I3S 2022

9th International Symposium on Sensor Science

20–22 June 2022, Warsaw, Poland

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#I3S2022

9th International Symposium on Sensor Science

The Centre for Advanced Materials and Technologies (CEZAMAT)

Warsaw University of Technology

Warsaw, Poland

20 – 22 June 2022

Conference Chairs

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Professor Tomasz Woliński

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Welcome by Assoc. Prof. Piotr Lesiak, Prof. Tomasz Woliński, Prof. Leszek Jaroszewicz

Dear Colleagues,

It is with great pleasure that we announce the 9th International Symposium on Sensor Science, to be held in Warsaw, Poland, from 20 to 22 June 2022.

Sensor technology has been shown to be suitable for applications in many important fields, including industrial applications, security medical diagnostics, and environmental monitoring. This international conference, supported by the Photonics Society of Poland, Warsaw University of Technology as well MDPI *Sensors*, will bring together scientists from different areas to discuss important recent developments in sensor technology. It will represent a great opportunity for an in-person meeting of an interdisciplinary community aiming to discuss important breakthroughs in sensor technology and its related fields.

We look forward to your participation in this exciting event.

Assoc. Prof. Piotr Lesiak, Prof. Tomasz Woliński, Prof. Leszek Jaroszewicz
I3S2022 Conference Chairs

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Contents

I3S 2022
20 – 22 June 2022, Warsaw, Poland

	Sunday 19 June	Monday 20 June	Tuesday 21 June	Wednesday 22 June
Morning		Registration Opening ceremony *Plenary Session 1*	*Plenary Session 3*	*Plenary Session 5*
		Coffee Break	**Coffee Break**	**Coffee Break**
		Regular Session 1: Chemical Sensors	*Regular Session 3: Optical/Photonic Sensors and Sensor Applications*	*Regular Session 5: Optical/Photonic Sensors and SPECIAL SESSION. Specialty Optical Fibers for Sensing*
		Lunch	**Lunch**	**Coffee Break**
Afternoon	Registration	*Plenary Session 2* *Regular Session 2: Biosensors*	*Plenary Session 4* *Regular Session 4: Physical Sensors and SPECIAL SESSION. Materials, Microfluidics, Configurations and Strategies for Sensing*	*Regular Session 6: Optical/Photonic Sensors and SPECIAL SESSION. Specialty Optical Fibers for Sensing* Closing Ceremony
	Welcome Cocktail	*Poster Session*		**Lunch**
			Gala Dinner	

Sunday 19 June 2022: Registration 16:00 / **Welcome Cocktail 18:00**

Monday 20 June 2022: Registration 7:30 / 08:30 - 13:00 / 15:00 - 20:00

Tuesday 21 June 2022: 08:30 - 13:00 / 15:00 - 17:20 / **Gala Dinner 19:00**

Wednesday 22 June 2022: 08:30 – 14:30

Conference Program

Sunday 19 June 2022

18:00 Welcome Cocktail

Monday 20 June 2022

07:30–08:30 Registration

08:30–9:00 Opening ceremony

Plenary Session 1
Chair: Tomasz Woliński

9:00-9:45 **Abraham Katzir** "MID-IR Fiber Optic Sensors"

9:45-10:30 **Richard B. Jackman** "Nanostructured Plasmonic Diamond for Marine SERS"

10:30-11:00 **Coffee Break**

Regular Session 1
Chemical Sensors
Chair: Artur Dybko

11:00-11:20 **Artur Moro** "Fluorescent Ion Sensing: Using DPA-Based Chemosensors for Targeting Metal Cations and Anions"

11:20-11:40 **Larissa Egger** "Efficient Screening of Hybrid Nanomaterials for Optimizing Chemical Sensor Devices"

11:40-12:00 **Julia Kuczak** "Reference Electrodes with Polymeric Membranes Containing Ionic Liquids of Various Physicochemical Properties"

12:00-12:20 **Andrzej Pepłowski** "Influence of the printing pastes' rheology on screen-printed electrochemical sensors' performance"

12:20-12:40 **Silvio Sciortino** "Timing performances and radiation hardness of 3D diamond detectors"

12:40-13:00 **Leonardo Bravo Thais** "Smart Insole Sensor for vGRF Measurement"

13:00-15:00 **Lunch**

Plenary Session 2
Chair: Dominik Dorosz

15:00-15:40 **Elżbieta Malinowska** "Towards versatile bioanalytical systems"

Regular Session 2
Biosensors
Chair: Dominik Dorosz

15:40-16:00 **Artur Dybko** "Lab on paper sensor for explosive materials detection"

16:00-16:20 **Iwona Grabowska** "Electrochemical biosensors for cardiovascular diseases (CVDs) biomarkers detection"

16:20-16:40 **Bruno Wacogne** "Online Monitoring of T-cells growth: assessment of the concentration and quality, real time detection of contamination"

16:40-17:00 **Mateusz Słowikowski** "SMART-BED – non-invasive system for monitoring heart and respiratory rate"

17:00-17:20 **Gloria Jimenez Miranda** "Er3+ wireless temperature sensor for hyperthermia treatment"

18:00-20:00 **Poster Session**

Tuesday 21 June 2022

Plenary Session 3
Chair: Leszek Jaroszewicz

8:30-9:10 **Anna G. Mignani** "ERC – Funding opportunities for creative minds from Europe and anywhere in the world"

9:10-9:50 **Emmanuel Scorsone** "Diamond: a chemical sensor's best friend!"

9:50-10:30 **Yuliya Semenova** "Ultra-sensitive gas detection with microfibers and fiber microresonators"

10:30-11:00 **Coffee Break**

Regular Session 3
Optical/Photonic Sensors and Sensor Applications
Chair: Mirosław Karpierz

11:00-11:20 **Mikhail Korpusenko** "Optical Studies of High Performance Predictable Quantum Efficient Detector Based on Induced-Junction Photodiodes Passivated with SiO2/SiNx"

11:20-11:40 **Stanisław Stopiński** "Optical gyroscope systems based on photonic integrated circuits"

11:40-12:00 **Ryszard Piramidowicz** "MIRPIC – integrated photonics platform for sensing applications"

12:00-12:20 **Marcin Kochanowicz** "1.5-2.1 um emission in rare-earth co-doped glasses and multicore optical fibers"

12:20-12:40 **Maciej Grzesiak** "Influence of geometrical parameters of nonlinear optical fibers on their optical properties."

12:40-13:00 **Romas Vijeikis** "Efficient Violence Detection in Surveillanc"

13:00-15:00 **Lunch**

Plenary Session 4
Chair: Małgorzata Kujawińska

15:00-15:40 **David D. Sampson** "Polarisation-sensitive optical coherence tomography – sensing order in the sub-wavelength biological world"

Regular Session 4
Physical Sensors and SPECIAL SESSION. Materials, Microfluidics, Configurations and Strategies for Sensing
Chair: Małgorzata Kujawińska

15:40-16:00 **Bernd Haehnlein "**Anisotropy of the delta-E effect in Ni-based magnetoelectric cantilevers: a finite element method analysis"

16:00-16:20 **Wojciech Skierucha** "Selected issues on electromagnetic standardization of soil moisture"

16:20-16:40 **Ryszard Buczyński** "All-fiber polarization maintaning supercontiuum source with a highly nonlinear liquid core"

16:40-17:00 **Roberto Pizzoferrato** "Tuning the sensing properties of carbon dots for colorimetric detection of heavy metals in water"

17:00-17:20 **Piotr Lesiak** "Influence of optofluidic parameters of one-dimensional photonic structures on the reflection spectrum for the mid-infrared spectral region"

19:00 **Gala Dinner – Buliding of Physics, Warsaw University of Technology**

Wednesday 22 June 2022

Plenary Session 5
Chair: Piotr Lesiak

8:30-9:10 **Shimshon Belkin** "Remote bio-detection of buried landmines by luminescent microbial sensors"

9:10-9:50 **Luigi Zeni** "Polymer optical fiber-based plasmonic biosensors for medical diagnostics"

09:50-10:20 **Coffee Break**

Regular Session 5
Optical/Photonic Sensors and SPECIAL SESSION. Specialty Optical Fibers for Sensing
Chair: Luigi Zeni

10:20-10:40 **Nitin Kumar Singh** "Electronic Versus Ionic Electroactive Polymers (EAPs) Strain Sensors for Wearable Electronics: A Comparative Study"

10:40-11:00 **Michał Nikodem** "Laser spectroscopy and gas sensing inside novel hollow core fibers"

11:00-11:20 **Joanna Konopka** “A microsystem for vascularization study. 12:00-12:20”

11:20-11:40 **Kinga Żołnacz** “Twisted microstructured fiber with core created by partially open rings of holes for bend sensing”

11:40-12:00 **Aleksandra Dzieniszewska** “The color-polarization filter array (CPFA) sensors to recognize skin lesions”

12:00-12:30 **Coffee Break**

Regular Session 6
Optical/Photonic Sensors and SPECIAL SESSION. Specialty Optical Fibers for Sensing
Chair: Tomasz Woliński

12:30-12:50 **Grzegorz Dudzik** “Solid-State Laser Intra-Cavity Photothermal Sensor (SLIPS) for gas detection with parts-per-billion sensitivity”

12:50-13:10 **Roman Yatskiv** “Temperature sensing down to 4 K with erbium-doped tellurite glasses”

13:10-13:30 **Dominik Korol** “Polypyrrole-based molecularly imprinted nanoparticles for the chemosensing of oestriol”

13:30-13:50 **Joao Avo** “Nanomaterials with thermally-activated delayed fluorescence for sensing and imaging: challenges and solutions”

13:50-14:10 **Lakshmi Devi Chakkarapani** “Poly(methylene blue)-Film Coated Carbon and MWCNTs Screen Printed Electrodes for Tyramine Detection”

14:10-14:30 **Closing Ceremony**

14:30 **Lunch**

9th International Symposium on Sensor Science will be held in Warsaw, Poland, on 20 – 22 June 2022.

This conference seeks to bring together scientists from different areas to discuss important recent developments in sensor technology. It will represent a great opportunity for an in-person meeting of an interdisciplinary community aiming to discuss important breakthroughs in sensor technology and its related fields..

Conference Venue

The Centre for Advanced Materials and Technologies (CEZAMAT) at the Warsaw University of Tecnology is located in Warsaw's Ursynów district. It is located 5–6 minutes away by car from the airport and has good public transport accessibility. The site also includes a covered parking lot for 180 cars and is accessible for people with disabilities. For further information please visit cezamat.eu.

Address: Poleczki 19, 02-822 Warsaw, Poland

Registration Desk

The desk for registration, information and distribution of documents will be open from 16:00h on 19 June 2022.

Certificate of Participation

The participants of the event will receive an electronic Certificate of Participation. The certificates will be available upon request to i3s2022@mdpi.com after the event has ended.

Disclaimer

Delegates will receive a name-badge at the Information Desk, upon registration. The badge must be worn prominently in order to gain access to the congress area during all scientific and social events. Admission will be refused to anyone not in possession of an appropriate badge.

Insurance

The organizers do not accept liability for personal accident, loss, or damage to private property incurred as a result of participation in *I3S2022*. Delegates are advised to arrange appropriate insurance to cover travel, cancellation costs, medical, and theft or damage of belongings.

