Face is the most natural human hallmark. This widely applied identifier attacks attention of researchers to develop more robust and efficient recognition systems. Most of the research is being done in the visible domain however, other modalities are available as complementary techiques. Thermal infrared spectrum seems to be very prospective for facial recognition but requires a lot of efforts to define capabilities for real-life applications. Since the recognition performance relies on variety of aspects ranging from algorithms, acquisition process, sensors, environmental conditions up to human related factors, it is justified to perform various investigation to assess impact of these aspects on overall system performance.

This paper presents results of investigations on using known local feature methods to assess impact of face position on recognition performance. The paper presents scheme of experiment, measurement methodology, processing scheme and results with various measures.

Broad-band planar waveguide interferometers

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Growing demand for efficient and inexpensive diagnostic devices in the healthcare and pharmaceutical industry is a major driving force behind the development of biochemical sensors. Different types of label-free biochemical sensors that are highly sensitive and can be miniaturized have been developed. Sensors of this type are non-invasive and resistant to external magnetic fields. Optical detection also allows a simultaneous measurement of several analytes. Biochemical optical label-free sensors utilize changes in the refractive index that occur near the surface on which the chemical reaction occurs or, more precisely, changes that occur within the field of penetration of the evanescent field of the light propagated in the planar structure. Changes of the refractive index of the surface area cause changes in the physical parameters field of the light propagated in the planar structure

Relatively recently it proposed distribution a division of waveguide interferometers system into common and double path ones [1] (single channel and two channel ones [2]). In his paper differential interferometers I consistently described as common path interferometers.

In a typical double path waveguide interferometer mode of the same order and polarization propagates along two laterally separated path: measured path (where the measuring agent affects the phase) and the reference path (which is isolated of this effect). The recorded signal inform about a change in the phase affected by factor of measurements (cover).

In a common path interferometer the waveguide mode propagate along one path and the measurement factor affects the phase of all the guided modes. The modes may differ in the state of polarization (TE, TM) or the order (TE_0, TE_1, TM_0, TM_1, ..). In such systems, it is important that there be as large as possible a difference in sensitivity between modes selected for interference.

Interferometers of this type constitute the base of constructing many kinds of sensors of physical, chemical and biological [1] quantities. Usually in investigations the waveguide structure is optimized in order to get the highest differential sensitivity.

An interesting solution permitting a magnification of even some hundred times is the application of an additional layer with a thickness of some scores of nanometers (with a high index of refraction), deposited on the waveguide

As described above, the structures it analyzed phenomenon of common path interference for one wavelength. The signal recorded by the detector is a function of the sine of the phase difference between modes (because it is a periodic function, there are such differences in the phase at which the light intensity at the output is the same). In 2008 published a work in, which describes spectropolarimetric common path interference in planar waveguide structure [3]. In the waveguide was excited mode both polarizations of the entire range of visible wavelengths and at the output of the spectrometer recorded broadcast spectrum.

Monotonic change of phase (between mods) causes monotonic shift of the recorded the spectral distribution. This method of detection also used in planar double path interferometers [4,5].

Integrated Optical Broad-Band Difference Interferometer is introduced as an alternative and economical measurement method to integrated optical label-free affinity sensors. A detailed theoretical analysis of the method will be presented and the effects of the waveguide layer on the operation of the system will be shown. A very short operating distance of less than 0.5 mm allows miniaturization of the interferometer. The analysis was performed for Si_3N_4/SiO_2 layers that can be obtained in standard microelectronics technological processes [6].

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A high-precision interferometric system for fast non-contact measurements of lens thickness

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From contact lenses to medical imaging equipment, optical elements, and lenses in particular, have become a crucial part of our lives. Produced on large scale in various shapes and sizes, lenses must meet their specifications to maximise satisfaction for the customers and to minimise order returns for the manufacturers. However, testing each lens individually during the production process is generally unfeasible. We present a low-coherence interferometer setup which provides a non-destructive non-contact measurement that can be fast enough and accurate enough for large scale industrial applications. Our fast high-precision interferometric system is the first that can be used for serial measurements on entire batches of lenses or other optical elements.

The lens thickness is one of the most fundamental parameters which describes the lens. None of the current methods of measuring lens thickness [1,2] is both fast and cost-effective. In the popular optical reflection methods (e.g. using the Michelson interferometer), the lens has to be perfectly aligned for the measurement. This takes time and requires highly skilled personnel.

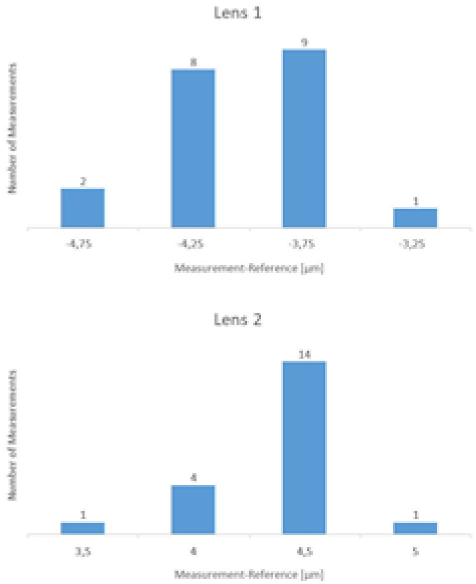

Fig. 1. Distribution of 20 consecutive measurements taken by our system with respect to reference values for two reference lenses. Lens 1 of true thickness of 3.965 ± 0.001 mm is made of fused silica. Lens 2 of true thickness of 3.647 ± 0.001 mm is made of BK7 glass. Our measurement system gives an accuracy of typically 5 µm or better

We present an alternative approach using a low-coherence interferometer, where the measurements are taken in transmission. This allows the preparation time to be reduced dramatically, as the lens does not need to be aligned perfectly. In fact, the system is able to measure tilted or unpolished lenses which would otherwise be difficult or impossible to measure.

In Fig. 1 we show representative results obtained using two test lenses, for which the true central thickness is known very precisely. We obtain typical accuracies of ± 5 μm and very good repeatabilities for measurements that take as little as 2 seconds. Together with negligible setup times, these results pave the way for fast automated measurements of every lens on lens production lines.

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Interrogation of fiber optic sensor networks using integrated optics

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Advantageous properties, like high sensitivity and well mastered fabrication technique makes the Fiber Bragg Gratings (FBGs) a very useful and efficient elements for sensing networks. Such a networks allow for e.g. strain monitoring in a number of various locations using a single optical fiber, which predestinates FBG-based systems to all applications where the information from multiple, distributed sensors of high sensitivity to mechanical strains offer an added value.

A typical measuring device exploiting FBG sensor network comprises of one or several optical fibers, each of these containing a number of serially coupled FBG sensors and an appropriate interrogator device comprising a light source(s) and detectors(s). For a number of applications it is strongly demanded to reduce an interrogator weight, size and power consumption, which makes integrated photonic circuits (PICs) excellent candidates for development of such devices.

In this work we analyze possibility of constructing optical interrogators basing on generic PIC technologies available on the market. We present a possible architectures of such devices discussing its advantages and drawbacks. Our analysis is supported by experimental results of two different interrogator topologies implemented - arrayed waveguide grating (AWG) spectrometer and a matrix of tunable laser sources, both fabricated in generic InP technology.

Bending optical beams in nematic liquid crystals

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We demonstrate that optical signal in general and spatial solitons in particular can propagate in a uniaxial dielectric with both a transversely and longitudinaly modulated orientation of the optic axis. Since curved waveguides are desirable elements in photonics, we investigate the propagation of optical signal in nematic liquid crystal cells subject to both transverse and longitudinal modulation of the director distribution and/or with specially design micro-electrodes.

To produce such NLC cell we applied to the boundary plates of liquid crystal cell a specialy design alignment layer prepared by electron-beam lithography or photo-orientation providing the desired distribution of the nematic liquid crystal molecules. In such a manner, a well defined regions with variable refractive index distribution in both, transverse and longitudinal directions are created. This enables to obtain a precisely designed structures with desired geometry (size and shape) that are able to bend the beam trajectory. Moreover exploiting the reorientational nonlinearity of nematic liquid crystals and imposing a linear variation of the background alignment of the molecule director and/or specially design micro-electrodes, we demonstrate that soliton trajectory can be effectively modulated and steered. Since reorientation solitons can act as passive waveguides for other weak optical signals, these results introduce a wealth of novel possibilities for all-optical signal routing and light induced photonic interconnects.

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A New trends in the development of radar technology

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The selected radar applications and radar types including MIMO radar architectures, passive radar, noise radar and the ground penetration radar are presented. The analysis of a new trends such as the path towards future fully digital frontends and software defined radar are described in the paper. In the analysis adaptive antenna arrays and real time digital signal processing are taken into account. High performance digital signal processing and transmit/receive (T/R) modules have made possible to use active electronically scanned array (AESA) technology will also be discussed. The develop of the transmit/receive modules using gallium nitride (GaN) technology applied in a radar systems will also be presented. Selected waveforms of radar signal are also important from the point of view of radar detection through its electromagnetic radiation. The application for the radar signal processing is demonstrated.

The new configuration have already showed interesting properties, especially at the detection of low RCS targets. This will make it possible to combine the benefits of the different types of radar systems.

The advances in computer science are important that can now provide data and signal processing in real time.

In this paper an advances technologies for future radar are outlined.

Theoretical and numerical researches on the propagation of waves in the shallow sea

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The work is devoted to the propagation of low frequency waves in a shallow sea. As a source of acoustic waves underwater disturbances produced by ships were adopted. Propagation of acoustic waves in shallow water is specific in that the closeness of boundaries of the limiting media characterized with different impedance properties results in the acoustic field coming from a source situated in the water layer being “deformed” by different phenomena. The distribution of the acoustic field in the real shallow sea is affected not only by multiple reflections, but also by stochastic changes in the shape of the free surface, and by the statistical changes in the shape and impedance of the seabed. In the paper, fundamental problems of modal sound propagation in the water layer over different types of bottom sediments are discussed. The basic task in this case is to determine the acoustic pressure level as function of distance and depth. Results of the conducted investigation can be useful in indirect determination of the type of bottom.

Optical response and applications of selected azo polymers

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Azo polymers, i.e., polymers containing azobenzene derivatives within their structures are very important photoresponsive materials. They are known from exceptional potential for technological applications in optical data storage and processing, photoalignment of liquid crystals or nanorobotics [1-3]. The usability of azo-polymers arises from unique phenomena, such as generation of optical anisotropy and stable surface patterns appearing upon irradiation with polarized light as a consequence of *trans-cis* photoisomerization reactions of azobenzene chromophores. Among many azo polymers, these belonging to polyimide family represent an important class of materials exhibiting high glass transition and decomposition temperatures as well as an enhanced stability of the light-generated azochromophore alignment.

In this study, we present a series of amorphous azo poly(ester imide)s and azo poly(amide imide)s containing side-chain azobenzene chromophores directly attached to the polymer backbone. We show the results of linear optical and thermal properties of the materials together with the results of photoinduced birefringence measurements and experiments on holographic grating recording. We show that extraordinary large and stable birefringence might be generated in some of the studied materials. Moreover, we try to correlate the ability of the materials to form well-defined surface relief gratings with their mechanical properties. Finally, we demonstrate that light-induced- and physicochemical properties of selected azo polyimides allow their use in photonic devices based on photoaligned liquid crystals.

Acknowledgements: This work was done under a partial financial support from the Foundation for Polish Science under grant no. POMOST/2013-7/6 cofinanced from the European Union under the European Regional Development Fund. This work was also partially supported by the Polish National Science Centre under the grant no. DEC-2013/11/B/ST7/04330.

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Formation and interaction of solitons in colloidal suspensions

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Colloidal suspensions of metallic nanoparticles constitute interesting optical medium with strong nonlinear response [1-3]. The light induced refractive index change is caused primarily by the gradient force which leads to agglomeration of particles with positive polarizability in light beam or their escape from the beam if their polarizability is negative. The net effect is always the same: the effective refractive index always increases in the illuminated region leading to self-focusing effect and formation of solitons. This effect was first observed in case of dielectric particles. The use of metallic colloids provides an additional opportunity offered by existence of plasmonic resonances whose spectral locations can be varied by changing geometry of particles. It appears that one can achieve positive or negative polarizabilities by tuning the operating wavelength of the incident light beam to either red or blue side of plasmonic resonance.

Furthermore, the proximity of resonance may induce absorption losses of the beam. The absorption leads to local heating of nanoparticles and subsequent refractive index drop due to thermo-optic effect. This decrease of refractive index amounts to defocusing nonlinearity which has a tendency to hinder beam localization. In effect in metallic colloids one may deal with competing focusing and defocusing nonlinearities. Moreover, because of heat diffusion the latter is also spatially nonlocal.

In this work we demonstrate our recent

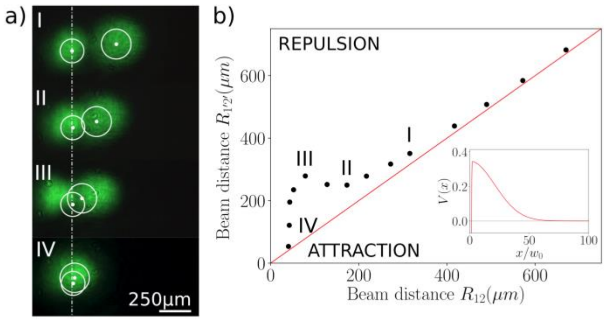

Fig. 1. Illustrating anomalous interaction of solitons. (a) recorder intensity of both beams as seen at the exit facet of the medium. Rings indicate positions of noninteracting solitons; (b) distance between interacting soliton as a function of their i

results on formation and propagation of fundamental solitons in gold nano-suspensions. We show formation and stable propagation of both bell-shaped as well as ring solitons with arbitrary polarization distribution. Finally we will demonstrate the nonlinearity competition-induced anomalous repulsion of mutually incoherent bright solitons [4].

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Periodic phase separation in 5CB nematic liquid crystal doped with gold nanoparticles

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We have investigated the use of a gold nanoparticles-doped nematic liquid crystal (5CB) composite to create a network in a form of one-dimensional (1D) photonic structure. We have shown that by heating the composite to the isotropic phase, gold nanoparticles reversibly self-assemble into highly regular structures in the process of phase separation, which is known in literature [1-5]. Morphologies and associated LC patterns are controlled by the heating rate, concentration, and elastic properties of the LC. In this work we demonstrate various approaches to describe the phase separation process. Additionally we demonstrate that creation of the periodic structure is highly correlated with gold nanoparticle density fluctuations in the liquid crystal host.

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Nanodiamond films for optical fiber sensors

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A optical fiber sensor using diamond films as a reflective layer was designed and built [1]. Its performance was investigated for selected diamond films: undoped, boron-doped and nitrogen-doped. The diamond films can be used in low-coherence interferometric sensors as a protective coating or reflective layer. The diamond films were synthesized using Microwave Plasma Enhanced Chemical Vapour Deposition (μPE CVD), which allows us to tune their properties as: thickness, grain size, roughness, chemical composition and surface morphology by changing the process conditions. Measurements were performed using two superluminescent diodes (SLD) with wavelengths of 1300 mm and 1550 mm. Detection of the measured signal was performed using an optical spectrum analyzer (Ando AQ6319). All devices were connected with single-mode telecommunications fiber (SMF-28) (Figure 1).

The use of the diamond mirror in the construction adds tolerance to the environmental conditions. The achieved results show that diamond film provides good visibility of the interference signal [2] (Figure 2).

Application of the nitrogen-doped diamond film allows to obtain the sensor of hemoglobin [3]. The interferometer can be the base for building new configuration sensors of physical quantities.

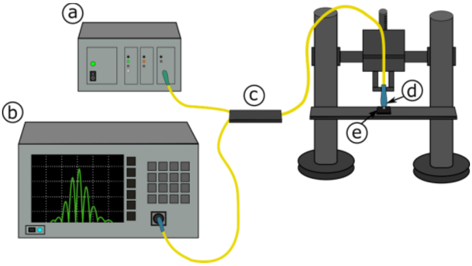

Figure 1. Measurement set-up: (1) light source, (2) optical spectrum analyzer (OSA), (3) coupler, (4) measurement head, (5) nitrogen-doped diamond film deposited on silicon substrate [3]

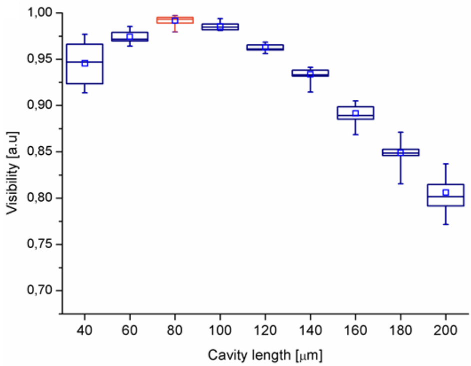

Figure 2. Visibility value as a function of cavity length measured on nitrogen-doped diamond. The straight lines inside the boxes indicates a median and the squares inside show an average value based on all measurement series [2].

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Optimization of the markers system on a flaccid membrane with the use of evolutionary strategy

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The article presents research on increasing the accuracy of determining the shape of the flaccid surface of the pneumatic diaphragm of the extracorporeal pump for cardiac support. The aim was to determine the optimal (suboptimal) location of measurement markers on the membrane, which are used to determine the shape of the membrane surface. The study used evolutionary computation technique. Accuracy of surface mapping of the membrane is important from the point of view of measuring the instantaneous ejection volume of the pneumatic pump supporting the heart with a small error. Experiments were carried out on a pump model and a measurement stand made at the Institute of Teleinformatics and Automation at the Military University of Technology

Metal coated dual-core fiber for interferometric temperature measurement in high temperatures

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Optical fibers attract attention not only for telecommunication but also as various kinds of sensors. They are especially promising in places with strong electro-magnetic field or in explosive atmospheres and can be used for among others temperature monitoring. Temperature measurement using optical fiber can be realized in many ways i.e. utilizing fiber bragg gratings[1–3] or by creating modal interferometers[4–6]. In this work we present a reflection based sensor utilizing a dual-core optical fiber with strongly coupled cores. A standard telecommunication fiber was spliced to one core of the dual-core fiber, hence such structure works as a temperature sensitive Michelson interferometer.

Usage of optical fibers in high temperatures of over 500 °C is limited by degradation of silica cladding due to hydrolysis[7]. To overcome this temperature limit we elaborated a low temperature chemical method of coating optical fibers with metals. The method allows us to create a dual-core fiber temperature sensor which, thanks to the metal coating, can reliably operate and measure temperatures up to 900°C. Moreover the metal coating not only significantly reduces degradation of optical fiber due to hydrolysis, but also increases mechanical durability of the presented sensor at elevated temperatures.

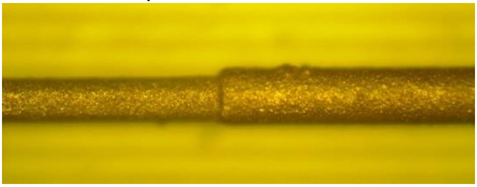

Figure 2 Metal coating of presented temperature sensor after 15 h in 900 °C

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T2SLs higher operating temperature detectors – where is the limit?

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Up to now many ideas to improve infrared photodetector performance for high operating temperature (HOT) conditions (T > 150 K) have been presented and successfully applied.

Firstly HOT conditions could be met by proper choice of the active layer (absorber) material exhibiting the highest absorption coefficient and thermal generation-recombination (GR) rate ratio. GR could be limited by designing the detectors’ active layer with materials inherently exhibiting lower GR rates. Here, due to the fact of carrier separation leading to suppression of Auger GR in comparison to the bulk materials the InAs/GaSb or InAs/InAsSb type-II superlattices (T2SLs) should be enumerated. Both T2SLs InAs/GaSb and “Ga-free” InAs/InAsSb theoretically offer higher performance to HgCdTe at an equivalent cut-off wavelength. On the other hand, T2SLs are very resisted in attempts to improve its SRH carrier lifetime where Ga is assumed to be responsible for that GR mechanism giving at the same time prospects for “Ga-free” T2SLs InAs/InAsSb.

Secondly, many detectors’ structures could be used where increase of operating temperature without suppression of the detector’s performance could be reached. Among them implementation of the non-equilibrium conditions in multilayer detector’s structures to suppress an Auger GR process could be listed. Except of the non-equilibrium structures the barrier detectors where suppression of the SRH GR components due to the theoretical lack of depletion layer in comparison to the traditional photodiode must be also taken into account. Unipolar barrier structures operating close to crossover temperature are perspective, however further improvement in HOT conditions could be met by complementary barrier detectors.

Lately, higher than room temperature operation conditions has been reached by interband cascade infrared detectors introduced to increase the absorption efficiency and suppression of the shot noise. The concept of operation is based on serial connection of active regions (shorter than diffusion length) through interband tunneling with carrier relaxation (transport) region.

In that paper we compare T2SLs HOT technologies pointing out on utmost performance.

Optical fibers protective coatings in optical fibers sensors

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The technology of each type of optical fiber consists typically three steps. The first is to fabricate the preform from which the fiber is drawed in the next step. The last step is cover the fiber with suitable protective coatings. Due to the fact that the second and third step are practically simultaneous, the descriptions of technologies usually omit covering the optical fiber with protective coatings. However, due to the protection of the fiber from the influence of the external environment, they are an indispensable part of the technology. Typical protective coatings have two functions. First of all, they protect the fiber against so-called water corrosion. Secondly, they perform an optical function, as a very effective trap of cladding modes. Mechanical properties like Young's modulus and Poisson's coefficient of typical protective coatings are much smaller than silica glass (cladding material) and high silica silica glass (core material). In spite of this, as shown in our previous works, considering the fiber optic sensor properties, it is not possible to omit their influence on the properties of the sensor.

This paper presents experimental studies on the impact of optical fiber coatings on the properties of a system of stress and temperature distributed sensors systems manufactured from typical telecommunication optical fiber.

Higher operating temperature photoresponse of MWIR T2SLs InAs/InAsSb photodetector

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Type-II InAs/InAsSb superlattices (T2SLs) are promising material for mid- (MWIR) and long- (LWIR) wavelength high-performance detectors due to longer minority carrier lifetimes in comparison to T2SLs InAs/GaSb [1,2]. The less complicated growth process and simpler interfaces control can yield in better structural quality of Ga-free T2SLs. Nevertheless, the influence of the growth conditions on the T2SLs material quality remains a critical issue. More detailed investigation of the structural properties seems to be essential for further improvement of the materials and device performance.

In order to fabricate low-cost IR detectors, it is recommended to utilize GaAs substrate. The latter has better structural, optical and thermal properties than GaSb. In addition, GaAs substrates are more affordable and available as large size "epi-ready" wafers. Transparent GaAs substrate allows the backside device illumination and the fabrication of monolithic optical immersion lenses which improves the devices' performance nearly 10 times.

In this work, we demonstrate higher operating temperature (HOT) MWIR T2SLs InAs (5.22 nm)/$InAs_{0.6}Sb_{0.4}$ (1.2 nm) photoresitor grown on GaAs substrates using MBE. The structure exhibits 50% cut-off wavelength equal to 5 m at 200 K. High-resolution X-ray diffraction (HRXRD), transmission electron microscopy (TEM), photoluminescence (PL) optical characterizations, spectral response and response time measurements were analyzed. In addition, kp simulation of the bandgap, absorption coefficient for selected temperatures was presented. Spectral responsivity for V = 0.5 V R_i = 0.07–0.25 A/W·mm^2/V is reported for T = 200–300 K.

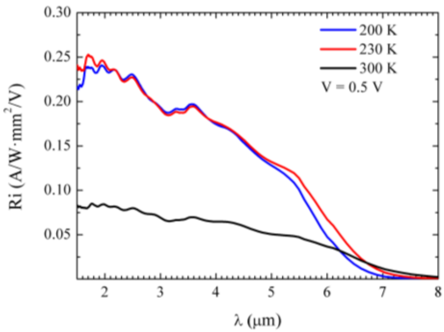

Fig. 1. Spectral responsivity of the T2SLs InAs/InAsSb photodetector

The authors would like to acknowledge the support by **The Polish National Research and Development Center** grant no. PL-TW4/3/2017.

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InAsSb photoluminescence in low temperatures

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Due to a wide spectral range (from SWIR to LWIR) InAsSb is an attractive material for IR applications, such as photodetectors or light sources [1 - 2]. In $InAs_{1-x}Sb_x$ the energy gap can be easily tuned by changing chemical composition [3].

In this paper, photoluminescence measurements of bulk InAsSb material grown by molecular beam epitaxy in MBE VIGO/MUT laboratory are presented [4]. PL spectra were measured using Bruker Vertex 70v FT-IR spectrometer, 637 nm laser mechanically chopped with frequency 1000 Hz as a source of excitation, MCT photodetector and lock-in. The whole system was working in step-scan mode [5].

Samples were measured as a function of temperature in the range from 300K to 20K (Fig.1) and laser power ranging from 1 mW to 200 mW (Fig. 2). In contrast to most of measured samples, for $InAs_{0.916}SB_{0.084}$ two distinct peaks were observed in the spectrum, as shown in Fig. 1. The high energy peak (0.33 eV) represents the donor-acceptor pair recombination, while the low peak represents the bound extortions [6].

We acknowledge support by **The National Science Centre - the grant no. UMO-2015/17/B/ST5/01753 and PBS 653**.

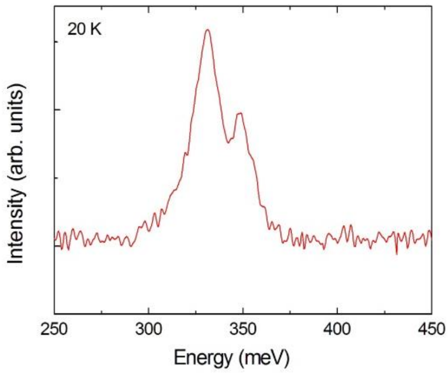

Fig.1 PL spectrum for $InAs_{0.916}Sb_{0.084}$ at 20 K.

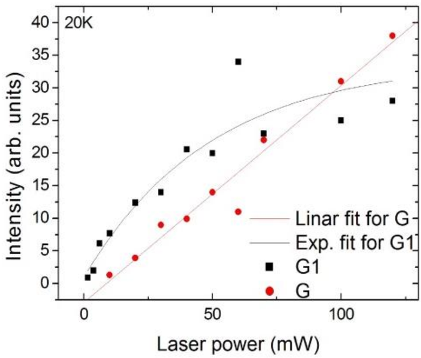

Fig. 2 Intensity in laser power function at 20 K temperature.

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Measurement of the stroke volume of artificial ventricle model in conditions close to real

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The research concern the measurement of the stroke volume of a heart assist pump. For her, a method based on determining the volume based on the shape of the membrane was proposed. The shape of the membrane was obtained using image processing and analysis. The effectiveness of the proposed solution has been confirmed for rigid membranes made in the form of models. Currently, tests are carried out to verify the method for a flaccid membrane operating in conditions close to real. The publication presents the laboratory stand, the way of measuring and the results obtained.

Optimization of the light source design for the sensor to measure the stroke volume of the artificial heart

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The article presents design process of the illuminator, which is an integral part of the vision sensor for the determination of stroke volume of the pneumatic heart assist pump. Problems resulting from the use of light sources such as: LED diodes, IR LED diodes, fiber optic illuminator and electroluminescent film are presented. We also present ways to overcome them.

System for visualization of hypodermic blood vessels

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The paper presents the effects of the work carried out to build a device for spatial visualization of hypodermic blood vessels. The device was built using a illuminators using polarized light with the wavelength λ = 850 nm and two cameras in a stereoscopic set up equipped with polarizers and interference filters with transmission adjusted to illuminators. Images captured by cameras are analyzed by software that increases the contrast of blood vessels and extracts information about the distance from the hypodermic blood vessels to cameras. In this way extracted course of blood vessels is recorded in the DICOM format, widely used in medicine.

Mobile biometric verification of passengers based on fingerprints

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Reliable and fast verification of people on the Schengen borders is a crucial issue nowadays. In case of mobile verification at land borders, border checks must are carried out for passengers traveling in cars or busses. Face verification is problematic in real scenario mainly due to changing lighting conditions and hence only fingerprints verification can be applied. The paper describes a small mobile system which was developed in the consortium of Polish entities. The system automatically acquires personal data and fingerprints from the Polish biometric passport. Simultaneously, fingerprints are also taken from passengers using a mobile reader. Basing on fingerprints matching verification of the passenger is performed. Moreover, the personal data are checked in the databases of stolen passports and wanted people. Average verification time is about 25 sec. The experimentally determined verification efficiency equals to 95%.