Photographs and/or video will be taken during the conference

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Gala Dinner

Tuesday 21 June 2022 at 19h
Building of Physics, Warsaw University of Technology
Koszykowa 75, 00-662 Warsaw

The Gala dinner will take place in the Building of Physics of the Warsaw University of Technology. The Building of Physics is, next to the Main Building, one of the oldest buildings of the Warsaw University of Technology. Both buildings have a common architectural concept (designed by Stefan Szyller). The building was shaped around a courtyard (Aula) covered with a colourful glass roof. The courtyard is surrounded by arcaded cloisters. Additional tickets for the accompanying persons for Gala Dinner and Welcome Reception only is 95 EUR.

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Abstracts I

Invited and Short Talks

MID-IR Fiber Optic Sensors

Abraham Katzir

School of Physics and Astronomy, Tel Aviv University, ISRAEL

During the last 60 years there have been continuous research and development in the field of Middle Infrared (mid-IR), in the wavelength range 3-30μm. New devices have been developed, including: 1. Broadband sources, such as thermal emitters and LEDs. 2. Narrow band emitters, including gaesous and solid state lasers and Quantum Cascade Lasers (QCLs.) 3. Photocoductive and photovoltaic detectors. 4. Fourier Transform Infrared (FTIR) spectrometers and tunable laser spectrometers.

Such devices and subsystems were incorporated in full mid-IR systems that included optics, mechanics, electronics and computer control. For example, an array of detectors is the basis of a full thermal imaging system, and a broad-band mid-IR source, a mid-IR detector and an FTIR interferometer form a full mid-IR spectroscopy system. The latest achievement is the development of integrated mid-IR photonics, such as a full spectroscopic system on a Si chip. This may lead to low-cost and high-performance mid-IR optoelectronic systems.

All these devices and systems have already proven themselves in many fields, such as defense, security, astronomy, biological and chemical studies, medicine etc. Many of these applications and new ones will require the guiding of mid-IR radiation within systems, or connecting systems to the outside, in ways lenses and mirrors cannot do. Towards this goal it would be highly beneficial to incorporate mid-IR transmitting optical fibers in these mid-IR systems. In particular, considering sensor systems, Mid-IR fibers will will make it possible to carry out sensing measurements that could not have been performed without such fibers.

Fibers made of silica are opaque in the mid-IR. However there are several families of other types of fibers: 1. Chalcogenide glass fibers, made of sulfides (e.g. As2S3) or selenides (As2Se3). 2. Fluoride glass fiber, made, for example, from ZBLAN (SrF4-BaF2-LaFe3-AlF3-NaF). 3. Polycrystalline fibers, made of Silver Halides (e.g. AgCl, AgBr or AgClBr) or Thalium Halides (e.g. TlF or TlBr). 4. Hollow core fibers (i.e. tubes) that act like fibers in guiding mid-IR radiation. All these fibers are flexible, fairly rugged and are highly transparent in the mid-IR. Incorporating such fibers or fiber bundles in mid-IR systems will make it possible to use these systems in new ways.

These developments may be illustrated by one important example: a mid-IR fiber-optic spectroscopic system. It is based on one or two mid-IR fibers connecting an FTIR spectrometer to the outside world. The system can be used

for measurements in a remote location, and in real time. This would be useful for process control, for studies of biological tissues and cells, and for medical diagnosis of tissues on the outside or the inside of the body, at the patient's bed. It would also be useful for food analysis, for water quality and air quality, and for general pure and applied scientific research.
It is expected that mid-IR fiber-optic sensor systems will have a great impact on standard applications and will pave the way for totally new applications, in the future.

Nanostructured Plasmonic Diamond for Marine SERS

Richard B. Jackman

University of the Basque Country UPV/EHU London Centre for Nanotechnology and the Department of Electronic and Electrical Engineering, University College London (UCL), UK

Surface-enhanced Raman scattering, or SERS, is an important optical sensing technique in which inelastic light scattering by molecules is greatly enhanced, enabling trace multi-component chemical detection. SERS typically involves metallic nanoparticles (NPs), Au or Ag, supported on a substrate such as Si, onto which the analyte of interest adsorbs. The primary mechanism for enhancement arises from local fields generated by plasmon excitation in the NPs. However, SERS substrates tend to degrade over time and are not suitable for re-use. Moreover, they are simply too fragile for use in environmentally challenging situations such as ocean analysis.

As a robust substrate for SERS, diamond has near-to ideal optical properties displaying only a single intense peak at 1332cm-1 enabling the Raman signal from many organic species to be detected with little interference. However, the reliance of van-der-Waals forces for NP adhesion to the diamond would offer little improvement over other substrates in terms of usefulness for marine applications. A possible solution is the inclusion of the NPs in diamond, sufficiently near the surface of the diamond to retain their plasmonic enhancement of the SERS signal. Metallic NP plasmonics can be significantly affected by dielectric environment, shape and inter-particle interactions. This paper will briefly present the results of simulations that have aimed to determine optimal NP sizes and distributions for SERS applications when a diamond matrix surrounds them. The need for well-ordered spherical Ag or Au with particular NP size to separation ratios within the diamond matrix will be shown.

Most methods for Au or Ag NP formation on diamond, lead to a range of NP sizes and separations whose inhomogeneous nature is then reflected in any layer created by overgrowth with diamond by CVD methods; as simulations have shown, these structures perform poorly as SERS substrates. Here, we have applied Nanoimprint Lithography (NIL) to direct the etching of ordered nanoholes into diamond substrates. Templated dewetting of Ag/Au films into diamond nanoholes was successfully demonstrated, encapsulating individual nanoparticles within diamond. Using this approach exact control over NP size and spacing can be achieved. Excellent SERS performance has been recorded and the prospects for the use of these novel Ag/Au NP nano-structured diamond layers for aqueous SERS applications will be discussed.

Fluorescent Ion Sensing: Using DPA-Based Chemosensors for Targeting Metal Cations and Anions

Artur J. Moro [1], Liliana J. Gomes [1], Pedro Mateus [2], Laura Rodríguez [3]

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[2] *ITQB-NOVA*
[3] *University of Barcelona*

Coordination compounds have been deeply associated with ion sensing since the 1980s, especially in the design of fluorescent chemosensors using chelating groups for metal cations. Over the latest years, these metal-coordinated sensor systems have been directed for anion sensing as well [1]. Establishing strong binding interactions with anions in aqueous media is extremely challenging because of the high stability of the solvation sphere by surrounding solvent molecules. Hamachi and co-workers were at the forefront of this research line, having designed a series of sensors based on di-2-picolyl-amine (DPA) to complex with Zn^{2+}, which were subsequently used for the detection of phosphate derivatives [2]. Herein, we introduced new fluorescent chemosensors bearing DPA units, capable of working in an aqueous environment [3,4]. Although detection mechanisms rely on interactions with the DPA chelating moieties, the chemosensors exhibit different behaviors upon cation and/or anion binding (luminescence quenching and/or enhancement, shift in absorption/emission wavelengths), which highlights both their complexity, as well as their potential for multiple analyte sensing applications.

Reference:

1. Jeong, Y.; Yoon, J. Recent progress on fluorescent chemosensors for metal ions. *Inorg. Chim. Acta* **2012**, *381*, 2-14.
2. Wongkongkatep, J.; Ojida, A.; et al. Fluorescence sensing of inorganic phosphate and pyrophosphate using small molecular sensors and their applications. *Phosphate Labeling and Sensing in Chemical Biology*, **2017**, 1-33.
3. Moro, A. J.; Santos, M.; et al. Selective coordination of Cu2+ and subsequent anion detection based on a naphthalimide-triazine-(DPA) 2 chemosensor. *Biosensors*, **2020**, *10*, 129.
4. Gomes, L. J.; Moreira, T.; et al. Chalcone-based fluorescent chemosensors as new tools for detecting Cu2+ ions. *Dyes and Pigments*, **2022**, *197*, 109845.

Efficient Screening of Hybrid Nanomaterials for Optimizing Chemical Sensor Devices

Larissa Egger[1], Lisbeth Reiner[1], Florentyna Sosada-Ludwikowska[1], Anton Köck[1], Jan Steffen Niehaus[2], Sören Becker[2], Öznur Tokmak[2], Hendrik Schlicke[2], Alexander Blümel[3], Karl Popovic[3], Martin Tscherner[3]

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[3] Joanneum Research, Institute for Surface Technologies and Photonics, Franz-Pichler-Strasse 30, 8160 Weiz, Austria

Chemical sensors based on metal oxides (MOx), are one of the most promising gas sensing devices due to their high sensitivity to numerous gases, fast response, miniaturization, and simple production. The detection principle of these sensors is a conductivity change of the MOx sensing material due to chemical reactions of gases with surface molecules. Cross sensitivities and interference to humidity, however, are still significant drawbacks of these sensors.
Functionalization of MOx sensing films with catalytic nanoparticles (NP) is a highly promising technology for optimizing sensor performance. The huge variety of potential MOx - NP-combinations requires efficient screening technologies to find proper hybrid material mixtures which enable controlled adjustment of the sensor response to specific target gases. This is of high importance for realization of a multi gas sensor device capable for clear discrimination of single gas components out of a gas mixture.
In this work we introduce our approach for efficient screening of hybrid MOx – NP material combinations. We have developed a specific Si-platform chip along with a gas measurement setup which enables simultaneous characterization of 16 chemical sensor structures in parallel. The Si-chips feature an array of Ti/Pt electrodes for contacting ultrathin MOx sensing films, which are deposited by spray pyrolysis and structured by photolithography to a size of 50 x 100 µm2. On these platform chips we tested three different MOx (SnO2, ZnO, and CuO) before and after functionalization with mono- and bimetallic NPs (such as Au, Pt, Pd, and NiPt) towards several test gases (CO, HCmix, toluene, CO2). Measurements are performed in a background gas of synthetic air at different relative humidity levels (25 – 75%) and at different operating temperatures up tp 350°C. We will present the sensing performance results of various MOx-NP combinations exhibiting an optimized response to specific target gases.

Reference Electrodes with Polymeric Membranes Containing Ionic Liquids of Various Physicochemical Properties

Julia Kuczak, Karolina Grzeszyk, Kinga Kochman, Marek Królikowski, Marta Królikowska, Łukasz Górski

[1] *Warsaw University of Technology*

In our work, reference electrodes with polyurethane membranes containing ionic liquids have been developed. Particularly, the influence of physicochemical properties of ionic liquids on the performance of polymeric membrane reference electrodes was examined. Other membrane modifications' effect on electrode potential stability have also been checked, including addition of plasticiser or plasticisers polarity. Each electrode's potential stability has been tested against various concentrations of strongly lipophilic ions. It was noticed that potential stability of prepared electrodes strongly depends on the differences in partition coefficient values between cation and anion of the ionic liquid. It was also shown that the amount of the ionic liquid in the polymeric membrane does not have significant influence on the performance of resulting reference electrodes. Moreover, results demonstrate that the addition of the plasticizer to the polyurethane membrane is not necessary to prepare reference electrodes that show sufficiently stable electromotive force values in solutions of various ion concentrations. Membranes of optimal composition were used to prepare All-Solid-State reference electrodes on glassy carbon disc electrodes, with acceptable potential stability. All-solid state membrane reference electrodes on screen-printed transducers have also been prepared and tested, exhibiting satisfying potential stability. This kind of membrane all-solid state electrodes may find application in miniature electrochemical sensors for health monitoring.

Influence of the Printing Pastes' Rheology on Screen-Printed Electrochemical Sensors' Performance

Filip Budny[1, 2], Marta Jarczewska[3], Piotr Aureliusz Walter[1, 2], Sandra Lepak-Kuc[1, 2], Dominik Baraniecki[1, 2], Andrzej Pepłowski[1], Małgorzata Jakubowska[1, 2]

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[2] Institute of Metrology and Biomedical Engineering, Faculty of Mechatronics, Warsaw University of Technology
[3] The Chair of Medical Biotechnology, Faculty of Chemistry, Warsaw University of Technology

The presentation will concern printed, disposable voltammetric electrodes for bioanalytical applications. Sensing electrodes' electrochemically active surface area was found to relate to the screen-printing pastes' rheology and manufacturing parameters. The sensors' response was examined for the constant carbon content in the electrode material and varying addition of surfactants and solvents, as well as the forces affecting the printing process. The printing pastes employed graphene nanoplatelets with the addition of carbon black as the functional phase and various polymers (PMMA, TPU, and others) as the composite matrix. Technological parameters examined included: the pressure and movement rate during the printing cycle, screen mesh density, curing, and ozonizing time. The rheological properties determined for each paste were: static viscosity, for zero viscosity, and yield stress. To estimate active surface area values, sensors were immersed in redox couple solution and employed for CV measurements at varying scan rates. Finally, the active surface area was calculated according to the transformed Randles-Sevcik equation. The results were compared to the electron transfer resistance and surface roughness. Multivariate analysis of variance (MANOVA) was performed for the above parameters. Obtained statistical relationships will allow fine-tuning of the printed sensors' performance as well as faster development of new applications of this technology in analytical devices.

Timing Performances and Radiation Hardness of 3D Diamond Detectors

Lucio Anderlini[1], Marco Bellini[2], Vladimir Cindro[3], Chiara Corsi[4], Keida Kanxheri[5, 6], Stefano Lagomarsino[1, 7], Chiara Lucarelli[1, 8], Arianna Morozzi[6], Giovanni Passaleva[1], Daniele Passeri[6, 9], Silvio Sciortino[1, 2, 8], Leonello Servoli[6], Michele Veltri[1, 10]

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High time resolution and extreme radiation hardness are key for detectors to be operated in future particle accelerators and in space or medical applications. With respect to these relevant properties, we report here on performances of pixel sensors prepared on mono- and poly-crystalline synthetic CVD diamond, by fast laser modification via multiphoton absorption from a 50 fs, 800 nm, Ti:Sa source. The research has been carried out in the framework of the Timespot experiment of the Italian National Institute for Nuclear Physics (INFN) aimed to achieve both high spatial resolution (55 um pitch) and very high time resolution (tens of picoseconds) with very tolerant detectors. Timespot exploits the recent 3D electrode architecture to enhance both time resolution and radiation hardness with respect to standard planar silicon and diamond detectors. We present here a major step forward in material engineering and fabrication procedure, yielding a time resolution improvement of our devices from the initial 280 ps to the present 80 ps, bringing this figure of merit very close to that allowed by the more mature 3D silicon technology. Recent results will be presented and strategies for further improvements will be discussed. Since diamond is known to be a very radiation tolerant material, it is considered very promising for implementing devices planned for very fast response and radiation hardness. We present results on a thorough study of polycrystalline and monocrystalline diamond sensors irradiated up to a fluence level of 1016 /cm2 1 MeV equivalent neutrons. The superior radiation hardness of the 3D architecture is demonstrated with respect to the planar detectors. We have also verified that the radiation hardness increases with increasing bulk electrode density. The results are discussed and compared with other radiation hardness studies carried out on 3D diamond sensors.

Smart Insole Sensor for vGRF Measurement

Leonardo Bravo Thais[1], Daniel Saromo Mori[2], Elizabeth Roxana Villota[1]

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Wearable devices are increasingly being used to objectively monitor and evaluate physical variables related to human movements, such as sports. Although wearables for kinematic measurement are widely used nowadays, many dynamic studies still employ force platforms to have reliable and valid data for estimating vertical ground reaction forces (vGRF). Not only are force platforms quite expensive, but they also cannot be easily accommodated in a practical scenario and significantly restricts the user's freedom of movement to a small fixed area. This article presents a smart insole sensor capable of providing a reliable and valid measurement for the vGRF. Regarding the hardware, the wearable comprises piezoresistive force sensors distributed along with the insole, which provides plantar force distribution measurements, and an embedded system for data collection and communication worn on the lower leg. In order to make the system more affordable, we made the prototype enclosure using 3D-printing technology. Also, to monitor the wearable outputs, the insole sensor uses a mobile application connected to the wearable via Bluetooth 4.0. The prototype underwent both unit- and value-calibration at the lab using gold standard force plates to guarantee accurate outputs. Regarding the software, we implemented a novel deep learning algorithm for vGRF estimation and insole sensor calibration. This research provides an advancement toward developing a wearable monitoring system for vGRF reporting in real-life scenarios.

Towards Versatile Bioanalytical Systems

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The need for the development of diagnostic tools, which allow rapid and reliable analyses is still of great importance. Recently more and more attention has been paid to diagnostic systems, which can be used for point-of-care testing (POCT) of biomarkers and pathogens, assuring uncomplicated operation and rapid results. This presentation will cover several topics that must be considered upon designing and fabrication of such devices, starting from the selection of biosensing elements and detection pathways, novel materials and technologies as well as appropriate analytical signal generation, data processing, miniaturization, and automatization of individual analytical steps up to cost-effectiveness. In the framework of this presentation, the electrochemical POCT system developed in our laboratory will also be presented. This system consists of: (i) disposable diagnostic cartridges containing a network of microchannels, bioreactor, specially designed carbon-based electrodes, and other elements (fabricated using a foil-to-foil technique), (ii) microelectronic reader, which can be used by doctors, nurses and paramedics under non-laboratory conditions and (iii) a measurement data management system with accompanying infrastructure. This universal device can be applied for the determination/detection of bacterial, viral, and fungal antigens, as well as cardiovascular and hormonal biomarkers (in blood, urine, and nasal swabs and other biological samples). The applicability of the developed POCT system for the determination of certain biomarkers e.g. C-reactive protein will be demonstrated and evaluated.

Acknowledgement
This work has been financially supported by the National Centre for Research and Development in Poland (grants no. POIR.04.01.04-00-0027/17 and POIR.01.01.01-00-0638/20).

Lab on Paper Sensor for Explosive Materials Detection

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Chemical sensors should give fast and reliable information on an analyte. One possible technology used in contemporary sensor research is the so-called lab on paper, in which appropriate chemical indicators are immobilized on a specially designed paper chip with hydrophilic and hydrophobic paths. The difference in wettability of the basic material is used to deliver a liquid sample to an appropriate place of the chip with the indicator. The sample is transported by capillary forces.
The article presents a new design of a lab on paper chemical sensor for the detection of explosive materials. The chemical sensors were based on Whatman chromatography paper which was covered with a wax layer. A precise wax pattern was deposited by a Xerox wax printer Color Qube 8700. Afterwards, the chromatography paper was heated up to 170 oC for 2 min. In this way, the wax layer penetrates the paper and creates a hydrophobic barrier. A solution of gold nanoparticles (a diameter of 20 nm) was modified with cysteamine. The paper-based chemical sensor was modified with such a solution. The sensing pads were then covered with 0.1 M NaOH solution. Colour of the sensing pad changes in dependence on explosive material. The designed sensor was tested with samples of 2,4,6-trinitrotoluene (TNT).

Electrochemical Biosensors for Cardiovascular Diseases (Cvds) Biomarkers Detection

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Cardiovascular diseases (CVDs), group of diseases related with heart and blood vessels disorders, are the main health problems worldwide. Therefore, the development of modern diagnostic technologies for rapid and accurate detection of cardiac biomarkers have become recently of high significance. Sensitive protein biomarkers identification can help prevent and slow CVDs progressions. The ability of electrochemical biosensors to determine cardiovascular biomarkers, such as cardiac troponin I (cTnI), brain natriuretic peptide (BNP-32), low density lipoprotein (LDL) and others, in serum of patients, is crucial for development of point-of-care sensing platforms. Electrochemical biosensors, cheap and scalable devices, offer moreover attractive alternative for conventional immunoassays. In our group, we have joined this research line and within this presentation we report on:

- electrochemical aptasensors for detection of BNP-32 and cTnI using differential pulse voltammetry (DPV) in PBS and $[Fe(CN)_6]^{4-}$, based on screen-printed gold electrodes modified electrophoretically with (1) polyethyleneimine/reduced graphene films, (2) subsequently with propargylacetic acid and (3) azide-terminated aptamers immobilized using Cu(I)-based "click" chemistry on propargyl groups;

- comparison of electrochemical immuno-and aptasensor for detection of LDL using square-wave voltammetry (SWV) in PBS containing $[Fe(CN)_6]^{3-/4-}$; an immunosensor based on anti-apolipoprotein B-100 antibody covalently attached to 4-aminothiophenol (4-ATP) on the surface of the gold electrode and an aptasensor based on gold electrode modified in a mixture of 6-mercaptohexanol and ssDNA aptamer specific for LDL containing -SH group;

- studies on the application of monoclonal antibodies against LDL labelled with redox active molecules (derivatives of ferrocene) immobilized on the surface of gold electrode for detection of LDL based on changes in ferrocene redox activity.

This work was supported by the National Science Centre, Poland, grant number 2017/25/B/ST4/00139 and Institute of Animal Reproduction and Food Research, Olsztyn, Poland.

Online Monitoring of T-Cells Growth: Assessment of the Concentration and Quality, Real Time Detection of Contamination

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Based on the modification of biological substances, either directly from the patient to be treated or from healthy donors, Advanced Therapy Medicinal Products (ATMPs) are promising therapeutic solutions (among others, CAR T-cells represent current and best known ATMPs). However, with a few hundred thousand dollars per dose, these products suffer from their prohibitive price, limiting the number of treated patients. The reasons for this can be summarized as follows. The whole process takes place in sterile facilities and requires trained staff (as well as onerous equipment) who perform sampling for the numerous quality controls performed throughout the production. The production can last over more than one week and each sampling further increases the risk of contamination and the need to fight against them.

Therefore, there exists a need for online controls of the content of the bioreactor during the production, especially focused on concentration measurements and quality assessments. Meanwhile, real time detection of possible contaminations would allow stopping the production as soon as a problem arises, hence saving days of useless culture and reducing the cost of the global production. In this conference, we present simple and real time white light spectroscopy means to simultaneously monitor T-cell growth, estimate the production quality and detect contaminations. The mathematical description of the absorption spectra shape allows achieving these goals. The contactless nature of white light spectroscopy avoids sampling the bioreactor's content and consequently reduces the risk of concomitant contaminations. Possible integration of such online methods in bioreactors will also be proposed with the ulterior motive of democratizing the use of ATMPs to as many people as possible.

SMART-BED – Non-Invasive System for Monitoring Heart and Respiratory Rate

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State-of-the-art solutions of contemporary medicine provide a large variety of devices and measurement techniques capable of accurate monitoring of the basic vital signs of a person under care—temperature, heart rate, respiratory rate, blood pressure, and saturation. A combination of electronic and photonic sensing techniques enables the realization of sophisticated measurement apparatus tailored for specific applications in terms of accuracy, energy consumption, compactness, portability, etc. A significant advantage of implementing photonic sensing techniques in medical applications is that they operate on optical signals, typically using a dielectric medium in which they are propagating. This, in turn, allows the avoiding of electro-magnetic interference, potentially disturbing the operation of numerous medical electronic devices.