Study of the influence of the object location in relation to the camera optical axis on the result of distance measurement by DFD technique

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The purpose of the work was to examine the effect of shifting the object relative to the optical axis of the camera on the result of distance measurement made by the Depth From Defocus method. The applied measuring technique supports the method of determining the shape of the flaccid membrane of the pneumatic heart assist pump. The tests were carried out with a camera equipped with a fixed focal length lens. The camera was observing an object with a diameter of 0.003 m. The object changed its position relative to the camera's optical axis in the range of 0.035 m in the OX and OY directions with a step of 0.001 m. In the Z axis the object moved in the working range of the flaccid membrane front, i.e. ± 0.020 m with step equal 0.001 m and accuracy 0.00009 m.

Photonic integrated circuits – an emerging technology for optical sensing

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Optical sensing is considered as an efficient and reliable technique for monitoring various physical parameters. In comparison to sensors based on electronic devices, optical systems can be deployed in harsh environments and are immune to electro-magnetic interference of every kind. Novel techniques of optical sensing typically require advanced optoelectronic components for providing the multiple probing signals and interrogating a network of numerous sensors. Among many potential solutions, systems deploying InP-based photonic integrated circuits are considered as one of the most promising.

Integration technology based on InP and its compounds allow realizing complex photonic systems in a form of a semiconductor chip. The big advantage of this platform is a possibility of monolithic integration of active devices as amplifiers and lasers, which provides perfect compatibility with fiber-optic sensors. Furthermore, nowadays several European generic foundries offer access to a standardized and cost-efficient technology process through organization of multi-project wafer runs. Thus, photonic integrated circuits can be designed in a form tailored for a specific application using a limited set of basic elements.

In this work we present the state-of-the-art of the InP-based photonic integration technology. Selected examples of photonic integrated circuits are discussed in detail with a specific focus on sensing applications.

Virtualization of the measurement system for the MIMO THz scanner

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The development of the THz scanner final form in MIMO technology (Multiple Input Multiple Output) requires the preparation of a measuring station that integrates control, measurement, vision and mechanical systems. The management of such a measurement system can be improved by using elements of virtual technologies. Spatial analyzes of the tested object can be made using the measurement space virtualization based on the ToF (Time of Flight) camera data. Collision-free operation of the XY type scanner and industrial robot arm can be verified in virtual space. The measurement system operation correctness can be examined with the augmented reality technology. The above-mentioned elements very well fit into the idea of the so-called 4.0 Industry in which we speak about, inter alia, cyber-physical systems. For the purposes of the research project being carried out, a simplified operation model of such system was proposed. The main focus of the developed solution was on the possibility of using virtual technologies and the benefits of using them.

Nonlinear optics in gas-filled photonic crystal fibers

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Due to their unique properties (negative dispersion, endlessly single-mode propagation, controllable birefringence, etc.), photonic-crystal fibers (PCFs) are the subject of intense studies in many laboratories all over the world. On their own, however, the fibers do not support rise of spectrally-narrow optical resonances that are of crucial importance in various quantum-optic and photonic applications. On the other hand, such signals can be generated in gases, where control over parameters of light, drastic changes optical properties of the medium. This enables all-optical control over transmitted light intensity or drastic change of propagating light group velocity (sub- and superluminal light propagation).

During the talk, we will present our investigations on a hybrid system combining advantages of both PCFs and gases. We will present an experimental scheme, where extremely low-power light controls generation of spectrally narrow (nonlinear) optical resonances. We will discuss various challenges related with operation with such a system. Experimental results demonstrating the ability to control optical density of fiber filling media will be provided. We will conclude with presentation of experimental data demonstrating propagation of light pulse through the gas-filled PCFs with a group velocity larger than the speed of light in vacuum.

Application of laser absorption spectroscopy to investigation of explosives chemical stability

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The paper presents the application of laser absorption spectroscopy (LAS) to analyzing the nitrogen oxides included in products of explosives decomposition during investigation of their chemical stability. LAS can replace existing methods of chemical stability investigation based on Polish standards, e.g.: PN-C-86202:1998 and PN-C-86013:1994. They describe determination of the explosives stability using chemical methods. The main disadvantages of these method is that nitrous compounds are only incompletely absorbed in water and nitrogen oxides like NO and NO_2 cannot be measured separately [1].

Preliminary studies were carried out in the laboratory of Military Institute of Armament Technology. Test were performed for selected powders using the optoelectronic sensor of nitrogen dioxide (NO_2) developed in Institute of Optoelectronic MUT. Operation idea of the sensor basis on cavity enhanced absorption spectroscopy (CEAS), which is one of the most sensitive gas detection method. Thanks to this, NO_2 concentration at ppb (parts per billion) level was monitored in real-time [2]. During the tests, the same powders ageing procedure as described in STANAG 4620 (AOP 48) was applied. The flow, pressure and temperature of air including gaseous decomposition compounds of aged powders were registered. It was necessary to measure NO_2 concentration with high accuracy during accelerated-aging procedure.

Achieved results of experiments and their comparison with standard methods described by current regulations show possibility of NO_2 optoelectronic sensor application as an effective tool in explosive aging study. Significant benefits of the proposed method are real-time observation, many times shorter tests procedure (at least 10 times) and simplification of procedures. Further research will provide new capabilities in explosives materials parameters investigation.

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Experimental investigation of mid-infrared laser action from Dy^{3+} doped fluorozirconate fibre

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Mid-infrared fibre sources with emitting wavelengths covering the range stretching from 2.5 µm to 6 µm have many applications in remote sensing, medicine and defence [1,2]. However, in order to access these wavelengths, low phonon host materials are needed. One promising low-phonon material is fluorozirconate glass.

In this contribution a mid-infrared rare earth doped fibre laser operating at 2.92 µm is reported. The output power generated by the laser was around 10 mW. A schematic diagram of the experimental set-up is presented in Fig. 1. A home built single mode ytterbium fibre laser emitting at 1.1 µm with output power around 4 W serves as a pump. 1 metre of Dy^{3+} doped ZBLAN fibre was used as a gain medium. The fibre had 1000 ppm concentration of Dy^{3+}, a core diameter of 15 µm and operates in a single mode regime above 2.5 µm wavelength. The laser cavity was formed by butt coupling one end of the fibre with a dichroic mirror (highly reflective for the wavelength between 2.8—3.2 µm and highly transparent for the wavelength at around 1.1 µm), while the other end was butt-coupled with 50% reflector (for signal wavelength only) which acts also as an output coupler.

The emission generated by the gain fibre in the spectral range between 2.5 µm-3.5 µm was monitored using a 150 mm optical monochromator with a diffraction grating blazed at 4 µm coupled to a thermo-electrically cooled MCT detector. The pump wavelength was rejected by a germanium optical filter. In order to improve the signal to noise ratio a lock-in detection technique was employed.

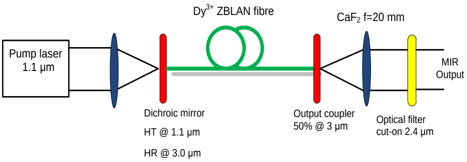

Fig. 1. Schematic diagram of the mid-infrared fibre laser

In Fig. 2 the spectral dependence of the mid infrared fibre laser emission is presented. It can be noticed that with increasing pump power spectral narrowing is observed, which can be attributed to amplified spontaneous emission. However, for higher pump powers the output spectrum becomes narrow and the optical intensity significantly increases, unambiguously verifying the occurrence of the laser action.

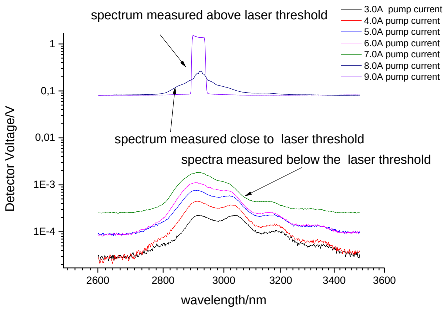

Fig. 2. Spectral dependence of mid-infrared fibre laser radiation

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Optical gyroscope systems using integrated optics

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Optical gyroscopes are nowadays commonly used in inertial measurement units (IMUs) for accurate monitoring of the angular velocity of flying objects. It should be noted, however, that contemporary devices are still fabricated using many discrete optoelectronic elements, which limits the reliability of the system. A promising technology that could enable realization of fully integrated devices is the state-of-the-art indium phosphide platform, which allows integration of active and passive components on a single chip [1].

In this work we present and discuss selected examples of photonic integrated circuits (PICs) designed for specific applications either in an interferometric fiber-optic gyroscope or ring laser based gyroscope system. The first type of PIC is an interrogator of an optical fiber loop. Rotation of the loop induces the Sagnac effect, manifesting itself as the phase difference between two counter-propagating signals, which can be extracted by measuring the intensity of the interference signal. The second variant of the PIC is a single frequency ring laser. Rotation of the resonator causes frequency shift between the clockwise and counter-clockwise cavity modes. Detection of the frequency change is done by monitoring of the beating signal. Both designs are compared and discussed with respect of the applicability in IMU devices.

The integrated interrogator provides both coherent and broadband amplified spontaneous emission (ASE) light sources, a C-band DBR laser or a semiconductor optical amplifier, respectively. The optical signal is coupled to the fiber through a cascade of two multi-mode interference couplers. An additional phase shifter section is used for increasing the sensitivity of the system. Phase modulation with a square wave ($\Delta\phi = \pm\pi/4$) changes the operating point of the system to its maximum and enables determining direction of rotation. Fig. 1 presents a photo of the integrated interrogator unit (6 mm × 2 mm).

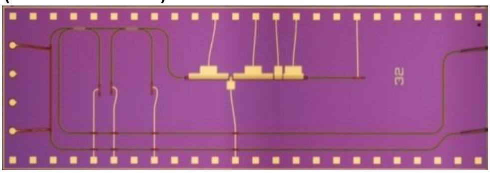

Fig. 1. Photograph of the interrogator of a fiber-optic gyroscope system

The fabricated chip has been mounted in a package that provides convenient electrical and optical interface. The device was then connected to a fiber coil (5 km) and mounted on a rotational stage. When the setup was rotating, the Sagnac interference signal was detected by two photodiodes.

The second variant of the PIC is a single frequency ring laser. The resonator has a racetrack shape and comprises two SOA sections inside. An arrayed waveguide grating (λ_c = 1550 nm, $\Delta\lambda$ = 1.6 nm, FSR = 12.8 nm) is a wavelength filter, which enables operation with a single longitudinal mode.

Rotation of the resonator causes a frequency shift between the clockwise (CW) and counter-clockwise (CCW) cavity modes. Detection of the frequency change can be done by monitoring the beating signal, which is generated as a result of interference between the CW and CCW signals. This is performed by an integrated readout circuit, that comprises a cascade of two 3 dB couplers and two PIN photodiodes.

The chip was designed and fabricated using the generic process provided by SMART Photonics [2]. Fig. 2 presents a microscope image of the chip (4.6 mm × 4.0 mm). Initial characterization results prove single frequency operation of the laser and relatively high output power - the measured on-chip power is as high as 10 mW. These results prove the general concept of the device and provide important feedback with respect to optimizing the laser design.

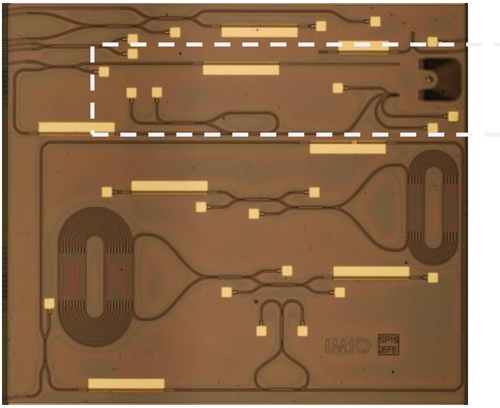

Fig. 2. Photograph of the integrated single-frequency ring laser (the discussed circuit is marked with a dashed rectangle)

Acknowledgement: The research leading to these results has received funding from the National Science Centre (decision DEC-2013/09/N/ST7/04430) and from the EU Horizon 2020 research and innovation programme under grant agreement No. 687777 (PICs4All).

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Numerical modelling of pulse formation in Er^{3+}-doped Q-switched fluoride glass fiber lasers

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Q-switched Er^{3+} doped fluoride glass fibre lasers are very promising sources of high energy and peak power light pulses for the 3 mm wavelength range [1]. Due to strong absorption of light by water at this wavelength, one of the potential application for Q-switched Er^{3+} doped fluoride glass fibre lasers is for fiber-laser medical surgery. However, the light emitted by these lasers is well absorbed by water, which predestines them to many other applications. To date, the numerical studies of Er^{3+} doped fluoride glass fibre lasers have been focused mainly on the analysis of the continuous wave operation [2]. Here we use a recently developed time domain model [3] to study the process of pulse formation in Q-switched Er^{3+} doped fluoride glass fibre lasers. The simulations are started using the solution of a steady state model applied as an initial seed, which is then refined by the time domain model to obtain the initial distribution of photons and ionic populations within the laser cavity in a consistent manner. Once the initial distributions are known the time domain analysis of the pulse operation is performed. In the model we use a 5-level approximation.

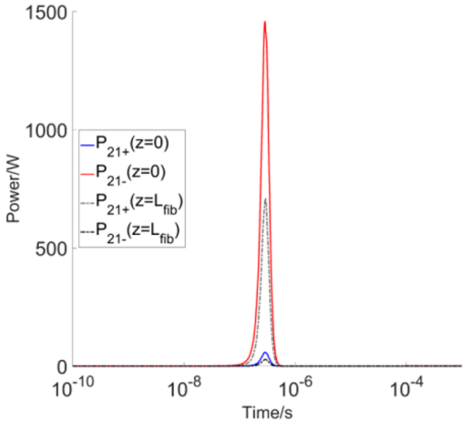

Fig. 1. Time dependence of the pulse power at selected positions within the cavity.

Figs.1 and 2 show the calculated time dependence of the pulse power and level populations at selected positions within the cavity. The pulse width (FWHM) is approximately equal to 80 ns and compares well with the pulse widths observed experimentally [1]. The fast pulse growth mechanism after activating the Q-switch relies on the different time constants determining the dynamics of photon and ionic population densities within the cavity, which is clearly observable in Figs.1 and 2. After the light pulse follows a relatively slow recovery of the level 2 and 3 populations, i.e. the levels that directly interact with the emitted light. In this contribution we study in particular the dependence of the pulse shape on the fibre length and the repetition rate.

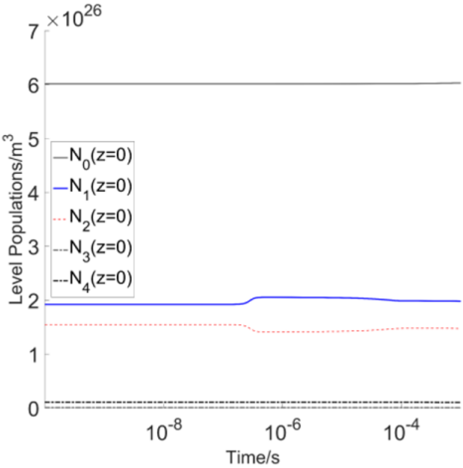

Fig. 2. Time dependence of level populations at selected positions within the cavity.

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Studying the influence of markers arrangement on the membrane shape mapping accuracy in the new Depth From Defocus method

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The new innovative Depth From Defocus (DFD) method was developed for visual distance measurement. It was used to determine the shape of the flaccid membrane of the extracorporeal pneumatic heart assist pump. In the previous conference paper the technique of accuracy measurement of membrane shape mapping of an artificial ventricle was presented. The study was conducted on two membrane shapes, which are well mathematically described: convex and concave as well as for the flat tight membrane. For all three cases, the rigid membrane models have been designed and produced. The next study focused on extending this technique to other models of membrane with the well-known math formulas. Two new irregularly shaped models were produced and tested. Analysis of the obtained results during the rigid membrane models tests revealed the significant effect of the markers arrangement on the membrane shape mapping accuracy. Therefore, another arrangement of markers was tested. In the paper the comparison of the results obtained for the different arrangements of markers was presented.

Vision sensor for a filament positioning in the optical fibre tapering system

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Tapered optical fibres, created as a result of optical fibre stretching to a few-micron diameter, are interesting for sensor applications. A vision sensor for a filament positioning presented at the paper is a key element of the optical fibre tapering system. It allows to control the speed of stretching the fibre, which significantly reduces the chance of its breaking. The paper presents the sensor developed on the basis of a fixed-focus camera equipped with a wide-angle lens and using image processing and analysis techniques. Determining the position of a filament consists in determining the angle of its deviation from the reference position. On the basis of the determined angle, the required stretching speed of the fibre is determined. In the paper the way of carrying out measurements of position of optical fibre using the sensor as well as the results obtained were presented.

New single-mode condition for rib waveguides

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Rib waveguides are the simplest but essential components of planar integrated optical circuits (PIC). Restricting one's attention to those PIC types which use the evanescent wave spectroscopy method [1] and are integrating a measuring transducers for optical sensing applications, one can see that rib waveguides can play two different functions. In the first case a rib waveguide can be an optical phase transducer itself. In combination with a proper sensitive film, a measurand renders phase changes of an optical wave guided in the rib waveguide through an evanescent part of that wave. PICs with phase transducers oftentimes contain planar interferometers, which transform phase shifts into changes of light intensity. Therefore, in order to maintain high interferometric contrast, the rib waveguide being a part the optical transducer must be single-mode. In the second case, rib waveguides are distributing optical wave among functional elements of a PIC. In this case rib waveguides should also be single mode and a fundamental mode should be well confined within the waveguide in order to minimize optical losses resulting from scattering on sidewalls and bend losses.

Therefore, a process of PICs design require choosing such a set of rib waveguides geometric parameters which ensure single-mode propagation. In literature there are two analytical conditions of single-mode propagation in rib waveguides. They are expressed in terms of effective normalized rib width u_{eff} and height r_{eff} of a side slab. A schematic view of a cross-section of a rib waveguide presenting these parameters is shown in the figure below.

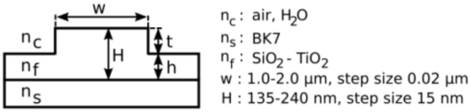

Fig. 1. Schematic view of a cross-section of a rib waveguide

The first condition obtained from the effective index method (EIM) is given by very simple inequality [2]:

$$u_{eff} < r_{eff}(1 - r_{eff}^2)^{-1} \qquad (1)$$

where: $u_{eff}=w_{eff}/H_{eff}$, $r_{eff}=h_{eff}/H_{eff}$, $h_{eff}=h+q$, $H_{eff}=H+q$,

$$w_{eff} = w + \lambda\gamma_c\left(\pi\sqrt{n_f^2 - n_c^2}\right)^{-1} \qquad (2)$$

$$q = 2\pi\lambda^{-1}(\gamma_c(n_f^2 - n_c^2)^{-1/2} + \gamma_s(n_f^2 - n_s^2)^{-1/2}) \qquad (3)$$

Coefficients γ depend on a polarization. For HE (quasi-TE) modes $\gamma_{c,s}=1$, whereas for EH (quasi-TM) modes $\gamma_{c,s}=(n_{c,s}/n_f)^2$. The second condition was given by Soref who focused its attention on large cross section silicon-on-insulator (SOI) and GeSi-Si rib waveguides. Soref modified the condition (1) adding a constant value [3]:

$$u_{eff} < a + r_{eff}(1 - r_{eff}^2)^{-1} \qquad (4)$$

In the paper [2] it was shown that the EIM condition is better than the Soref condition. However, the analysis presented in [2] is limited to a range of normalized effective rib width from u=0,4 to u=2,2. A waveguide stops being single-mode if effective indexes of HE10 or EH10 modes increase above a effective index of a fundamental mode of a slab waveguide adjacent to the rib. It takes place for a single value of rib height, t_{sst} [4]. Equations (1) and (4) transformed to a coordinate system $t(w)$ are an approximation of a characteristics $t_{sst}(w)$. Rib waveguides being analyzed in this work are silica-titania rib waveguides on BK7 glass substrates [5]. Their normalized width is varying from u=3,2 to u=6,8. It was shown that neither the condition given by (1) nor (4) properly approximate $u(r_{sst})$ characteristics. Approximation error for Soref condition is better than EIM, however the errors of the former is substantially bigger for EH modes. It is shown that modifying the condition (4) by adding two additional parameters approximation is very good. The new condition for single-mode propagation is given by the following equation:

$$u_{eff} < a + br_{eff}(1 - r_{eff}^2)^{-c} \qquad (5)$$

where: a, b and c are free parameters.

The $u(r_{sst})$ characteristics were obtained from eight sets of modal characteristics, $n_{eff}(t)$, in a way described in [5]. There was used the rigorous FMM method implemented in the FIMMWAVE 6.3 solver. Each set was corresponding with given value H. Further the $u(r_{sst})$ characteristics were approximated using (4) and (5). It was shown that condition (5) gives the smallest approximation error and that approximation coefficients a,b and c are slowly varying functions of H. This allowed to find approximation coefficients of $u(r_{sst})$ function for some arbitrary value of H belonging to the input range of H.

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Distributed curvature measurements using Φ-OTDR and a seven-core microstructured optical fiber

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In the past decades, distributed optical fiber sensors have attracted the attention of both the academic and industrial community due to their intrinsic capability of continuously monitoring a wide range of physical magnitudes along tens of kilometers of fiber, featuring thousands of sensing points. All of these sensing schemes are based on the analysis of the backscattered light within the fiber due to different scattering phenomena. A widely-employed solution to do so is the so-called Optical Time Domain Reflectometry (OTDR) [1], which analyzes the backscattered wave in a time-domain manner. Depending on the particular implementation of such approach, the application, and the scattering effect analyzed, one can find a vast range of different techniques, such as plain OTDR [1], Coherent-OTDR [2] or Brillouin-OTDR, among others [3].

In this work, we present a distributed curvature/bend sensor based on a seven-core micro-structured fiber and phase-sensitive Optical Time Domain Reflectometry (Φ-OTDR) [3], which is based on the analysis of Rayleigh scattering. When using a highly coherent laser source, the light reflected from different points in the fiber creates an interference pattern, which represents a current "fingerprint" of the fiber, remaining stable if the conditions of the fiber are unfluctuating. If there would be a change in strain or temperature at any point in the fiber, this would impose a change in the interference pattern. However, one can recover the original "status fingerprint" of the fiber by appropriately changing the frequency/wavelength of the incident light. Hence, by knowing the applied frequency shift, one can precisely measure the change in temperature and/or strain along the fiber [4].

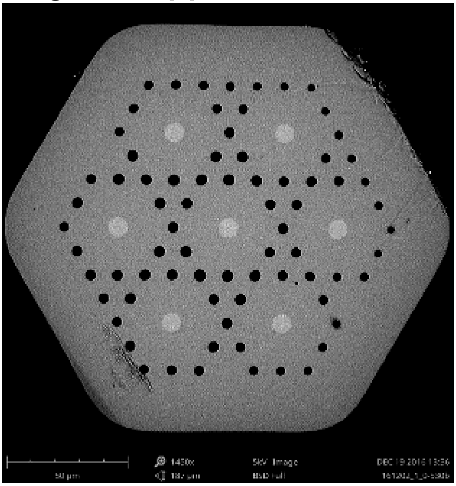

Fig. 1. Microstructured seven-core fiber. Individual cores are isolated by air holes.

Our novel approach considers using a seven-core microstructured optical fiber (Fig. 1.) for measuring curvature/bending. Thanks to detecting the strain in three lateral cores, one can calculate the 3D curvature and bending along the entire length of the fiber, based on the model presented in Fig. 2. The proposed method provides a very high sensitivity and avoids the commonly-faced issue of strain-to-temperature cross-sensitivity.

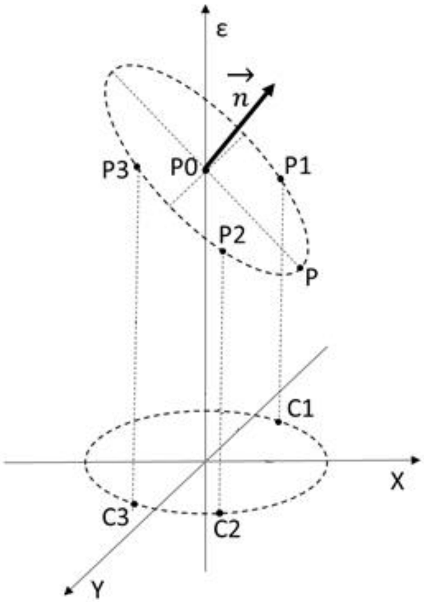

Fig. 2. Analytical drawing of the microstructured seven-core fiber subject to a non-homogeneous strain along all of its cores (i.e. bending). At the bottom, all of the cores are aligned with the plane XY at the origin. At the top, the cores are displaced and within a plane tilted a certain angle with respect to the reference position.

This presentation describes the implemented experimental setup, highlights the promising results and shows possible future applications and upgrades.

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Photonic sensors of the magnetic field using NV color centers in diamond

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We report on our recent results on optical and microwave spectroscopic studies of the NV color centers in diamond. Thanks to their paramagnetism the NV centers enable measurements of the external magnetic and/or electric fields as well as temperature and pressure. We present recent results obtained with various diamond samples (mono- and polycrystals, nanodiamonds) and discuss their possible applications.

Roadmap on liquid-crystal fiber optics and photonics

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The roadmap provides an outlook on the field of liquid-crystal fiber optics and photonics. It starts from early works with classical optical fibers modified with liquid crystals and ends up with the latest achievements in nanoparticles-enhanced photonic liquid crystal fibers. Potential applications as well advances in science and technology required to meet future challenges are shortly addressed.

Microbendings loses in optical fibers with different cross-sections

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Present development of microstructural optical fibers technology allows to design fibers with very different internal cross-sections, what often determinates their outer shape. Good examples are gaining increasing popularity telecommunication multicore microstructural optical fibers, in which necessity of "packing" multiple single mode sections enforces their external hexagonal shape. At this same time their geometrical parameters have to be compatible with standard telecommunication optical fibers.

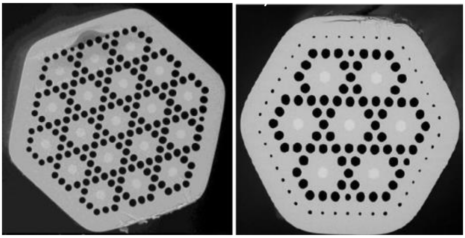

Fig. 1. Examples of microstructured multicore fibers with an outer hexagonal cross-section manufactured in Laboratory of Optical Fibers Technology, fibre: a) 19-core optical fiber, b) 7-core optical fiber.

As in the conventional optical fiber, on the surface of microstructural fibers we observe accidentally distributed microdefects. Such microdefects are source of microbendings which generates additional mechanical stresses in the fiber. This mechanism is observed on following elements in the cross-section and largely increased in the doped core. It is obvious that in fibers with a highly complicated cross-section stresses are differently transferred into the core area, so that in another manner change losses level.

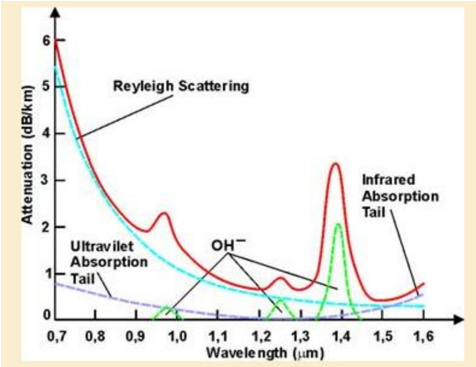

Fig. 2 Characteristic of the spectral attenuation in a typical optical fiber (red line), with components: Reyleigh scattering (blue line), absorption in the UV and IR (purple line) and attenuation peaks resulting from the presence of OH- ions (green line).

In our studies we prepared three types of microstructural preforms. The first, classic preform was made completely in MCVD machine and had a regular - circular cross-section. To produced next preform we apply a stacking method. The second preform possessed hexagonal shape of the outer clad and core. Last preform was prepared by a combine method. At the beginning we manufactured a stack structure, which was drowned at the first stage. Then we put the outer clad on the MCVD machine. This preform had a hexagonal shape of the core and circular shape of the outer clad.

From each preform we drowned two types of fibers in hard and soft outer coating. In every case geometrical parameters were corresponding to the classic single mode telecommunication fiber. At the end all fibers were measured to determinate their microbending losses level.