In this work, we present SMART-BED, a demonstrator of a fiber-optic system for non-invasive monitoring of the basic vital signs of a patient. The system uses an array of fiber Bragg gratings mounted on a polymer board and inserted into a bed mattress. The principle of work is based on the fact that movements of the patient's chest, as well as the cardiac activity, induce stress on the sensors, causing a detectable change of the Bragg wavelength. The signals from the gratings are read out using a commercial FBG interrogator with a frequency of 3 kHz. A dedicated algorithm processes all signals in parallel, allowing to extract the heart rate and respiration rate based on the recorded time traces in the real-time mode.

Furthermore, we present the latest results obtained with the use of in-house developed photonic integrated interrogators with respect to the analysis of the vital signs of a patient lying on a SMART-BED sensor array.

Acknowledgment: This work was supported by the National Centre for Research and Development (OPTO-SPARE, PBS3/B9/41/2015) and the Institute of Applied Research Warsaw University of Technology Sp. z o.o. (Innovation Incubator 4.0).

Er3+ Wireless Temperature Sensor for Hyperthermia Treatment

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In recent years, the use of hyperthermia to induce cellular activity of hippocampal neurons, where in-vitro and in-vivo experiments have shown to evoke a promising neural activity, has been explored. This is due to the hyperthermia effect which improves the neurotransmission process, this could be related with the fact that cells and neurons are temperature sensitive. However, if the temperature exceeds the physiological range (35–39 °C), can occurred abnormalities and life-threatening health complications, for that reason it is essential to have an accurate temperature monitor for such a technique. For that reason, the use of a non-invasive biosensor to monitor temperature changes remotely with high temporal resolution is essential. In this work, temperature sensing properties of fluoroindate glasses doped with Er3+ and Yb3+ were examined with the aim of evaluating their potential as a wireless temperature sensor. The main advantage of the use of such a matrix is its low phonon energy, high refractive index, and transparency in the infrared spectra region. Their glass structure was analyzed using XRD, FTIR, and Raman spectroscopy while their ability as a non-invasive temperature sensor was evaluated using radiative transition analysis, along with calculation of absorption, emission, and effective emission cross sections. Finally, the adequate functional models of temperature sensing were established for Er, Yb co-doped glass systems utilizing temperature dependences of luminescence spectra.

ERC – Funding Opportunities for Creative Minds from Europe and Anywhere in the World

Anna G. Mignani

European Research Council Executive Agency (ERCEA) and National Research Council of Italy (CNR)

The European Research Council (ERC) funds frontier research that enables breakthrough discoveries and establishes the conditions for future innovations that address key scientific and societal priorities. ERC supports individual researchers of any nationality at different career development stages, performing cross disciplinary research in Europe. Pioneering ideas, new research fields and emerging applications introducing unconventional and innovative approaches are funded.

The main funding schemes of the European Research Council (ERC) will be presented, together with its main achievements in the last 10 years. The portfolio of ERC projects in sensing will be also presented and some success stories highlighted.

Diamond: a Chemical Sensor's Best Friend!

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Diamond has been grown in some laboratories by either HPHT process or Plasma-Enhanced Chemical Vapor Deposition (MP-CVD) since a few decades. Single crystal diamond exhibits outstanding properties including a high optical transparency over a broad electromagnetic spectrum, high thermal conductivity approx. five times higher than copper, and acoustic wave velocity close to 19 000 m.s-1. It displays also remarkable mechanical properties with e.g. a Young's modulus exceeding 1000 GPa along with high resistance to fracture, to name a few. Some of these properties remain also remarkable in its polycrystalline form when compare to most other materials. Furthermore, diamond can be doped e.g. with nitrogen or boron during growth, offering electrical properties from semiconducting to quasi-metallic regimes. When heavily doped with boron (~2.1021 cm-3), the so-called Boron Doped Diamond (BDD) electrodes become attractive electrodes featuring a high potential window > 3V in water and low double-layer capacitance. Moreover, diamond is extremely resilient to corrosion and more generally to chemical attacks. It is also biocompatible, which makes it very attractive for in-vivo sensing applications. Finally, the carbon nature of the diamond offers wide opportunities for surface grafting of chemical or biochemical functional groups through highly stable covalent carbon-carbon bonding. One can take advantage of these properties to enhance the analytical performances and stability of chemical/biochemical sensors and this has motivated our research over the last 15 years.

Our work focuses mainly on polycrystalline diamond thin films that can be grown typically on 4 inches silicon substrates, thus offering access to some clean-room processes and potentially large-scale production. As examples, diamond based MEMS devices (microcantilevers, SAW sensors) take advantage both of the mechanical properties of diamond, along with steady carbon interface for convenient bio-functionalization. Our work here focused mainly on the detection of odorant molecules, using biomolecular receptors involved in olfaction in Nature as sensitive layers, including Odorant Binding Proteins (OBPs), Major Urinary Proteins (MUPs) and Olfactory Receptors (OR). Multisensor array instrumentations were developed around this concept, for applications ranging from breathe analysis to security applications. Beside, heavily doped diamond electrodes were developed successfully both as macro- and micro-electrodes for biomedical, pharmaceutical or foodstuff analysis applications. These applications benefit both from the high analytical performances of diamond electrodes in particular due to their low background

signals and high reactivity, and high stability and reliability. BDD electrodes offer also significant advantages in electrochemiluminescence (ECL) techniques, which are being investigated for various applications ranging from foodstuff analysis to narcotics detection. A key benefit of BDD electrodes for all of the above applications is certainly that they can be electrochemically reactivated following fouling, sometimes directly in the analytical medium, to maintain high reactivity thus opening the way to reusable sensors and online monitoring.

Ultra-sensitive Gas Detection with Microfibers and Fiber Microresonators

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Optical vapor sensors have been employed in many applications such as environmental protection, healthcare, food, pharmaceutical industries, and security. Sensors of volatile organic compounds (VOCs), which are common air pollutants, are of particular interest, since a number of VOCs are toxic or carcinogenic and thus can have adverse health effects. Accurate monitoring of VOCs indoors is important to safeguard public health and to keep atmospheric emissions under control in order to avoid environmental hazards. Moreover, there is increasing evidence that certain VOCs in exhaled breath can serve as biomarkers for the early disease diagnosis, thus making VOCs sensors a promising non-invasive diagnostic tool.

Many of the optical fiber sensors rely on measurements of the refractive index (RI) change due to the absorption of gas molecules into polymer layers coated on the sensor surface. Several typical optical fiber structures that have been extensively investigated for RI-based vapor sensors will be briefly reviewed, including optical fiber Bragg gratings, surface plasmon resonance, and interferometers. Then two most promising fiber optic platforms that can be used for ultra-sensitive optical vapor sensors: microfiber interferometric and microresonator-based sensor structures will be discussed in greater detail. Several examples of specific microfiber and microresonator based vapor sensors will be introduced and analyzed. Finally, future prospects and challenges for the optical fiber based vapor sensors will be discussed, including the need for simultaneous detection of multiple VOCs and overcoming the drawbacks of fabrication and readout complexity.

Optical Studies of High Performance Predictable Quantum Efficient Detector Based on Induced-Junction Photodiodes Passivated with SiO2/SiNx

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The Predictable Quantum Efficient Detector (PQED) is a silicon-based optical sensor which is designed to convert every photon in the incident photon flux to an electron–hole pair. The sensor thus produces a photocurrent with the spectral responsivity of $R(\lambda) = e\lambda/hc$ depending only on fundamental constants and wavelength. In this work, we describe recent advances in achieving the ideal photon-to-electron conversion ratio within the uncertainty of a few tens of ppm (parts per million) [1].

We performed optical studies of silicon p-type 7-reflection trap detectors made of two induced-junction photodiodes with SiO_2/SiN_x passivation layer. The PQED has 50 ppm spatial uniformity of responsivity in the center of the aperture and exceptionally low reflectance below 1 ppm in the spectral range from 400 nm to 800 nm. Very small reflectance allows to avoid correction due to reflectance losses and makes the PQED insensitive to small shifts of incidence angle. The recombination loss of the electron–hole pairs was determined by measuring the photocurrent ratio of the SiO_2/SiN_x PQED and earlier SiO_2 passivated PQED [2] using the same incident photon flux in both sensors. The results indicate that at 488 nm wavelength the losses of both types of sensors are similar within the measurement uncertainty of 30 ppm. At the 785 nm wavelength, the recombination loss of the SiO_2/SiN_x PQED is 75 ppm lower than that of the earlier SiO_2 PQED.

The responsivity of the earlier SiO_2 passivated PQED was compared with a cryogenic electrical substitution radiometer [3] with the result that the photon-to-electron conversion losses are (76 ± 60) ppm and (117 ± 60) ppm at the wavelengths of 532 nm and 760 nm, respectively [4]. The conclusion is that the PQED with SiO_2/SiN_x passivation layer tends to have recombination losses at the level of a few tens of ppm, a value that is lower than achieved with any other silicon sensor produced earlier.

Optical Gyroscope Systems Based on Photonic Integrated Circuits

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In recent years photonic integration technologies have been rapidly evolving. The progress may be exemplified by telecom and datacom applications of photonic integrated circuits (PICs), for which an evident transition from experimental and laboratory-grade systems to fully commercial products has been observed. Nowadays, key players in the field offer on the market high-speed, multi-channel transmitters and receivers using PICs fabricated in indium phosphide or silicon platforms.

In the coming years, a similar trend is anticipated in the case of optical sensing solutions based on photonic integrated devices. In this work, we present and discuss a demonstrator of an interferometric fiber-optic gyroscope (IFOG) system that utilizes a PIC as an interrogator of a fiber loop. The photonic chip comprises a laser light source and a booster optical amplifier, a cascade of two multi-mode interference (MMI) couplers for signal distribution, and two PIN photodiodes to detect the interference signal. The IFOG demonstrator also comprises an electronic control system for driving the light source and reading out the signal from the detectors. A proper operation of such an experimental IFOG system has been confirmed by a series of measurements, in which the Sagnac interference signal has been detected under rotation with an angular velocity up to 1.2 rad/s.

Furthermore, we demonstrate three generations of photonic circuits designed and realized in the framework of the development of an integrated ring laser gyroscope (RLG) system. These are single-frequency ring lasers with a different scheme of filtering within the laser cavity. The devices comprising an arrayed waveguide grating, a cascade of asymmetric Mach–Zehnder interferometers, and a combination of both these filters are presented and discussed with respect to their applicability in the gyroscope application.

Acknowledgment: Studies were funded by FOTECH-1 project granted by Warsaw University of Technology under the program Excellence Initiative: Research University (ID-UB).

MIRPIC – Integrated Photonics Platform for Sensing Applications

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Integrated photonics is considered one of the most important technologies of modern photonics, offering great advantages of compactness, high reliability, low power consumption, cost-optimized packaging and manufacturing. These features, similar to those offered by electronic integrated circuits, have a decisive impact on the impressive dynamics of the development of integrated photonics technologies. At present, two technologies have dominated the market – indium phosphide and silicon, both addressing the telecom-originated spectral range of near-infrared. The third platform – silicon nitride, with the clear and already confirmed market potential, addresses mainly the visible spectral range, offering access to several non-telecom applications. It should be noted, however, that there is still plenty of room for another technological platform, extending the spectral range and, thus, the application area of integrated photonics.