Detection of single adsorbing nanoparticles by plasmon assisted microscopy

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Surface Plasmon Resonance (SPR) is well-established optical biosensor technique used in the study of biomolecular interactions [1]. However, it is of limited use when it comes to a detection of biomolecules of small size and low molecular weight. The main limitations come from a large penetration depth and propagation length of the plasmon mode (SPP) what results in a relatively poor surface sensitivity and low lateral resolution. Recently several methods like phase interrogation [2], imaging with polarization contrast [3] or nanoparticle (NP) signal enhancement [4] have emerged as an upgrade of SPR-based sensors.

In this study we exploit the improvement of the technology by the detection of single NPs by means of the SPR imaging system. Adsorption of a NP leads to local enhancement of reflectivity and diffraction of SPPs excited on gold surface of SPR chip what leads to the formation of characteristic patterns in the image. In the experiment Au NPs are electrostatically trapped to the surface functionalized with thiol-based surface chemistry and the NPs of size down to 30 nm has been detected in real time and area of a few mm^2. The method has been successfully applied in the detection of oligonucleotide TP53, which is often used as a biomarker for the germ line cancer.

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High precision aligning method for fiber-coupled single-photon sources based on semiconductor quantum dots

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Development of a long distance single photon fiber-optic communication systems based on semiconductor quantum dots (QDs), which can be potentially used for quantum key distribution, is conditioned by availability of an efficient QD-to-fiber coupling methods. For optically pumped QDs, the coupling method must be effective in two directions, i.e., for pump and emission wavelengths. To enhance coupling efficiency, high quality telecom-wavelength (1.3 µm) QD structures fabricated by metal organic chemical vapor deposition (MOCVD) method were embedded in GaAs microlens and placed over 23 pairs of In(Ga)As/GaAs monolayers creating a distributed Bragg reflector (DBR) designed and optimized to enhance emission towards the fiber end face. Such semiconductor QDs structures operate in low temperature of about 30 K achievable in a portable Stirling cryostat.

In this communicate we present alignment procedures allowing for localization of the GaAs microlens containing the InGaAs QD, which were used in two different coupling systems. In the first one, light emitted by a QD is coupled via the microlens with a base diameter of about 2.6 µm to the core of a specially fabricated high numerical aperture fiber (NA=0.4, core diameter of about 2 µm) placed in a direct contact with the microlens. The second coupling system employs two collimating GRIN lenses, the high aperture one (NA=0.6) to collect the light emitted by the QD and the low aperture one (NA=0.2) to focus light on the end face of a standard single mode fiber (SMF-28). Since the semiconducto QDs are dim at room temperature, we used a light back reflected from the top surface of the semiconductor structure as a feedback signal, which makes it possible to conduct the alignment procedure in room temperature. As the direct QD-to-fiber coupling requires the use of a special highly doped fiber, a low-loss splicing technique with a standard SMF has been developed, in which an insertion loss of the order of 0.2 dB is achieved by diffusion of GeO2 in highly doped fiber at elevated temperature, creating an adiabatic transition region with gradually increasing core size. Vertical alignment of the fiber was controlled with a precision of tens of nanometers by interrogating spectral interference fringes arising due to interference of light back-reflected from the fiber end face and the sample top surface. Lateral fiber alignment was conducted by monitoring the phase shift of the interference fringes induced by a change of the cavity length while scanning the sample with the fiber end face in horizontal direction. The achieved accuracy of lateral fiber positioning over the center of the microlens was about 100 nm.

For the GRIN lens coupling system, an intensity of light back reflected from the top surface of the semiconductor substrate with microlens containing the QD was used as a feedback signal in the alignment procedure. Similarly as for the direct QD-to-fiber coupling system, a precision of the lateral positioning of the QD with respect to the high NA GRIN lens focus was about 150 nm. In the final step of both procedures, the semiconductor substrate with QD was glued to the precisely aligned fiber or the GRIN lens using a UV curable ceramic glue resistant to low temperature. Successive steps of the alignment procedures as well as the results of experiments conducted at low temperature and illustrating the performance of the proposed coupling systems will be presented.

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POSTERS ABSTRACTS

Resistive humidity sensors based on ITD transducers featured Nafion® as sensing component.

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Nafion® is well known copolimer from DuPont that is used in different gas and humidity sensors. It is also known as a material for membrane in fuelcells. We use this copolimer to make humidity sensors. Proposed sensor is build as thin layer of Nafion® copolimer dipped on a ITD transducer. The ITD transducer is made of gold layer deposited by PVD method on SiO2 layer on Si substrate.

Proposed Nafion® sensor must be maintained under constant temperature conditions (40-100°C) for proper sensing parameters. Sensor responds in change of its resistance from 100GΩ to 1MΩ due to the humidity change from 5%to 95% of RH. The sensor resistance is measured in microprocessor controlled environment to maintain faster response and regeneration of the sensor. To regenerate the sensing structure there is a necessity to reduce applied to the sensor voltage.

Investigation of optical fiber current sensor with external conversion in unstable standsTitle

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High power protection systems use signals from current transformers. Decisions about switching off some elements of the power systems are made based on these signals. In this work are presented possibilities of using optical fiber current sensors with external conversion [1] in power protection (PP) of high power protection system.

From the standpoint of PP the most important is that the secondary signal (from the current transformer) accurately reflected the primary signal (current). Fidelity of this process is characterized by signal parameters such as: shape, amplitude, phase, number of transformed harmonics of the signal [2].

The tests were performed on a measuring setup allowing simulation of real conditions using an air coil. The coil was powered from the power protection testing system OMICRON CMC 256-6. Signals were registered by a hybrid signal analyzer OMICRON DANEO 400.

Results of tests proved very good dynamic properties of the sensor allowing its application as an element of a power protection system (Fig. 1).

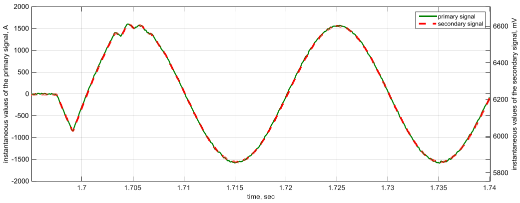

Fig. 1. Sensor response signal (red line) in case of switching on of a power supply.

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Application of polysulfones for the synthesis of polymeric blends as a new materials in optical fiber technology

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Polysulfones are amorphous, thermoplastic and transparent materials with high glass-transition temperature [1,2]. These polymers are characterized by excellent thermally stability (distribution between 400 and 550 °C regardless of the environment), flexibility, good strength and low creep. Additionally, these compounds are highly resistant to inorganic acids and bases. Therefore, polysulfones are used in specialty applications e.g. fabrication of membranes for gases and liquid separation [3].

Polysulfones have also found many biomedical applications because, they are hydrolytically very stable, so products made of these polymers withstand repeated cycles of steam sterilization and other high-temperature methods of cleaning [4,5].

Unfortunately, polysulfones are soluble in some solvents and are affected by atmospheric conditions. Thus, the latest experiments are focusing on the use of polysulfone as an additive to modify other polymers properties, particularly related to the increase of thermal and chemical resistance [6].

An example of such materials are *polymer blends*. In their structure at least two polymers (or polymer-monomer) are blended (mixed) together to create a new polymer systems with different physical properties. In many cases, they exhibit new, exceptional properties, such as those required for specific applications for them [7].

In this work, the synthesis of in situ polymer blends is presented. In the first stage, bisphenol A polysulfone (PSU), (synthesized elsewhere, $M_n \approx 8000$) was dissolved in N-vinyl-2-pyrrolidone (NVP) during 24 h at room temperature (15 % w/w).

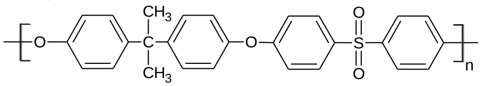

Fig. 1. The chemical structure of bisphenol A polysulfone

Next, the precise amount of PSU (as a solution in NVP) and bisphenol A glycerol diacrylate were transferred to the flask and mixed together. Then, of 2,2-dimethoxy-2-phenylaceto-phenone (Irqacure, 2 % wt.) as a UV-initiator was added. Finally, the content of the flask was poured into a Petri dish, placed under a UV lamp and polymerized with the use of UV light for 30 minutes.

In this method, five polymer blends were synthesized with different amounts of PSU: 0%, 2.5%, 5%, 7.5%, 10% wt.

The detailed information about synthesis are presented in Table 1.

All blends were analyzed by means of thermogravimetric (TG and DTG) and DSC analyses. Their hardness were investigated by Shore method. The effect of polysulfone amount on their mechanical and thermal properties was determined.

Figure 2 present photos of the synthesized polymeric blends.

I II III IV V

Fig. 2 Photos of polymeric blends after UV-polymerization

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Tab. 1. Amounts of all components used in the synthesis of polymeric blends.

Sample number	**I**	**II**	**III**	**IV**	**V**
% wt. PSU	0	2.5	5	7.5	10
PSU [g]	0	0.25	0.5	1.5	1
NVP [g]	5	4.75	4.5	4.25	4
Bisphenol A glycerol diacrylate [g]	5	5	5	5	5
Irqacure [g]	0.2	0.2	0.2	0.2	0.2

Single and multimode optical fibers with numerical aperture larger than 0.3

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In recent years there has been observed growing interest in technology of special optical fiber. In particular, are being developed technologies of optical fibers with exotic shapes of cross-sections. They also include optical fibers in which the distribution of the refractive index in the core is significantly different than in typical telecommunication optical fibers. For this optical fibers is required to develop a special technique for preform fabrication. This is especially important if you need to add large quantities of GeO_2 admixture to the glass for fabrication of optical fibers with large NA. In this case, due to the large differences in coefficients of thermal expansion at the core-cladding boundary, high stresses are generated which in many cases lead to destruction of the preform.

This paper presents the special MCVD process allow fabrication of optical fibers with numerical aperture higher than 0.3.

LC stabilization for planar devices

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We present a new way of constructing and a different approach in controlling planar devices based on liquid crystals. This method utilizes LC material enriched with monomer and a waveguide is created in the LC cell thanks to the photo-polymerization process allowing for LC molecules to be "frozen" in desired state (e.g. planar or homeotropic)[1]. For this purpose LC molecules are reoriented (e.g. by external electric field) and the selected area is irradiated with UV light to polymerize a monomer and to "lock" a stable orientation. LC molecules in the remaining area go back to their original orientation state when reorienting factor is disabled. There are several advantages of this technique when compared to other methods for creation of controllable waveguides in LC material, which are: low optical power of the light beam to be transmitted (no need to use soliton to create a waveguide) [2], orienting layers can be uniform in a whole area of the LC cell [3], complex structures might be created by selective irradiation. The main difficulty is a photo-polymerization process and uniformity of the liquid crystalline material itself. In this communication we present two preparation methods of LC material and results of inducing stable distinct orientations of liquid crystalline molecules within the LC cell.

The basic application of this method is presented in Fig. 1, where 4 main steps are shown. The idea behind using LC with monomer in planar devices is creating a desired structure (special distribution of LC orientation) by photo-polymerization of the selected area with a specified LC orientation. When such procedure is completed only not polymerized LC can be reoriented, while the whole polymerized region has LC orientation fixed indefinitely.

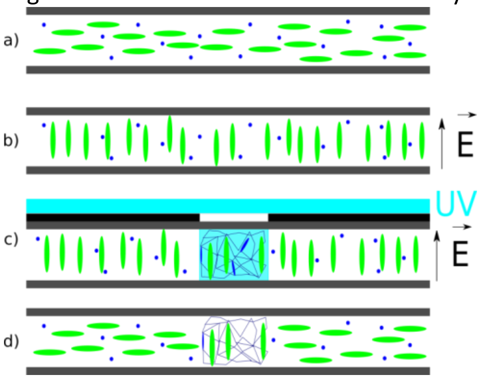

Fig. 1. A scheme of the proposed planar device preparation procedure. Four main steps of this method include: a) preparation of LC cell filled with LC enriched with monomer, b) reorientation of LC molecules, c) UV induced polymerization of selected area, d) disabling external electric field

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The influence of the oxidation method on the properties of graphite oxide and graphene oxide

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Graphene oxide is the material which is using as a sensor layer in gas sensor. In this paper we present the differences in the properties of graphite oxide and graphene oxide (obtained directly from graphite oxide by thermal reduction process). A simplified scheme of preparation of graphite oxide and graphene oxide was shown in the Fig. 1.

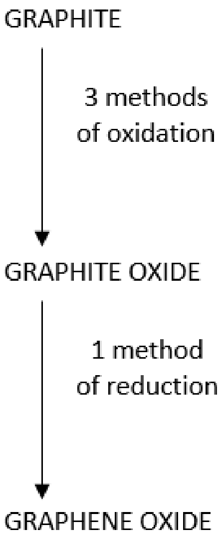

Fig. 1. A scheme of preparation of graphite oxide and grapheme oxide

All graphite oxides were prepared using various methods of oxidation although the basic material (graphite) was the same in all cases. The results of the measurements show that the way of preparation impacts on elementary composition (carbon, oxygen, hydrogen, sulphur and nitrogen), the types of bonds in the structures or interplanar distances. In addition, the results will be supplemented by data obtained using Scanning Electron Microscopy (Fig 2). All presented results show how important is the process of preparation of this materials.

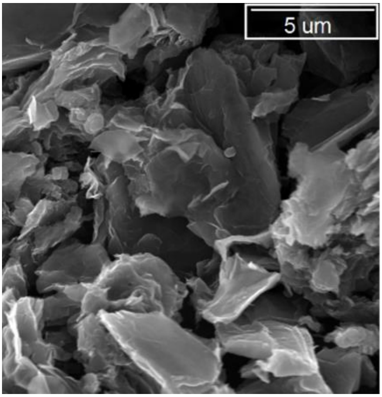

Fig. 2. A image of graphite oxide obtained using Scanning Electron Microscopy

Enhanced fluorescence of NV color centre nanodiamond pretreated by sonication

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The color center may couple an electron to become negatively charged (SiV– or NV–) with spin S=1. The nonzero spin is responsible for paramagnetic properties of the center. The vacancies may be created in diamond powders or in a bulk CVD or HTHP diamond. Due to photo-conversion between the charged and neutral forms of the center and its light-power dependence, the NV centers are very attractive for applications in various quantum devices. Nitrogen-vacancy (NV) centers are the most widely studied crystallographic defect in the diamond lattice since their presence causes strong and stable fluorescence. The negative charge state of the defect (NV-) is especially desired because of its potential for quantum information processing.

In this study, fluorescent suspensions of diamond particles have been produced by microbead assisted ultrasonic disintegration of commercially obtained diamond powder containing NV color centers[1]. The sample characterization was be based on optical (absorption, emission, Raman) and microwave spectroscopy with high spatial (confocal, ~µm3) and spectral (sub-Hz) resolution. The measurements were performed using a technique of optical detection of magnetic resonance (ODMR) improved by development of the microwave hole burning technique[2]. Moreover, thin layer of the diamond particles has been deposited on a silicon substrate and examined using scanning electron microscopy (SEM).

The development and applications of quantum technologies and nonlinear spectroscopy for studies of color centers in diamonds is very fast. Thanks to the stable crystallographic and electron structure of diamond, NV-color centers exhibit very stable electronic spectra, resistant to various perturbations. Their excellent optical and spin properties (paramagnetism) allow one to use different resonance and spintronic methods of and enable precision metrology.

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Study of physico-chemical properties of the new potential optical polymers based on 2-hydroxyethyl methacrylate

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2-Hydroxyethyl methacrylate (HEMA) belongs to the group of hydrophobic monomers which found widespread interest especially in biomedical applications. The high popularity of this monomer and polymer p(HEMA) has been observed since the 1960s, when it was first used to obtain contact lenses [1].

Due to presence in its structure hydroxyl group, HEMA is a one of the main monomer in the synthesis of hydrogels [2-3].

Lin at al. reported about “smart” polymer hydrogels. These materials were used to convert miniature pressure sensors into novel chemo-mechanical sensors [3]. Tauer at al. presented stable latex particles in the nanometer size range, synthesized by homopolymerization reaction of HEMA [4].

The high transparency of p(HEMA) makes it a very interesting compound for the synthesis of optical polymers.

In this work synthesis, optymalization and study of physico-chemical properties of the new functionalized copolymers are presented.

The bulk copolymers obtained in this study consisted of HEMA and 2,4-dichlorophenyl methacrylate (2,4ClPh-M). 2,4ClPh-M was obtained according to procedure presented in Ref. 5 (Figure 1). As a polymerization initiator (α,α’-azoiso-bis-butyronitrile) was used. For all compositions, a different weight ratio of HEMA to 2,4ClPh-M (0-50 % w/w) was applied. After the monomers have dissolved, the initiator (0.3%) was added, and the compositions were placed into the glass forms.

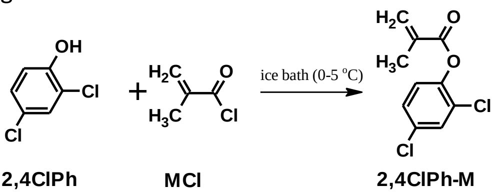

Fig. 1. Scheme of synthesis of 2,4ClPh-M

Next, the forms were moved into a water bath for 12 h at 55 °C, for 4 h at 65 °C and for 4 h for 80 °C, and finally into a heating chamber for 4 hours at 90 °C in order to complete the crosslinking reaction.

Figure 2 presents the chemical structure of monomers used in reaction polymerization.

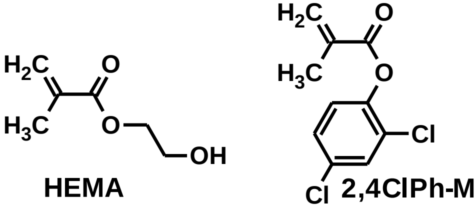

Fig. 2. Chemical structure of monomers

In Table 2 the experimental parameters of all copolymerization reactions are presented . The structure of new materials was confirmed by spectroscopic methods (ATR-FTIR). The thermal stability of the obtained copolymers was studied by thermogravimetric analysis (TG/DTG).

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Tab. 1. Experimental parameters of the synthesis

Copolymers	HEMA [g]	2,4ClPh-M [% w/w]	AIBN [% w/w]
HEMA-homo	2	0	0.3
HEMA-2,4ClPh-M1	2	0.25	0.3
HEMA-2,4ClPh-M2	2	0.50	0.3
HEMA-2,4ClPh-M3	2	0.75	0.3
HEMA-2,4ClPh-M4	2	1	0.3
HEMA-2,4ClPh-M5	2	2	0.3
HEMA-2,4ClPh-M6	2	5	0.3
HEMA-2,4ClPh-M7	2	10	0.3
HEMA-2,4ClPh-M8	2	20	0.3
HEMA-2,4ClPh-M9	2	50	0.3

Coordination complexes useful for active polymers – theoretical approach

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Polymer materials, doped by rare-earth elements, are of crucial importance to optoelectronics and are widely used in soli-state lasers and fiber amplifiers. Trivalent RE ions can be used for many photonics applications. Erbium (Er), neodymium (Nd), praseodymium (Pr) ions are well known, because are used in telecommunications systems. In addition to those mentioned, many others are also tested. Among many reasons to be interested in rare-earth elements the main interest arise from their potential wide range of applications including medicine, energy storage or automotive [1-2].

The main problem in working with rare-earth elements is that beyond critical concentrations their ions tend to form precipitated in most solid hosts. Therefore, the introduction of rare earth elements coordinated by organic compounds can prevent their aggregation. In addition, the appropriate coordinator can increase the antenna effect. Before conducting a series of experiments, it is worth to perform theoretical calculations that are able to visualize how a given coordinate will affect the properties of the rare earth element.

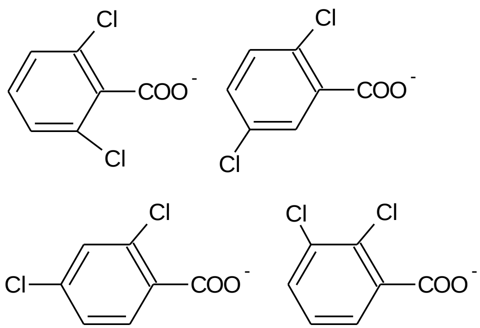

Figure 1 The chemical structure of theoretically calculated coordinates.

Paper presents the calculated UV-VIS spectra of coordinates presented on fig. 1.

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Theoretical investigation of properties of InAsSb mid-wave infrared detectors

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In this work we present the theoretical investigation of the electrical and optical properties of high operating temperature (HOT) mid-wavelength infrared detectors (5 µm at 230 K) based on InAsSb/AlSb heterostructure [1].

Generally, barrier detector (nBn) proposed by A.M. White consists of a MWIR-absorbing *n*-type semiconductor, large band gap undoped barrier, and a second thin *n*-type cap layer. The primary advantage of the nBn design is the suppression of the dark current due to Shockley-Read-Hall (SRH) generation recombination (GR) processes and surface leakage contribution [2–7].

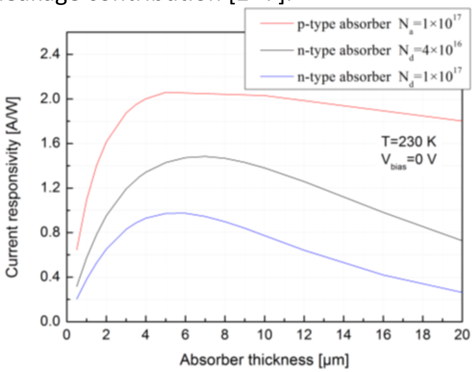

Fig. 1. Calculated current responsivity of $InAs_{0.81}Sb_{0.19}$ detectors versus absorber thickness at zero bias operation at 230 K

In this work the performance comparison of barrier detectors with different type of absorbing layers: *n*-type doped and *p*-type doped is presented. The barrier structure was simulated by commercially available software APSYS.

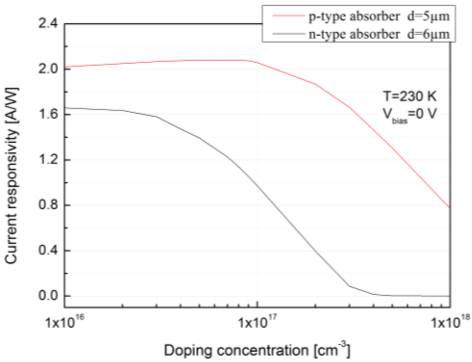

Fig. 2. Calculated current responsivity of $InAs_{0.81}Sb_{0.19}$ detectors as a function of doping concentration at zero bias operation at 230 K

We report on the dependence of the calculated current responsivity on the active layer thickness for a different type (Fig. 1) and doping concentration for optimal absorber thickness (Fig. 2). The results show that the device performance depends on absorber layer type, absorber thickness and doping concentration. Devices with a *p*-type absorber show the highest values of current responsivity, up to 2.0 A/W for 5 µm absorber layer. The detector with *n*-type doped absorber requires use of thicker active layer. For devices with a *p*-type absorbing layer, optimal parameters are reached using doping concentration in the range of 10^{16} – 10^{17} cm^{-3}. In devices with *n*-type active layer, the maximum current responsivity is reached for Si doping concentration up to 2×10^{16} cm^{-3}. Increasing doping leads to significant deterioration of device performances.

Acknowledgements:
The authors would like to acknowledge the support by **The National Centre for Research and Development (Poland) – the grant no. POIR.04.01.04-00-0027/16.**

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The use of laser printers for obtaining masks for the photolithography process

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For several decades, microfluidics and related fields have been dynamically developing. Biologically, microfluidics seems to be particularly important as most processes involve micro-flow, from transport through cell walls, through oxygen diffusion into the lungs, to blood flow in the capillaries. Micro-scale analysis has many advantages, both from an analytical and economic point of view. One of the biggest challenges of miniaturization is the chip microstructures fabrication. The SU-8 mold preparation is known as the most used and expensive technique in microfluidic system development. The SU-8 technique is very sensitive to the preparation parameters, therefore those protocols involve many sensitive preparation steps. The processing of SU-8 is a challenging task that involves the crucial step of photomasks fabrication. The standard chrome photomasks are difficult to produce and therefore very expensive. For the implementation of structures with a size of several dozen micrometres instead of expensive chrome photomasks, in some cases patterns printed on a typical film by special type of laser printers can be used. This work will compare chrome masks and masks made by high quality laser printers. The structures obtained by the less expensive masks printed on the film will also be presented.

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ALD films in fiber-optics sensors

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The fiber-optic sensors based on the phenomenon of light interference are used in broad range of application in research and industry alike [1]. Among those Fabry-Perot interferometers are one of the most interesting as they can offer relatively simple and compact setup as well as the excellent metrological performance. The use of low-power light sources in this type of sensors allows for safe operation in hazardous areas and measurements of fragile biochemical samples. The most commonly used construction of such sensors is an interferometer where the cavity-fiber interface act as a mirror of the reflectance described by Fresnel equations. Such setup offers flexible setup and uncomplicated production process. However, a drawback of the solution is that reflection at the cavity boundary depends on contrast of refractive indices of the fiber and the cavity material. The device is unable to operate when the refractive index of the cavity is the same as that of the fiber (e.g. 1.467 for SMF28) and visibility of interference signal is severely diminished as that values are close.

Presented study shows simple and innovative solution for increasing and adjusting the operating range of fiber-optic Fabry-Perot interferometer via application of thin metal-oxides films [2,3]. In presented work the requirements for film parameters were investigated. The selection of the applied material and thickness of the film were evaluated through numerical simulation. The metrological performance of the interferometer with chosen ALD thin films was also assessed in series of experimental measurements.

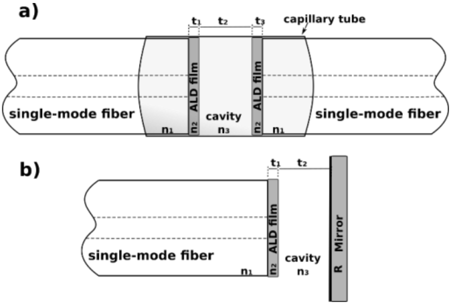

Fig. 1. Proposed construction of ALD-enhanced fiber-optic Fabry-Perot interferometer: a) in-fiber configuration, b) with extrinsic mirror.

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LUMINESCENCE SPECTROSCOPY DIAGNOSIS SYSTEM FOR NON-INVASIVE IN VIVO SKIN CANCER RESEARCH

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Nowadays there are many methods, which are used for cancer diagnosis. According on the type of tissue, scientist and doctors can use one the most effective methods, like biopsy, mammography and many else, but all of these methods are invasive to the patient being examined. Therefore researchers are focusing on the search for non-invasive methods for early diagnosis of cancer. Through the use of visible light, we are able to stimulate the cells to luminescence, which is based on naturally occurring photosensitizers e.g. HpD (hematoporphyrin derivatives), which occurs in human blood. The levels of HpD in tumor tissues are increased due to extensive network of blood vessels in cancerous tissue, which gives noticeable differences in comparison to healthy tissues. The spectral analysis shows, that tumor tissue (by the presence of HpD), when excited by near UV light (λ=405 nm), gives a specific peaks of emitted spectrum in a different range (620 to 680 nm) of visible light than healthy tissues (500 to 550 nm). In addition, differences in luminescence intensity levels are noticed in emitted spectra between different types of skin cancer (e.g. SCC, BCC).

In this paper we present the design of skin cancer optical diagnostic system, which use a non-invasive optical method of detection, that can be used to image of malignancies based on luminescence spectroscopy analysis of given tissues. Through a comparative analysis of red and green peaks in given spectra, the detection of cancerous tissues can be increased. Proposed method and given luminescence spectra (Pic. 1.) shows that this system can be used, as one of the criteria for skin cancer diagnosis.

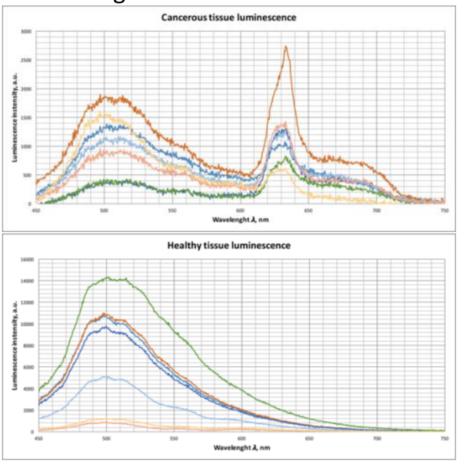

Fig. 1. Luminescence spectra for cancerous and healthy tissue.

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Spectroscopic ellipsometry measurements and nanocharacterization of conducting graft copolymers thin films

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Many different conductive polymers have attracted the attention of optoelectronics engineers and interdisciplinary scientists for its specific properties, which are desired in micro optoelectronics devices, such as gas sensors and photovoltaics. Polytiophene, polypyrrole and polyaniline are nowadays widely used on optoelectronics market, but due to its poor processability (solubility, durability, adhesion) a lot of researchers are focused in finding polymers with better processability. Polymers that are highly processable and soluable can be obtained by grafting synthetic polymers, which also increases their stability [1]. Moreover, this novel comb-like graft copolymer can be also used as a gas sensing layer [2] for gas sensing structures (e.g. polymer thin film transistors).