In this work, we present and discuss the potential of a new integrated photonics platform for sensing applications, MIRPIC, developed jointly by VIGO Photonics, Warsaw University of Technology and Institute of Microelectronics and Photonics (Ł-IMIF). The general concept is similar to other IP platforms and is based on the development of the fundamental building blocks like light sources, waveguides, detectors etc. enabling the design and development of photonic integrated circuits operating in the mid-IR part of the spectrum (between 3 and 5 micrometers), which is preferable from the perspective of sensing applications. All critical aspects of the technology will be discussed and the current state of technology will be presented, with a specific focus on waveguiding components (straight and curved waveguides, MMI couplers, arrayed waveguide gratings) and laser-to-waveguide and detector-to-waveguide integration issues. The perspectives of the technology will be presented in the context of demands defined by the markets of environmental monitoring, digital health, agriculture, automotive and others.

This work received support from the National Centre for Research and Development through projects MIRPIC (TECHMATSTRATEG-III/0026/2019-00).

1.5-2.1 um Emission in Rare-Earth Co-Doped Glasses and Multicore Optical Fibers

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Ultra-broadband emission in the range 1.0-2.1 mm is required in medicine (OCT) metrology, and sensing systems. Novel ideas are connected with rare-earth co-doping of low phonon energy glasses (further fiber core) and obtaining ultra-broad emission as a result of the superposition of particular luminescence bands. The 1.5 - 2 um broadband ASE in both germanate glasses and glass fibers co-doped with Tm^{3+}/Ho^{3+}, $Yb^{3+}/Tm^{3+}/Ho^{3+}$ and $Er^{3+}/Tm^{3+}/Ho^{3+}$ can be realized as a result of radiative transitions in the 1.4-2.1 mm range due to Tm^{3+}: $^3H_4 \rightarrow {}^3F_4$ (1.45 um), Er^{3+}: $^4I_{13/2} \rightarrow {}^4I_{15/2}$ (1.55 um), Tm^{3+}: $^3F_4 \rightarrow {}^3H_6$ (1.8 um), Ho^{3+}: $^5I_8 \rightarrow {}^5I_7$ (1.55 um) transitions and the partial donor- acceptor energy transfer and superposition of the particular emission bands. This work presents two important issues: 1) optimization of the co-dopants concentration in germanate glasses and construction of double-clad, multicore fiber to obtain flat broadband emission in the 1.5-2.1 mm range 2) development of the multicore glass-ceramic optical fiber co-doped with rare earth and d-block metals that enabled extending of the emission band. The effect of the rare-concentration on the donor acceptor – energy transfer and finally obtaining broadband luminescence in glasses do-coped with $Er^{3+}/Tm^{3+}/Ho^{3+}$, $Yb^{3+}/Tm^{3+}/Ho^{3+}$ and glass-ceramics co-doped with Ni^{2+}/Er^{3+} will be presented. Constructions of the multicore characterized by broadband, eye-safe ASE will be also analyzed.

Influence of Geometrical Parameters of Nonlinear Optical Fibers on Their Optical Properties

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Properties of specialty optical fibers in their technology are determined by many aspects such as material choice, from which optical fibers are made of, refractive index profile, or optical fiber manufacture method. Typical optical fibers are made of ultrapure silicon dioxide (SiO2), called fused silica, in a process called chemical vapor deposition (CVD). The difference in refractive indexes is most often obtained by doping silica glass with selected inorganic compounds, mainly germanium dioxide (GeO2), which increases the refractive index, and fluorine, which lowers it accordingly. Proper design of the dopant profile in the optical fiber core and in the layer surrounding the core is crucial for nonlinear optical fibers with shaped dispersion characteristics. Such optical fibers can be used for the generation of nonlinear phenomena such as supercontinuum generation (broadband light source) or soliton self-frequency shift.

As part of the research, structures of nonlinear optical fibers with flattened normal dispersion in the near-infrared range were designed with the use of numerical simulations in COMSOL Multiphysics. Theoretical chromatic dispersion characteristics and dependence of the effective mode field area on the wavelength were obtained from the theoretical structures. Based on the designed optical fiber structures, a series of nonlinear optical fibers were produced, characterized by high concentration of GeO2 in the core and presence of a fluorine-doped layer around the core. The influence of geometrical parameters, e.g., width of the fluorine-doped layer (ratio of the radius of the fluorosilicate layer to the radius of the core) and the imperfections resulting from technological aspects on the optical properties of manufactured optical fibers, with the particular emphasis on chromatic dispersion and effective mode field area, were determined experimentally. Theoretical optical fiber models along with their calculated properties (chromatic dispersion and effective mode field area) were compared with real measurements.

Efficient Violence Detection in Surveillance

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Intelligent video surveillance systems are rapidly being introduced to public places. The adoption of computer vision and machine learning techniques enables various applications for collected video features; one of the major is safety monitoring. The efficacy of violent event detection is measured by the efficiency and accuracy of violent event detection. In this paper, we present a novel architecture for violence detection from video surveillance cameras. Our proposed model is a spatial feature extracting a U-Net-like network that uses MobileNet V2 as an encoder followed by LSTM for temporal feature extraction and classification. The proposed model is computationally light and still achieves good results—experiments showed that an average accuracy is 0.82 ± 2% and average precision is 0.81 ± 3% using a complex real-world security camera footage dataset based on RWF-2000.

The authors of this research work propose to use a dedicated AI method that is efficient in the sense of energy and memory consumption and capable of running on embedded edge devices. The application of the AI method addresses several issues. First, a specific dedicated task, such as face recognition and or in this case violence detection, can be done locally on the edge device. Secondly, all privacy-related data can be filtered by leaving only the video data that directly relates to a certain crime or accident.

The authors are focusing on developing a deep learning-based algorithm that is capable of detecting violence from the surveillance video stream. The main value of such intelligent surveillance interpreting scenes on the network edge is the reduction of the reaction time in case of harm to public health and safety.

NOTE: article can be found: https://www.mdpi.com/1424-8220/22/6/2216/htm

Polarisation-Sensitive Optical Coherence Tomography – Sensing Order in the Sub-Wavelength Biological World

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Alteration of the polarisation state of light is an appealing source of contrast used in polarised light microscopy of very thin sections for many decades – with applications in geology, materials, and biology. The polarisation-sensitive (PS) version of optical coherence tomography (OCT) probes, by contrast, probes a sample volume (rather than thin section) in identifying the presence, relative arrangement, and orientation of sub-wavelength-sized fibrous structures. In biology, PS-OCT is sensitive to such structures as collagen fibres or muscle cells, and the shape of individual scatterers, such as cells. PS-OCT has been in existence since the early 1990s, but has yielded less to date than its early promised suggested. The received signal is complicated by the cumulative influence of the propagation path on the contrast, and the complex physics of polarised light-soft tissue interactions. Thus, image interpretation has been challenged by the lack of one-to-one correspondence between PS images and OCT structural images. Nonetheless, applications have been pursued in glaucoma, tumour and burns assessment, and wound monitoring. In this talk, I will describe what has changed recently to overcome the challenges, focussing on our recent work, and why we expect polarisation-based contrast to yield great advances over the coming years.

Anisotropy of the Delta-E Effect in Ni-Based Magnetoelectric Cantilevers: A Finite Element Method Analysis

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Magnetoelectric sensors based on microelectromechanical cantilevers consisting of TiN/AlN/Ni are investigated using finite element simulations in regard of the anisotropy of the delta-E effect and its impact on the sensor sensitivity. The delta-E effect is derived from the anisotropic magnetostriction and magnetization of single crystalline Nickel. The magnetic hardening of Nickel in saturation is demonstrated for the (110), as well as the (111) orientation. It is shown, further, that magnetostriction caused the bending of the cantilever has a negligible impact on the eigenfrequency and, thus, sensitivity. The intrinsic delta-E effect of Nickel is, depending on the crystal orientation, decreased in magnitude when integrated in the magnetoelectric sensor design. The transitions of the individual magnetic domain states are found to be the dominant influencing factor on the sensitivity for all crystal orientations. The peak sensitivity was determined to 41.3% for (110) in-plane orientated Nickel at a magnetic bias flux of 1.78mT. It is found, that the transition from domain wall shift to domain rotation along the hard axes yields much higher sensitivity than the transition from domain rotation to magnetization reversal. The results achieved in this work show, that Nickel as hard magnetic material is able to reach almost identical sensitivities as soft magnetic materials, such as FeCoSiB.

Selected Issues on Electromagnetic Standardization of Soil Moisture

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A large number of electromagnetic sensors for measuring soil moisture available on the market, differing in the method of measurement, price, shape, measurement volume, durability, etc., mislead the potential user. They cannot compare the right measurement equipment because there is no easy and reliable way to do so. The response of the sensors depends on the measurement frequency used, soil salinity, density, texture, just to name a few. The growing concern for the sustainable use of water resources for agricultural, industrial, and domestic purposes and the growing market for the right measuring tools are putting pressure on the right choice. The article presents the issues and efforts towards standardization of electromagnetic measurements of soil moisture, especially in the field of selection of measurement methods and reference materials that would enable the comparison of the performance of dielectric sensors available on the market. Work on the standardization of electromagnetic soil moisture measurements requires the cooperation of an interdisciplinary group of scientists and producers. The work done so far is an initial attempt to synchronize research in some international laboratories, learn about mutual research methods and formulate research tasks for the future. Key questions about the concept development process leading to standard testing and evaluation practices for electromagnetic soil moisture measurements are still unanswered.

All-Fiber Polarization Maintaning Supercontiuum Source With A Highly Nonlinear Liquid Core

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All fibre coherent broadband sources are highly required for photonic sensor systems. Polarisation noise is identified as important limit of coherence in all-normal dispersion fibre supercontinuum sources. Several strategies based on microstructured fibres have been proposed, however internal structure of the fibre is complex or soft glass fibres are applied. The propped solutions suffer from small effective mode area or low nonlinear coefficient. In this paper we study properties of new concept of polarization maintaining all-fibre source composed of hole core infiltrated with carbon disulfide. We introduced a core in a form of a twin circular air holes with diameter below 2 µm each. This solution is more practical than previously considered elliptical air holes impossible to realize with current state of the art fiber drawing technology. The optimised fibre with a twin circular holes infiltrated with carbon disulfide with the diameter of 1.6 µm has a flat, all-normal dispersion for y-polarized and anomalous dispersion for x-polarized mode and is practically single mode over entire near infrared range above 1 µm. Numerically calculated supercontinuum spectrum with bandwidth of 1400 nm in the range 1000 – 2400 nm and polarization extinction ratio over 15 dB is predicted for 10 cm long fibre sample pumped with 20kW 90 fs pulses at central wavelength of 1550 nm.