This work presents an an investigation on conductive graft comb copolymer polymethylsiloxane (PMS) with poly(3-hexyltiophene) (P3HT) and poly(ethylene) glycol as functional side groups [3] and its mixtures with different nanomaterials like graphite oxide or reduced graphite oxide. Morphology and optical properties, like sample roughness, graphite oxide particles distribution, optical transmittance were measured of obtained thin films deposited on glass substrate using spin and drop coating method. Samples were also measured by spectroscopic ellipsometry under the influence of a gas atmosphere.

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Optical fiber sensor with nitrogen-doped diamond film

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Diamond materials are highly appreciated because of their unique mechanical and chemical properties. This makes them a very good material for sensor applications. Hence, we present the use of nitrogen-doped diamond (NDD) film as a reflective layer in a Fabry-Pérot interferometer working in a reflective mode. This solution introduces many advantages to the sensor: a very good signal visibility value, better mechanical resistance of the mirror, a reduction of required sample amount and an opportunity to perform biomedical measurements.

The measurement set-up consisted of a light source with a central wavelength of $\lambda = 1550$ nm, optical spectrum analyzer (OSA) and a telecommunication coupler. All devices were connected by single-mode commercially available fiber optics. This configuration was successfully used for measurements of hemoglobin concentration. The developed sensor works with a linear characteristics. Correlation coefficient (R2) is equal to 0,988. The maximum value of this parameter is equal to 1 which means the perfect data fit. This indicates that data are very well fitted and thus, that the developed sensor works properly.

Field application of optical fiber sensor for rotation and tilt registration

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Rotational Semiology is a dynamic developing scientific branch which deals with a wide range of interests including seismological and engineering aspects of rotational ground motions. In order to expand the knowledge about rotational effects and their influence on constructions as well as their contribution to the seismic waves one needs to apply sensors which will fulfilled all requirements for research regarding Rotational Seismology [1, 2].

In this paper we present optical fibre interferometric sensor which is based on the Sagnac interferometer [3,4]. The Sagnac effect makes it totally insensitive to linear motion as well as enables to detect rotation directly. FOSREM's (Fibre-Optic system for rotational events & phenomena monitoring) developed electronic system enables to control the system remotely via Internet using special designed software. Moreover, the optimized parameters of an optical part and integration with the electronic system ensure high theoretical sensitivity equals $2\cdot10^{-8}$ rad/s/√Hz. The obtained accuracy is in the range from $3\cdot10^{-8}$ to $1.6\cdot10^{-6}$ rad/s in detection bandpass from 2.56 Hz to 328.12 Hz. The applied mechanical housing printed on the 3D Printer MakerBot guarantees mechanical resistance which was confirmed during vibration test on a orbital shaker. The thermal stability of this sensor has been verified in the climatic chamber, whereas the obtained signal instability was equaled to 0,03 %/^{o}C.

The two FOSREMs have been installed in Książ seismological observatory (Fig.1). This area is prone to seismic events due to a mining activity. The presented in this paper first data recorded in seismological observatory indicates that FOSREM is appropriate system for Rotational Seismology.

Fig. 1. Two FOSREMs installed in seismological observatory in Książ, Poland.

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Investigation of physicochemical properties of hybrid combcopolymers graft P3HT/transverse metal oxides (TMO) composites

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Hybrid comb copolymer/inorganic TMO nanoparticle blended photonic and electronic active structures are reported. The subject of the work are receptor structures, which are designed and prepared on the base of functional grafted comb-like copolymer with the polysiloxane (PMS) core and functional poly-3-hexylotiophen (P3HT) side blocks. PMS graft P3HT as organic hole transport material has been used in this study.

Transition metal oxides (TMOs) have been found to be very good p-type dopants for hole transport materials. The penetration of TMOs such as MoO_3 or WO_3 into the organic layers enhances hole-transport characteristics by forming charge transfer states [1, 2].The effects of TMO nanoparticles on morphological and compositional features, electronic and NO_2 and NH_3 gas sensing properties of PMS-graft-P3HT-graft-PEG/TMO thin film were investigated. The results showed that hybrid blended thin film sensor exhibited considerable improvement of sensing response and reversibility compared to the pure copolymer graft-P3HT film sensor.

Acknowledgements

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Long term stability study of InAsSb mid-wave infrared HOT detectors passivated through two step passivation technique

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The quality of the surface have a strong influence on detector performance. Unfortunately during the processing of the $A^{III}B^{V}$ heteroepitaxial structures the sidewalls of mesa are exposed to aggressive environment and ambient atmosphere, leading to the formation of thin native antimony, indium and arsenic oxides layer [1-3].

Some of those oxides are conductive in nature, creating a surface leakage path which contribute to the dark current`s increase. Moreover, charged ions from the atmosphere might be incorporated in the newly formed oxide layer which adds to the surface leakage current through band bending near surface. Because of nonstechiometric composition and ability of react with air contaminates the additional interfacial states can be created. Interface states can trap carriers thereby disrupting normal $A^{III}B^{V}$ device operation [4, 5].

Optimum mesa surface passivation become an absolute necessity to enhance the performance of $A^{III}B^{V}$ photodiodes. The purpose of passivation is to saturate the active surface states (dangling bonds) which were arisen during the mesa etching.

In present work we would like to demonstrate the influence of different anodic films growth in electrochemical cell and encapsulation layer on dark current densities of mid wave infrared HOT detectors after long term stability studies.

Acknowledgements:

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Signal correlation methods for photodetector noise characterization

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We present the performance comparison of two correlation methods [1], [2] for photodetector noise determination. These methods apply the correlation of a time series with itself (autocorrelation method - *ACM*) and the similarity between two time series (cross-correlation method with two-channel signal readout - *CCM*). Both correlations were analyzed using designed simulator (MATLAB/Simulink). The simulation results indicated some advantages of noise measurement using *CCM*. It made it possible to design a special system consisted of electronic block of two-channel signal readout (constructed based on transimpedance preamps (*TIA*) with AD797 opamps) and signal processing unit (data acquisition card with the prepared software). The verification of the system performances for noise measurement was made using some low-noise resistors with well-defined resistances. In comparison to *ACM*, the applied cross-correlation method provided better results in the case of 1/f noise spectral range and resistors above 1kΩ. It results from e.g. suppression of opamp current noise (for AD797 2pA/√Hz) and voltage noise of TIA feedback resistors. Finally, the system was also used to measure noise spectral density of low-impedance MCT detector.

Acknowledgments:

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Design and characterization of integrated transceivers for fiber-optic access systems

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In recent years fiber-optic telecommunication systems experienced significant progress, driven by a constantly growing need for broadband telecommunication services, such as 3D and HD TV, video-on-demand, video-conferencing and others. One of the most promising solutions which enable meeting the market's demands is to apply wavelength division multiplexing (WDM) techniques to optical access systems.

Deployment of photonic integrated circuits (PICs) in access systems offers attractive features of compact size, low power consumption and high reliability of the modules, together with a key advantage of optimized manufacturing costs. Considering the silicon and indium phosphide technology platforms, the latter was chosen since it supports light propagation, amplification, detection and fast phase modulation in a monolithic chip. The InP platform nowadays provides basic building blocks like deeply and shallow etched waveguides, semiconductor optical amplifiers (SOA), electro-optic phase modulators, PIN photodiodes and DBR gratings. These enable constructing versatile photonic devices.

This work is focused on technical aspects of novel integrated multichannel transceivers for application in fiber-optic access systems. We present and discuss several InP-based WDM transmitters and receivers, designed at Eastern Europe Design Hub of Warsaw University of Technology and manufactured in generic technology by the SMART Photonics foundry. The designed circuits allow to transmit/receive information using four wavelength channels compliant with the ITU grid, making use of a set of DBR lasers followed by Mach-Zehnder modulators. Arrayed wavelength gratings (AWG) provide multiplexing/demultiplexing functionality, while an array of PIN photodiodes enables receiving the transmitted signals. Fig. 1. presents the designed mask layouts of the two exemplary transceivers, the devices have dimensions of 4.6 mm × 4.0 mm.

All of the designed and manufactured chips were carefully characterized with respect of their optical properties, which enabled discussion of their potential deployment in commercial optical access systems.

The designed chip cells include also test structures. These are Bragg gratings with different length and pitch, lasers with a different amplifier length, lasers with a booster SOA, and Mach-Zehnder amplitude modulators with different length of the electro-optic phase shifters.

The measurement results obtained both for the transceivers and test structures provided information about compliance of their performance with respect of the design parameters. This, in turn, enabled designing optimized circuits and further development of the transceivers.

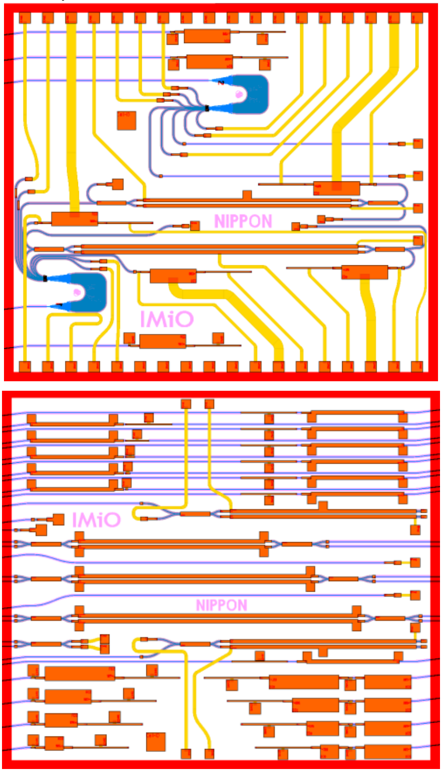

Fig. 1. Mask layouts of 4-channel WDM-PON transceivers for optical line terminal (top) and optical network unit (bottom).

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Thermal and optical study of the new methacrylic copolymers useful in POF technology

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The primary monomer used in polymer optical fiber technology (POF) is methyl methacrylate (MMA). This organic compound is a methyl ester of methacrylic acid. MMA is a main monomer of poly(methyl methacrylate) (PMMA). Among other derivatives of meth/acrylic acid, which also found wide industrial applications, are can included: butyl met/acrylate, 2-hydroxyethyl methacrylate, ethylhexyl met/acrylate, ethylene glicol dimethacrylate etc.

PMMA is a transparent thermoplastic, therefore is often used as a lightweight and safe alternative to glass [1-3]. Due to impurities and intrinsic absorption caused by C-H bonds, PMMA is not favorable material according to silica in long distance applications. To decrease the C–H absorption losses, substituting hydrogen with heavier atoms such as deuterium or fluorine is an effective method. There have been previous reports on low-loss POFs consisting of perdeuterated PMMA (PMMA-d_8) and perfluorinated polymer (CYTOP®) [3-5].

This study the copolymerization and physico-chemical properties of the copolymers of commercial methacrylic esters: butyl acrylate (AB), ethylhexyl acrylate (AEH) or methyl methacrylate (MMA) with 2,2,2-trifluoroethyl methacrylate (TFEMA) used as a dopant are presented [6-8].

Copolymerization of TFEMA with AB, AEH and MMA was carried out in glass form in a water bath. 0.5 % (w/w) α,α'-azoiso-bis-butyronitrile (AIBN) was used as an initiator. The composition mass ratios and amount of TFEMA and MMA used for copolymerization are given in Table 1. Analogous amounts of AB and AEH as for MMA were used for bulk polymerization. Homopolymers of MMA, AB and AEH were obtained under the same conditions. Figure 1 presented the structure of dopant - 2,2,2-trifluoroethyl methacrylate (TFEMA).

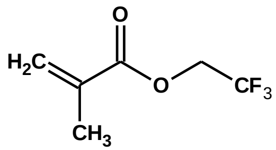

Fig. 1. The structure of 2,2,2-trifluoroethyl methacrylate (TFEMA)

Chemical structures of the copolymers were confirmed by attenuated total reflection–Fourier transform infrared (ATR/FT-IR) spectroscopy. Exemplary MMA copolymers are shown in Figure 2. Thermal properties of the synthesized materials were investigated by means DSC and TG/DTG analyses. The influence of fluorinated dopant on the thermal and optical properties of the copolymers will be evaluated in detail.

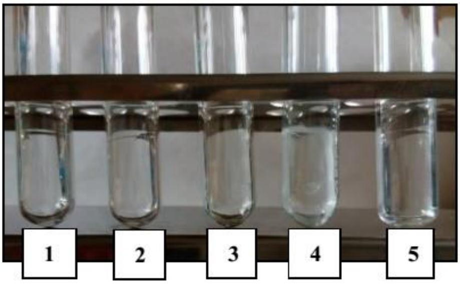

Fig. 2. Images of TFEMA-MMA copolymers (**1**- MMA-homo; **2**- MMA0.5%TFEMA; **3**- MMA0.75%TFEMA; **4**- MMA1%TFEMA; **5**- MMA2%TFEMA)

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Table 1. The amount of TFEMA and MMA used for copolymerization

Dopant	Monomer	Rates of dopant (% wt.)	Amount of dopant /g	Amount of monomer /g
1		0	0	0
2		0.50	0.01	2
3 TFEMA	MMA	0.75	0.015	2
4		1	0.02	2
5		2	0.04	2

Testing the SteamVR trackers operation correctness with the OptiTrack system

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SteamVR technology has become very popular in virtual reality applications. The most common example of its use are the HTC VIVE controllers. Applications, however, are not limited to controllers held directly in the hands. SteamVR trackers can also be placed on real objects that have their representation in the virtual world.

Due to the specificity of use, it is necessary to choose the optimal part of the object to which the tracker will be attached. However, it is not always possible to obtain satisfactory results with this method. An alternative solution is a dedicated tracker project sometimes with an original detector constellation. Regardless of which path the trackers and VR applications designers will follow, it is indispensable to be able to verify the correct operation of the system: object and associated tracker, in a laboratory condition.

The experimental measuring stand and the testing method has been developed based on the OptiTrack motion tracking system. The initial positive results of such a measurement stand were obtained. The tests carried out concerned both the production models and the own design tracker construction placed on various shapes test objects.

Virtual 3D object manipulation with graphics tags and AR technology.