Tuning the Sensing Properties of Carbon Dots for Colorimetric Detection of Heavy Metals in Water

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Carbon dots (CDs) have recently emerged as a new class of fluorescent nanomaterials that can be prepared and modified in order to exhibit sensitivity to a variety of chemical and biological analytes. This versatility originates from different strategies of synthesis, top-down or bottom-up, that provide the means to heteroatom doping and modulating surface and edge-attached functional groups. In particular, the great affinity with heavy metal ions in water has stimulated a great number of studies on the response to these toxic species. While most investigations have exploited the fluorescent emission of CDs, much less has been reported on variations of optical absorbance, which could be more suitable to colorimetric detection in simple and cheap visual-based devices. Previous studies on top-down undoped CDs demonstrated how slight modifications of synthesis could turn a simultaneous sensitivity to As(III), Cd (II), Cu(II) and Pb(II) into a selective response to Cr(VI), due to exposure of the functional groups on the surface and formation of hydrogen bonds. In this study, we report on the sensitivity of bottom-up nitrogen and sulfur co-doped CDs (NS-CDs) prepared by a simple one-pot hydrothermal method. We show how tuning the pH of sensing solution greatly reduced interference effects by Fe(III) and enhanced sensitivity to Cu(II) through the emergence of a distinct absorption band at 660 nm. This was attributed to the formation of cuprammonium complexes through N-containing functional groups. Arising of a concurrent response to Co(II) in a different spectral region also suggests the possibility of dual-species multiple sensitivity. NS-CDs were characterized by TEM, STEM-coupled EDX analysis, NMR and IR spectroscopy. Response to Cu(II) was linear in the concentration range 1 - 100 µM with a limit of detection of 100 nM. Interestingly, the present system neither requires any other reagents nor any previous assay treatment.

Influence of Optofluidic Parameters of One-Dimensional Photonic Structures on The Reflection Spectrum for the Mid-Infrared Spectral Region

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A self-organized one-dimensional photonic crystal (1D PC) based on gold nanoparticles suspended in a nematic liquid crystal may allow design and fabrication of spectrally adjustable optofluidic photonic devices with a broad tuning range. This self-assembly process is completely reversible and can be controlled by modifying the diameter of the confining space. The period of the observed self-organizing periodic structure depends on the capillary diameter and varies in the range from 10 to even 60 mm. Additionally, the system is characterized by high refractive indices contrast as the refractive index changes between the nematic phase and the isotropic phase. It makes this structure a good candidate for being one of the components of systems intended for a mid-infrared spectral (MIR) region. However, this structure is not a perfect photonic crystal. Many parameters, such as the period of the structure, the refractive indices difference in or the ratio of the lengths of individual areas can vary quite randomly. Therefore, it should be expected that the fundamental and higher order Bragg reflections of the real one-dimensional photonic structure will be different than it results from the calculations made for the theoretical structure. Based on the actually registered one-dimensional photonic structures this work presents an analysis of the influence of individual factors on photonic band gaps (PBGs) in terms of spectral responses resulted from the light interaction with such a periodic medium. Fluctuations of the period and the ratio of the length of the areas characterized by higher and lower refractive index were analyzed. Additionally, an influence of attenuation and the refractive indices contrast ratio have been investigated.

Remote Bio-Detection of Buried Landmines by Luminescent Microbial Sensors

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Landmines and explosive remnants of war pose a global humanitarian problem which claims numerous casualties long after the conflict has ended. Current approaches for the location of landmines, such as metal detection, which require physical presence at the minefield, involve high risk to personnel; these methods are also costly, time consuming, and have a high rate of false-positive results. There is no currently viable technology for the remote detection of buried explosive devices. A possible solution may be provided by the use of genetically engineered microorganisms, molecularly "tailored" to emit an optical signal in the presence of trace explosives escaping for the landmine and accumulating in the soil above it. This optical signal, imaged from a remote location, can then serve to generate a physical map of the mine location. A few years ago, we described (Belkin et al, Nat Biotech. 2017, 35:308-310) the remote detection of buried landmines using alginate-encapsulated fluorescent microbial (Escherichia coli) bioreporters spread over the tested minefield. Since then, we have modified the system to one based on bioluminescent (rather than fluorescent) bacteria, and have employed several synthetic biology approaches to significantly enhance their major performance parameters: higher signal intensity, faster response time, and lower detection threshold of the target explosives. These molecular approaches and their effect on sensor performance will be described.

Polymer Optical Fiber-Based Plasmonic Biosensors for Medical Diagnostics

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In the last years, the classic geometries of sensors based on Surface Plasmon Resonance (SPR) have been adapted for optical fibers (both extrinsic and intrinsic configurations), thus providing a simple approach to low-cost plasmonic sensing. For instance, polymer optical fibers (POFs) are particularly advantageous due to their excellent flexibility, easiness of manipulation, great numerical aperture, large diameter and, last but not least, to the fact that plastic can withstand smaller bend radii than glass. In bio-chemical applications, a very specific medium (receptor layer) for the selective binding of the considered analyte is deposited on a gold layer of the SPR platform. A simple and low-cost experimental setup, consisting of a halogen lamp and a spectrometer, can be arranged to measure the light spectrum transmitted through the SPR-POF sensors. Interesting applications have been devised and successfully implemented exploiting these low-cost plasmonic POF platforms combined with different receptors, such as molecularly imprinted polymers (MIPs), chemical receptors, and bio-receptors (Aptamers and Antibodies). For example, exploiting SPR in a D-shaped POF probe with different receptors, interesting results have been achieved in medical diagnostics for cancer bio-markers detection, Celiac disease antigens monitoring, L-nicotine detection, thrombin detection, SARS-CoV-2 virus and Pancreatic Amylase detection. A survey of the above medical applications will be presented, highlighting the strengthness points and the limitations of each one, and pointing out the possible future implementations of the platform as point-of-care device, as well.

Electronic Versus Ionic Electroactive Polymers (EAPs) Strain Sensors for Wearable Electronics: A Comparative Study

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Electroactive polymer (EAP) strain sensors have gained appreciable attention as a potential candidate for their application in the area of soft electromechanical devices and have been widely used in soft-robotics, healthcare, augmented reality, and wearable devices. In this research, a systematic comparison has been made by fabricating the electronic and ionic types of capacitive EAP strain sensors. To accomplish this, a combination of silicone rubber sandwiched between silver-coated stretchable electrodes is used as an electronic type of EAP sensor, while a conducting and stretchable freestanding film consisting of SEBS rubber and DBSA-doped polyaniline composite film sandwiched between carbon grease electrodes is chosen as an ionic type of EAP sensor. Mechanical characterization in terms of the uniaxial tensile testing was performed on both types of sensors using our custom-made tensile testing system, while capacitance under reversible stretching and relaxation under variable strains was measured using a computer-controlled XY-stage and an electrometer. Constitutive equations based on various existing mathematical models were used for analyzing stress–strain curves obtained from uniaxial tensile testing for predicting the mechanical behavior of the sensor in multiaxial loading. The stress–strain curve for the electronic type of EAP sensor was fit with Ogden's second term, while Yeoh's third term demonstrated a very good agreement for the ionic type of sensors. It was found that the observed capacitance was dramatically enhanced for the ionic sensors, which was almost 1000 times higher compared to that observed for the electronic EAP-based sensors. Conducting fabric used as stretchable top and bottom electrodes limit the elasticity of the sensor, while the ionic type of sensor can be stretchable up to >200% compared to the fabric-based sensors.

Laser Spectroscopy and Gas Sensing Inside Novel Hollow Core Fibers

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Laser-based gas detection plays important role in various applications, including environmental monitoring, leak detection or industrial process control. In many sensing configurations sensitivity may be improved through increasing the effective sensing path length. This is usually accomplished with multi-pass cells. Alternative approach is to use hollow core fibers (HCF), which may provide better opto-mechanical and thermal stability and exceptional path-length to sample volume ratio.
During the conference I will present laser-based spectroscopy in the mid-infrared spectral region inside novel, silica-based anti-resonant (AR) HCF. The fibers have been fabricated using pure silica glass tubes and the stack-and-draw technique, and their structures were optimized for the mid-infrared transmission. Two sensor configurations will be discussed in which distribute feed-back (DFB) interband and quantum cascade lasers are used for trace gas sensing of methane (near 3.3 μm) and nitrous oxide (near 4.54 μm). For both gases detection limits down to parts-per-billion levels were obtained. In the case of methane detection, I will also present the result obtained during a week-long continuous monitoring of ambient air. With exceptional stability and sensitivity of the setup, diurnal changes in methane concentration could be observed. This experiment confirms suitability of HCF-based spectroscopic sensors for applications that require continuous concentration monitoring.

A microsystem for Vascularization Study

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Angiogenesis is the development of new blood vessels from the already existing vasculature.[1] Its course is controlled by many pro- and anti-angiogenic factors. Disorders of the distribution of these agents lead to the development of cancer and cardiovascular diseases qualified by the World Health Organization as the leading causes of death globally. Understanding the mechanisms regulating physiological and pathological angiogenesis will allow for more effective treatment. A simulation of angiogenesis under microflow conditions is a promising alternative to studies on 2D cell

The microsystem consists of two layers. The upper layer contains a mapped network of channels. It is made of PDMS with the use of a micro-milled stamp. The bottom layer (microscope slide) acts as a seal. The design of a microchip includes three parallel microchannels. Cylindrical microchannels seeded by Human Umbilical Vein Endothelial Cells (HUVECs) were generated by viscous finger patterning technique in the two lateral microchannels. Their diameter corresponds to the size of human arteries (701.5 ± 3.1 μm).

The ultimate procedure will enable the reconstruction of narrower blood vessels such as veins or capillaries. The middle microchannel allowed the introduction of a pro-angiogenic factor solution. The influence of Vascular Endothelial Growth Factor (VEGF) with a concentration of 50ng/ml, on the migration of HUVECs was verified. The spatial arrangement of the cells and their morphology was visualized by fluorescence and confocal microscopy.

The research conducted so far is the basis for developing more complex vascularized multi-organ-on-a-chip microsystems.

Twisted Microstructured Fiber with Core Created by Partially Open Rings of Holes for Bend Sensing

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We report on a phenomenon of light guidance in a fiber core created by an arrangement of holes making a partially open ring. The straight, non-twisted fiber with such a core cannot guide localized modes, because there is no complete refractive index barrier to confine them. However, if the core is shifted off the fiber symmetry axis and helically twisted during the drawing process, the mode confinement is observed in certain spectral range due to purely geometrical effect, i.e., the elongation of the optical path length in the region surrounded by air holes. We studied numerically and experimentally transmission properties of such fibers, including modal field distributions, short and long wavelength loss edge, polarization of eigenmodes and birefringence. All of the analyzed parameters can be modified to the great extent by the number of holes surrounding the core, holes size, thickness of glass bridges between the holes, helix pitch and the distance between the core and the fiber symmetry axis. We have also investigated the effect of bending on the transmission characteristics of the analyzed fibers. Because of helical twist, the core rotates with respect to the bending plane, which leads to periodic modulation of the mode confinement and consequently the bend-induced loss. Furthermore, we demonstrate a possibility of displacement measurements based on bend-induced loss using some of the fabricated fibers in which the sensitivity to bend is controlled by a twist rate and core structure.

The Color-Polarization Filter Array (CPFA) Sensors to Recognize Skin Lesions

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Early diagnosis of skin diseases, and specifically diagnosis of skin cancers, might have a crucial impact on people's health, providing the information enabling immediate implementation of the appropriate therapy, and, eventually, saving the patient's live. The automation of the diagnosis process based on image analysis is broadly exploited in current research. Among others, the methods of polarization analysis in imaging systems have been growing in popularity in recent years. The image processing supported by the light polarisation sensitive device has been used in numerous imaging applications, including medical imaging, machine vision, and autonomous vehicle navigation, to enumerate a few.