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In the real world, we can easily manipulate small objects that we hold in our hands. We can see them carefully from each side, look at the details by bringing them close to the eyes, etc. And what if the object has microscopic dimensions or on the contrary - it is very large. In this case, the matter is not so simple.

However, if we have digital models of such objects, the above problems can be solved with the use of virtual technologies. An interesting example may be the use of augmented reality for this purpose and graphic tags that act as triggers for the visualization process. The process of determining spatial parameters is initiated by the results of image processing and analysis.

Tests of such a solution were carried out using the optical see-through display. Initial positioning and orientation of the object relative to the observer is carried out by analyzing the video stream coming from the integrated camera. Tests of such a solution were carried out using the optical see-through display. Initial positioning and orientation of the object relative to the observer is carried out by analyzing the video stream coming from the integrated camera.

Influence of near UV irradiation on ZnO nanomaterials gas sensing properties

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In this work resistance gas sensors based on different zinc oxide nanostructures are investigated. The nanostructures with different morphologies and grain sizes were obtained using relatively inexpensive and easy chemical methods. Sensors were prepared using drop-coating method on IDT transducers (Au electrodes on Si/SiO_2 substrate).

Sensor response to low concentrations of NO_2 were tested at different operating temperatures (room temperature RT = 23 ˚C, 100˚C and 200˚C) and under different lighting conditions (dark conditions and UV irradiation – LED λ = 390 nm) are compared and discussed.

Research showed that the impact of near UV irradiation and temperature on ZnO nanostructures gas sensing properties dependents on their morphology. Results proves that sensors can operate at room temperature when it is activated by UV light. Sensors 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 relatively high, however, operates slow (response times at the level of hundreds of seconds). For properly chosen morphology of the ZnO nanostructure combination of elevated temperature and UV irradiation provides faster responses and regeneration processes. The work is the continuation of our previous works [1–3] where other ZnO nanostructures were investigated.

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Problems of Quantum Fields Theory QFT within the Standard Model of fundamental particles

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Quantum Fields Theory it is a modern physical theory explaining the basic interactions in nature. QFT is an extension of the classical quantum mechanics, ensuring its compliance with the special theory of relativity.

QFT, in contrast to the original relativistic quantum mechanics developed by P. Dirac, takes into account phenomena in which the number of fundamental particles changes over time: they take place creations and annihilation of pairs, as well as their absorption.

The author puts forward a hypothesis about the electrical non-neutrality of the Universe. The lack of electrical neutrality is the result of the formation of quarks and leptons in different eras of the early Universe, under different physical conditions. The electrical non-neutrality of the Universe is manifested by the existence of an average volume of charge density, in the order of: an elementary charge per many km3. Due to the fact that the lack of electric neutrality of the Universe is not taken into account in current researches, its size is most likely slightly different (smaller) than the currently estimated sizes.

The study also analyzes the problem of the observed acceleration in the expansion of the Universe in the aspect of the lack of its electrical neutrality.

Intense mid-infrared luminescence in bismuth-germanate glass co-doped with lanthanide ions

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Nowadays, studies focused on new materials for mid-infrared radiation generation are being conducted in scientific centres around the world. Particularly interesting range is located near 3 µm, where exists strong absorption band originating from hydroxide ions, due to the potential and practical applications in civilian or military fields, including eye-safe laser radar, medical microsurgery, remote sensing or atmosphere pollution monitoring [1,2]. Among amorphous materials, non-oxide glasses are mostly used for mid-infrared emission because of the low maximum phonon energy (e.g. 590 cm^{-1} and 350 cm^{-1} in fluoride and chalcogenide glasses [3], respectively). Low lattice vibrations are beneficial in terms of reduced non-radiative relaxation phenomenon, which is competitive processes to quantum radiative transition [4,5]. Despite of good structural and spectroscopic properties for mid-infrared emission, non-oxide glasses are characterized by poor chemical durability and mechanical strength as well as low thermal stability, which make it difficult to draw them into optical fibres and limits further application in high power fiber laser systems [6-8].

On the other hand, glasses based on heavy metal oxides are characterized with relatively low phonon energy among oxide materials, which is favourable in terms of generating radiation in mid-IR region, and possess advantageous properties like high thermal stability parameter, high refractive index, good chemical and mechanical durability [9,10].

In this work we focused on possibility of obtaining intense emission in the mid-infrared spectral range. The bismuth-germanate oxide glasses have been co-doped with erbium, holmium and ytterbium ions. Glasses have been synthesized in terms of high mid-infrared transmittance and low hydroxides content using low vacuum atmosphere (50 – 70 mBar). In order to maximize the mid-infrared luminescence, optimization of the rare earth ions content has been conducted.

The highest emission have been observed in sample co-doped with molar concentration 0.1 Ho_2O_3 / 0.7 Er_2O_3 / 0.25 Yb_2O_3 %mol under 980 nm laser diode excitation. Moreover, rare earth ions system enables to observe broadband mid-infrared luminescence in the range of 2.7 – 2.9 µm due to the energy transfer phenomena. Furthermore, high thermal stability and totally amorphous structure are favourable from the perspective of further material processing into photonic structures.

Acknowledgements

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Hybrid radio-optical data link

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The paper presents a project of the wireless data link (*LasBITer*) consisted of two transmission channels. The link uses radio (RF) and optical (FSO) radiation to transmit signals. Such configuration provides better communication performances, e.g. data rate, availability, security level, immunity to intentional interference, etc.

Nowadays, some RF/FSO hybrid constructions were described and practically applied. However, in these constructions, optical link operated at the NIR or SWIR wavelength ranges were used. Application of LWIR-quantum cascade lasers (QCLs) and mercury cadmium telluride (MCT) detectors in the *LasBITer* construction provide to obtain better data ranges in the case of worse weather. The preliminary tests of this device confirmed its full functionality as a hybrid system. The tests were performed at the optical link distance of 200 m with data rate of 5 MB/s. Basing on parameters of FSO key elements, the estimated data link range was 1.2 km with BER=10^{-7}.

During further work, both data rate and range of *LasBITer* will be improved by the development of a special QCL construction (Institute of Electron Technology), transceiver construction (Institute of Optoelectronics), photodetectors (VIGO System S.A.) and a modulation/coding system (KenBIT Sp.J.).

Keywords: free space optics, RF/FSO data link, wireless optical communication

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Optical properties of monomer-doped liquid crystalline materials for waveguiding structures

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Specific optical properties of liquid crystals (LCs) cause that such materials are widely used in many photonic applications. To this end, great number of practical realizations of LC-based optical elements and devices have been successfully demonstrated [1]. In this context, polymer dispersed and stabilized liquid crystals have been appeared recently as promising candidates for new elements in photonic systems, while offering wider functionality than this achieved in pure LC assemblages. The domains size achieved in such polymer networks, and thus also optical properties of such monomer-doped liquid crystalline materials, have to be carefully adjusted, mainly by changing monomer concentration. The latter parameter is typically used for categorization of LC polymer composites which are: polymer-stabilized LCs (<10 wt. %), polymer-network LCs (10÷20 wt .%) and polymer-dispersed LCs (>20 wt. %).

In this communication we present experimental results on determination of optical parameters of monomer-doped liquid crystalline materials. In particular, refractive indices, as well as propagational losses, have been found as a function of monomer concentration (in the percentage limited reserved for polymer-stabilized LCs). Materials characterized in this way can be applied for fabrication of the liquid crystalline waveguiding structures with a use of the photo-polymerization process [2]. For this purpose typical liquid crystalline material is combined with a small amount of the mixture of RM257 monomer [3] and UV-sensitive activator (PPD, typically used in dental light cured composite rasins), with percentage weight less than 10%. Several factors, such as composition of the LC-monomer mixture, UV pulse energy and time interval between illumination, are needed to be taken under consideration when fabricating the waveguiding structures of satisfactory quality [2]. Importantly optical properties of such structures may be additionally altered after their fabrication. In particular, thanks to the molecular reorientation induced by external electric field or by light beam itself, it is possible to control light propagation in the structure. Due to such huge advantage in comparison to waveguiding structures manufactured in other materials, proposed polymer-stabilized waveguiding structures in liquid crystalline materials may find potential applications as functional elements and devices for LC-based integrated optics.

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Critical technical aspects of manufacturing photonics integrated circuits on a silicon platform

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The technology of manufacturing passive silicon photonic integrated circuits has grown from electronic components technology – basic processes have their common roots and can be realized using the same type of tools and technologies.

In comparison to the electronic technology, passive photonic structures require fewer process steps, but also a higher accuracy than electronic components of analogous critical dimensions. Among the basic stages of production, one should distinguish wafer surface preparation, application of a resist, exposition of a pattern, etching and separation of structures. Each production step can introduce characteristic defects resulting in potential distortions of final elements, like waveguide discontinuities, dimensions deviating from the designed ones, roughness of the walls surfaces, overetching or insufficient etching as well as cracking of the waveguide end facet.

The resulting defects may cause a dramatic increase of the optical power loss in elements or even disable the propagation of light. For this reason, at each stage of manufacturing it is necessary to optimize processes for compliance of the results obtained with the project assumptions and limitations of the next manufacturing steps.

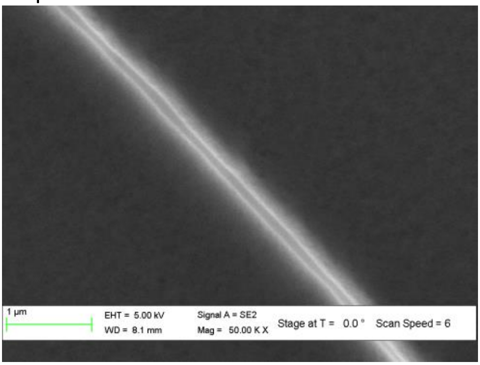

Fig. 1 Example of an overetched silicon rib waveguide captured by scanning electron microscope after reactive ion etching process

Wafer preparation requires selection of appropriate oxide and silicon thickness, as well as cleaning processes and, if necessary, also removal of the native oxide. Obtaining desirable thicknesses of a uniformly distributed resist on the surface is a result of viscosity of the resist, velocity and time of spin coating as well as the method of dosing the resist on the surface. Transferring the pattern to the resist can be done by various techniques, the most popular are photolithography, electron beam lithography and laser lithography. Each of these methods requires a number of parameter optimizations to achieve a desired results [1].

The same applies to the etching processes which transfer pattern from the resist to silicon, most often carried out by reactive ion etching.

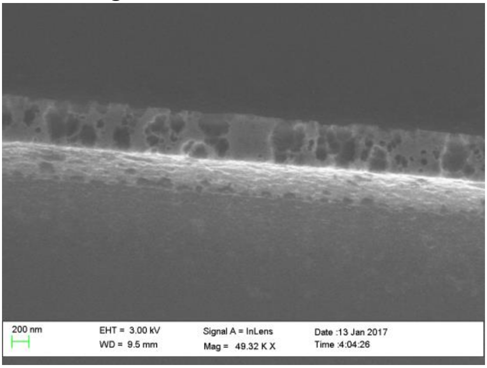

Fig. 2 Example of an etched silicon rib waveguide with high walls roughness

The final product in the form of a passive element of integrated photonics is the result of multi-dimensional optimization of all production steps. This work is focused on analysis the main critical points and discussing the main technological challenges, which integrated silicon photonics platform faces today and will face in the future.

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CEZAMAT Environment - Polish Center of Excellence as a bridge between science and industry

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As a part of the Horizon 2020 perspective, Warsaw University of Technology as a consortium leader together with Fraunhofer-IZM (Germany) and CEA-Tech (France), is preparing a project for the Teaming for Excellence competition. The goal of this project is to create CEZAMAT Environment, a new center of excellence where it would be possible to carry out scientific research at a high technological level. CEZAMAT Environment will be an institution focused on environmental protection with permanent cooperation with government institutions and entities as well medium-sized and small companies.

Numerical analysis of integrated optics structures based on wide band-gap oxide semiconductors ZnO and TiO_2

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The paper presents numerical analysis of integrated optics structure in the form of planar waveguide based on wide band gap oxide semiconductor material - zinc oxide ZnO or titanium dioxide TiO_2. The analyzed structure consists of waveguide layer based on ZnO or titanium dioxide TiO_2 deposited on substrate and optional covered by additional cladding layer. The optical and geometrical properties of each layer of planar waveguide structure such as: refractive index and thickness of waveguide layer and cover layer as well as refractive index of substrate have an impact on planar waveguide properties such as: value of effective refractive index N_{eff}, number of waveguide modes and its modal field distribution, critical thickness of waveguide layer for which selected waveguide mode can propagate into the structure. The theoretical analysis of planar waveguide structure was focused on determination of mentioned waveguide properties as a function of: waveguide layer thickness for two type of applied waveguide materials – titanium dioxide TiO_2 or zinc oxide ZnO deposited on one of substrate materials: BK7 glass, quartz or sapphire. The numerical analysis was carried out also for the waveguide structure with additional cover layer. The theoretical analysis of the waveguide structure was carried out for the following value of refractive index of each layer: TiO_2 n=2.426 and ZnO n_{ZnO}=1.932 deposited by reactive magnetron sputtering, refractive index of substrate was accordingly: BK7 n_{BK7} = 1.513, quartz n_Q=1.455, sapphire n=1.764 for wavelength l=677nm, refractive index of additional cover layer was in the range of n_{ac}=1-1.33, refractive index of cladding $_{AIR}$=1.000.

Investigation of physical properties of ZnO semiconductor material for sensor applications

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This paper presents investigation of physical properties of a wide band gap oxide semiconductor - zinc oxide for sensors applications such as temperature and detection selected gas environment. The first part of presentation was focused on deposition technology of ZnO semiconductor for obtain structure with relatively low surface roughness - RMS at the level of single nanometers. The next part of research was focused on deposition technology of porous ZnO layers and additional doping by palladium or platinum materials. The selected ZnO/Pt and ZnO/Pd layer was additional annealed after deposition. The research of ZnO layer was focused on investigation of selected physical properties as a function of deposition technology as well as a function of doping by palladium or platinum. The investigation was beginning from determination of surface morphology by atomic force microscopy AFM and scanning electron microscopy SEM methods. The next part of research was focused on determination of chemical composition of ZnO as well as ZnO/Pd or ZnO/Pt layer by energy dispersive X-ray spectroscopy (EDS) method. The crystalline structure of ZnO layer was determined by Raman spectroscopy method. The research of optical properties of ZnO layer was focused on research of spectral transmission characteristic in a variable ambient conditions - temperature and gas environment.

Review of blood transfusion devices

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