The main goal of this work is to develop a new solution for a comprehensive automated skin analysis system allowing the classification of skin lesions based on multimodal image data and deep machine learning models. The most important challenge of this research is to improve the sensitivity and specificity of the melanoma diagnosis, and, finally, determine the optimal configuration of the system for the acquisition of diagnostic data.

In particular, a specific setup for polarisation image analysis will be presented and discussed in the context of its sensitivity and applicability. Also, method of digital analysis and classification of acquired images will be presented and discussed in detail. As a part of this work, the possibility of using deep learning to enhance the recognition of human skin lesions was also investigated, with specific focus on optimizing the method of using available image data sets for the initial training of neural network models.

Acknowledgement: This work was funded within the *IDUB against COVID-19* programme, project "Diagnosis of tumor skin lesions in the conditions of limited social mobilty", granted by Warsaw University of Technology under the program Excellence Initiative: Research University.

Solid-State Laser Intra-Cavity Photothermal Sensor (SLIPS) for Gas Detection with Parts-Per-Billion Sensitivity

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We report a novel, miniaturized gas sensor configuration with ppbv (parts-per-billion by volume) sensitivity, where detection of the gas sample concentration is realized inside Nd:YVO_4/YVO_4/Air-Gap structure (2x2x14 mm^3) of the double-beam, monolithic diode-pumped solid-state laser (DPSSL) resonator operating at 1064 nm. Both generated *probe* and *reference* beams are passed through an ultra-compact sensing volume (4 µl) of the air-gap section filled with gas molecules. Simultaneously, an auxiliary laser beam is targeted absorption line of a measured gas sample and focused on a 1064 nm *probe* beam only. Due to the absorption effect, excited gas molecules are heated locally, resulting in a negligible change in a gas refractive index (RI), which is inherent to the photothermal effect (PT). Hence, the PT-induced variations of the gas RI inside the laser resonator are modulating the optical path-length of the *probe* beam, which resulted in a significant optical frequency shift of the *probe* beam against the *reference* one. The optical frequency changes were measured applying the heterodyne detection technique, where both 1064 nm beams were coupled onto the near-IR high-speed photodiode (PD) resulting in a beat note signal readout down-converted into the radio-frequency (RF) domain. The RF mixer was used to shift the beat note in frequency accordingly to the FM demodulator range. The demodulator converts the beat note frequency changes into a proportional voltage signal. To provide better gas sensor properties, a typical wavelength modulation spectroscopy (WMS) technique was additionally used. The solid-state laser intra-cavity photothermal sensor (SLIPS) is a unique approach to gas spectroscopy, which provides tens of ppbv sensitivity, more than 5000 signal-to-noise (SNR) ratio, baseline-free measurements, miniature, versatile and non-complex sensor setup based on inexpensive DPSSL technology. The SLIPS has no limitation in terms of the excitation wavelength because only one near-IR detector for signal retrieval is needed.

Temperature Sensing down to 4K with Erbium-Doped Tellurite Glasses

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Accurate determination of temperature is indispensable in many fields including medicine, military applications, and a variety of technological and industrial processes. This is particularly important where the use of conventional contact sensors is limited due to, for example, strong electromagnetic fields, high or low pressure, spatial limitations, etc. Under these conditions, an optical temperature sensor operating based on the luminescence/fluorescent intensity ratio technique (LIR/ FIR) is a viable alternative. The possibility to use the LIR/FIR technique for temperature sensing was described years ago, and this approach conventionally uses two thermally coupled energy levels of rare-earth ions incorporated into various matrices – usually in glass, ceramic, or crystalline host materials. The LIR technique is also inexpensive and resilient to disturbing effects such as excitation beam fluctuations, and also to photo-induced effects in the material. Ongoing research in optical temperature sensing focuses on the development of new, highly efficient materials, measurement accuracy improvements, on extension of the range of measured temperatures, and on reduction of production costs.

In this work, we prepared binary/ternary tellurite glasses: $PbCl_2$–TeO_2, WO_3–TeO_2, and $PbCl_2$-WO_3-TeO_2, doped with erbium ions at different concentrations with the aim of evaluating their potential for non-contact optical temperature sensing. With respect to temperature sensing, we demonstrate that the thermally uncoupled levels and Stark sublevels of Er^{3+} ions can be used, in addition to the thermally coupled levels. Optical properties of the investigated glasses depend on the concentration of erbium ions, which opens the possibility to optimize it for use in temperature sensing down to cryogenic temperatures (T>4 K).

Polypyrrole-Based Molecularly Imprinted Nanoparticles for the Chemosensing of Oestriol

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Molecular imprinting is a well-known technique that allows the recognition of certain compounds at the molecular level; however, the use of nanoparticles for such purposes is still novel. Our research was focused on the imprinting of oestriol, one of the major female sex hormones in the structure of conductive polypyrrole nanoparticles prepared based on recent studies.1,2 Imprinting the water-insoluble hormone was non-trivial; therefore, the applied procedure has been modified in order to adjust the conditions to the components used.
Polypyrrole nanoparticles were synthesised with the aid of micelles; therefore, the first step was to obtain micelles based on poly(maleic anhydride-alt-1-octadecene) and cross-link them with bis(hexamethylene triamine). After their preparation, monomer and template were added to the synthesis medium. Then, iron(III) p-toluenesulfonate was introduced to induce polymerisation of pyrrole and simultaneous imprinting of oestriol in MIP nanoparticles. Moreover, standard, non-imprinted nanoparticles without the template were obtained.
Purified MIP or NIP nanoparticles were then extracted with chloroform that dissolves the template and micelle components and eventually were drop-cast on the glassy carbon electrodes. The system prepared with electrodes covered with nanoparticles acted as a chemosensor for the sensitive and selective determination of oestriol. Oestriol was dissolved in acetonitrile containing supporting electrolyte and ferrocene – the redox probe providing an electrochemical signal governed by 'the gate effect' phenomenon.[3] The binding of oestriol to the MIP structure was manifested by the turn-off signal from a DPV peak current over a series of analyte additions, and only slight signal changes were observed on the NIP nanoparticle-modified electrode. Moreover, the fabricated chemosensor was selective towards the structural analogues of oestriol. In the presence of interferents, the chemosensor response was close to that of non-imprinted nanoparticles, which confirmed the high selectivity of the chemosensor.

Nanomaterials with Thermally-Activated Delayed Fluorescence for Sensing and Imaging: Challenges and Solutions

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Thermally activated delayed fluorescence (TADF) recently emerged as the most effective strategy to convert non-emissive triplet states in emissive excitons in OLEDs [1]. Due to its intrinsic mechanism, the TADF process results in a luminescence in the micro-to-millisecond timescale that is highly sensitive to external conditions, including polarity, temperature, or oxygen concentration. This provides an ideal platform to develop optical probes with long-lived luminescence for application in time-resolved optical imaging or in sensing of local temperature or oxygen concentration *in vivo* [2]. However, TADF molecules perform poorly in polar media, and additional steps must be taken to enable their use in biological applications. Herein, we describe how nano-aggregation and nanoencapsulation of TADF emitters in silica and polymeric nanoparticles can be effective straightforward methods to achieve TADF emission in water with high luminescence quantum yields and remarkable delayed-to-prompt fluorescence ratios and discuss the advantages and disadvantages of the different approaches. Through careful selection of optical probes and nanocarrier matrix, it is also possible to tune luminescence lifetime and oxygen permeability for optimal oxygen sensitivity in physiological conditions, as well as achieve luminescent probes with excellent biocompatibility and cellular uptake and distribution for application in fluorescence microcopy imaging [3,4].

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Acknowledgements
FCT is acknowledged for funding under grant SFRH/BPD/120599/2016 and project PTDC/QUI-QFI/32007/2017. Liga Portuguesa Contra o Cancro is acknowledged for funding under a Terry/Fox Research Grant

Poly(methylene blue)-Film Coated Carbon and MWCNTs Screen Printed Electrodes for Tyramine Detection

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Tyramine is a known biogenic amine commonly found in some fermented foods and beverages. Large amounts of food contaminated with tyramine can cause food poisoning and severe allergic reactions in the human body. A healthy person can intake about 200–800 mg with a single oral intake. However, higher concentrations of tyramine can cause food poisoning and health problems if the concentration is exceeded. In this case, it is extremely important to detect and quantify the tyramine content in food samples to ensure food quality. In the present work, we developed a poly (methylene blue) film (PMB)-modified carbon and multi-walled carbon nanotubes (MWCNTs) screen-printed electrode for rapid and timely tyramine analysis. The proposed sensor is used for the oxidation of tyramine by electrochemical techniques such as cyclic voltammetry and differential pulse voltammetry (DPV). The electrochemical techniques were performed with tyramine under optimal conditions, such as supporting electrolyte, pH, working potential window, and scan rate. The PMB-modified electrode showed an oxidation potential of tyramine of 0.68 V in phosphate buffer solution (0.1 M PBS, pH 7.4) at a scan rate of 50 mV/s. The plain screen-printed electrode showed an oxidation potential of tyramine of 0.9 V with a lower current response under the same experimental conditions. The modified method can detect tyramine over a wide linear range from 0.29 µM to 3.3 µM by DPV and 9.9 µM to 48.53 µM by cyclic voltammetry, with a low detection limit of 0.096 µM (S/N = 3). Based on the voltametric results, it was concluded that the developed modified electrodes provide accuracy, rapid analysis, selectivity, and reproducibility for tyramine analysis.

Abstracts II

Poster Exhibition

Poster Session – Monday, 20 June 2022; 18:00-20:00h

P1. **Marko Boskovic** Humidity and CO2 sensing by graphene film based sensor obtained by liquid phase exfoliation

P2. **Francesco Arcadio** - Plasmonic Sensors based on Plastic Light - Diffusing Fibers.

P3. **Maciej Cieplak** - Molecularly imprinted polymer based capacitive chemosensor for determination of heterocyclic aromatic amines in food samples

P4. **Christine Bauer** Detection of Foreign Items in Laundry Industry – a Dual Energy XRT approach

P5. **Szymon Baczyński** Novel, electrically-controlled periodic optical structures in the LC:PDMS architecture

P6. **Sylwia Karoń** Development of functional receptor layers based on DNA-directed immobilization for the SPRi immunosensing of viral infection biomarkers

P7. **Marcin Drozd** Miniaturized immunoplatforms supporting the diagnosis of lung cancer biomarkers and immunotherapies

P8. **Polina Ivanova** Nanozyme-based electrochemical immunodetection of genetic biomarkers of SARS CoV-2

P9. **Katarzyna Tokarska** A fully integrated microfluidic-based POC device for COVID-19 testing

P10. **Ewa Kobylska** Studies on recombinant insulin analogs interactions with partner cell membrane receptors using the SPR technique

P11. **Michał Dudek** Evaluation of thermo-optical properties of selected liquids by photonic crystal fiber based sensor

P12. **Anna Kurzych** Development of 3-Axis Fibre-Optic Seismograph for direct and autonomous monitoring of rotational events

P13. **Chun-Chi Chen** CMOS Delay-Line-Based Smart Temperature Sensor

P14. **David Valiente** Time degradation analysis of organic solar cells based on ITO / PEDOT:PSS / P3HT:PCBM / Al structure

P15. **Krzysztof Herman** Sensor actuator network for in situ studies of antarctic plants physiology

P16. **Tetiana Manyk** Theoretical study of the effect of stresses on the effective masses in the InAs/InAsSb type-II superlattice

P17. **Anna Kiczor** Comparison of the properties of PMMA layers containing an organic dye and CdSe quantum dots for sensor applications.

P18. **Magdalena Flont** A Body-on-a-chip microfluidic system for the analysis of inflammatory processes in the cancer microenvironment.

P19. **Anna Szymczyk** Electrochemical detection of SARS-CoV-2 genetic markers using DNA biosensor based on stem–loop probe

P20. **Jacek Majcher** Point measurements of soil moisture using TDR technique - comparison of probes

P21. **Milija Sarajlic** Humidity and CO2 sensing by graphene film based sensor obtained by liquid phase exfoliation

P22. **Patrycja Sokołowska** 5-hexadecanoyloxyoctadecanoic acid (5-PAHSA) as a potential therapeutic agent in diabetes? - preliminary studies using the newly developed, fully functional Islet-on-chip model

P23. **Katarzyna Kurzątkowska-Adaszyńska** Electrochemical aptasensors as an ultra-sensitive tool for the detection of antibiotics after cattle antibiotic therapy

P24. **Bartosz Sakowicz** Towards to automatic correction of unwanted artifacts observed in digital data continuously recorded by a rotational seismograph

P25. **Iason-Ioannis Panagos** Tracking Multiple Instances of Retail Consumers from RGB and Thermal Images

P26. **Joanna Korec** SPR sensor based on tapered optical fiber with a low refractive index liquid crystal cladding

P27. **Monika Żuchowska** Threshold volatile organic compounds sensor based on polymer microtip

P28. **Karol Stasiewicz** Research on optical properties in a tapered optical fiber with higher alkanes cladding doped with Fe3O4 nanoparticles

P29. **Deuk Ju Lee** Compact Camera Fluorescence Detector for Real-Time PCR Devices Using a Parallel Light Lens

P30. **Tomasz Grzywacz** Gas chambers shape design for electronic nose

P31. **Angelos Stamou** Implementation of a smart lifejacket for assisting the evacuation process on large passengers ships

P32. **Ji-Soo Hwang** An impedance-based label-free polymerase chain reaction chip and detection system

P33. **Spela Trafela** Portable, highly sensitive and selective electrochemical biosensors for SARS-CoV-2 detection

P34. **Rafał Tarakowski** Electronic nose designs for Dendrolimus pini odour detection

P35. **Katarzyna Tokarska** A fully integrated microfluidic-based POC device for COVID-19 testing

P36. **Kristina Zagar** Soderznik Indirect detection of acrylamide using novel biosensor element

P37. **Arjan Lock** FBG-based sensing of the back during gait cycle

P38. **Piotr Garbat** Application of polarization sensing for detection in scattering media

P39. **Andrzej Olszewski** Well-secured tests of innovative hydrostatic levelling system

P40. **Jelena Stevanovic** Humidity and CO2 sensing by graphene film based sensor obtained by liquid phase exfoliation

P41. **Trang Anh Nguyen** Cell counting in silicon nanosensor for CAR T-cell therapy monitoring

P42. **Ángel Solé Morillo** PPG EduKit: An Adjustable Photoplethysmography Evaluation System for Educational Activities

P43. **Filip Łabaj** Design and development of a miniature mid-IR spectrometer for environmental sensing and food safety applications

P44. **Diogo Gará Caetano** Public Lighting Recognition System based on Colored Reflection Index and Computational Machine Learning

P45. **Ester Catalano** Distributed liquid level sensor based on Brillouin sensing and active thermometry.

P46. **Wojciech Żołnowski** Multispectral portable optical fiber reflectometer.

P1. Humidity and CO_2 Sensing by Graphene Film Based Sensor Obtained by Liquid Phase Exfoliation

Milija Sarajlic, Marko V. Bošković, Stevan Andric, Jelena N Stevanovic, Marko Spasenovic, Ivana Jokic

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Detection of humidity levels is a very important and ubiquitous process in the many fields of human activity. Medicine, various types of industry, weather forecast and everyday life require humidity sensing as an important information for decision making and monitoring of future trends. In this presentation we will show our work in the development of humidity sensor based on ultra-thin graphene layer obtained by liquid phase exfoliation. The fabricated sensor showed very good responsivity on various humidity levels, at the same time having very short response and recovery time. The sensor was also capable of detecting human finger proximity thus opening the possibility to be used in touch screen applications. Detection of CO_2 levels was achieved by the sensor made out of sulfonated polyaniline (PANI)-functionalized graphene layer. The sensor was capable of detecting low CO_2 levels, between 300 ppm and 10 000 ppm, while at the same time showing a full dynamic range, from zero to 100% CO_2 in the atmosphere at the normal conditions (1 bar, 20 °C). In the same development we have applied a specially devised numerical analysis by which it was possible to obtain a real-time read-out of the adsorption based sensor. This will be shown in this presentation.

References
[1] Andric et al., Nanotechnology 32 (2020) 025505 (8pp) https://doi.org/10.1088/1361-6528/abb973
[2] Andric et al., Chemosensors 2021, 9, 342. https://doi.org/10.3390/chemosensors9120342

P2. Plasmonic Sensors based on Plastic Light-Diffusing Fibers

Nunzio Cennamo[1], Francesco Arcadio[2], Domenico Del Prete[2], Aldo Minardo[2], Luigi Zeni[2]

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A very simple to realize, low-cost, and highly sensitive plasmonic sensor, based on a polymeric light-diffusing fiber (LDF), is presented. The proposed surface plasmon resonance (SPR) sensor is realized by sputtering a gold nanofilm on an LDF made of PMMA. More specifically, a plastic LDF manufactured by GLOBAL ENGINEERING NETWORK SRL (Dosson di Casier, Italy) has been used to realize this sensor. The optical fiber is a uncladded POF, with a simil-PMMA core of about 1600 µm in diameter, and a removable jacket of about 400 µm (total diameter of about 2 mm). The SPR sensor is achieved by removing the jacket with a mechanical stripper and covering the exposed LDF surface with a 60 nm thick gold film for a length of about 120 mm. The obtained sensor's sensitivity varies linearly with the refractive index and it ranges from about 1000 (nm⁄RIU) to almost 3000 (nm⁄RIU) in the considered refractive index range (from 1.332 RIU to 1.392 RIU). The obtained sensitivity values are comparable with those achieved by other SPR optical fiber sensors, but with the advantage of a very simple production process, which does not require optical fiber modifications (such as polishing process, tapering process, etc). So, the proposed LDF-based plasmonic sensor could be used to realize novel kinds of optical biosensors and chemical sensors.

P3. Molecularly Imprinted Polymer Based Capacitive Chemosensor for Determination of Heterocyclic Aromatic Amines in Food Samples

Viknasvarri Ayerdurai[1], Maciej Cieplak[1], Alvaro Garcia-Cruz[1], Joanna Piechowska[1], Krzysztof R. Noworyta[1], Agnieszka Pietrzyk-Lee[1], Francis D'Souza[2], Wlodzimierz Kutner[1,3], Piyush Sindhu Sharma[1]

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Quinoxaline heterocyclic aromatic amines (HAAs), are formed during meat and fish cooking, frying, or grilling at high temperatures. They are usually generated at very low concentrations (~ng per g of a food sample). However, they are classified as potent hazardous carcinogens. This is because HAAs may effectively damage DNA due to intercalation or strand break. Hence, chronic exposure to HAAs, even in low doses, can lead to the lung, stomach, and breast cancer. HPLC comonly applied for the determination of HAA toxins in food matrices. However, this technique is expensive, tedious, and time-consuming. Therefore, fast, simple, inexpensive, and reliable HAAs determination procedures are in demand.

Molecularly imprinted polymers (MIPs) are excellent examples of bio-mimicking recognition materials. Therefore, they have found numerous applications in selective chemosensing. Within the present research, we shave synthesized a nucleobase-functionalized molecularly imprinted polymer (MIP) as a selective recognition unit of an electrochemical sensor for determination of 2-amino-3,7,8-trimethyl-3H-imidazo[4,5-f]quinoxaline (7,8-DiMeIQx) HAA. MIP-(7,8-DiMeIQx) film-coated electrodes were highly sensitive and selective to 7,8-DiMeIQx. The linear dynamic concentration range of the devised capacitive chemosensor extended from 47 to 400 µM of 7,8-DiMeIQx, and the imprinting factor was high, IF = 8.5. The MIP-(7,8-DiMeIQx) film-coated electrodes succefully applied for 7,8-DiMeIQx determination in meat samples.

Acknowledgments: We thank The National Science Centre (NCN) of Poland for financial support (grant no. 2018/31/D/ST5/02890 to MC.) Moreover, the present research was partially funded from the financial resources for science in 2017-2021, awarded by the Polish Ministry of Science and Higher Education to implement an international co-financed project. Furthermore, the present publication is part of a project that has received funding from the European Union's Horizon 2020 Research and Innovation Program under the Marie Sklodowska-Curie grant agreement no. 711859.

P4. Detection of Foreign Items in Laundry Industry – a Dual Energy XRT approach

Christine Bauer, Dr. Rebecca Wagner, Johannes Leisner

Fraunhofer IIS, Fraunhofer Institute for Integrated Circuits IIS, Division Development Center X-Ray Technology

Not only in times of a global pandemic, the proper cleaning of professional work wear is crucial – thus, laundry technology becomes more and more efficient and automated. A bottleneck in the professional laundry process of working garments is the detection of foreign items in pockets and belts: undetected items may not only stain the clothes, but also harm the laundry machines and cause malfunctions or damages. However, also the process of locating them is potentially dangerous, as state-of-the-art is the manual scanning of every piece of garment to find items like scissors, highlighters, syringes, screwdrivers, scalpels, paper notepads and sweets. Some of the found objects are completely harmless, but several bare a high potential of injury for the worker involved in the laundry process. Due to the variety of the objects' materials – plastics, paper, metal, and glass – the items are very challenging to detect with conventional sensors such as cameras or metal detectors. In non-destructive testing, X-ray transmission (XRT) proved to be a powerful tool for detecting items inside of objects that cannot be found by superficial sensors. Unfortunately, XRT does not allow to distinguish between thick objects of low X-ray attenuation and thin objects of stronger attenuation. Thus, similar gray values may be detected, for instance, for components of clothes like reflective stripes and pens. In this case, a segmentation by simple thresholding would be hopeless. In contrast, dual energy XRT allows obtaining quantitative information concerning the chemical composition of the scanned materials, which helps to identify objects. In this study, different kinds of working garments were loaded with realistic foreign items to show the potential of dual energy XRT in the laundry industry.

P5. Novel, Electrically-Controlled Periodic Optical Structures in the LC:PDMS Architecture

Szymon Baczyński [1], Katarzyna Rutkowska [1], Piotr Sobotka [1], Kasper Marchlewicz [1], Artur Dybko [1], Marcin Juchniewicz [2]

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Optofluidics is a constantly developing research area combining technologies known from chemistry and photonics. Various systems are created, which are used, among others, in biology or chemistry. The combination of such materials as PDMS and liquid crystal gives a lot of possibilities to create functional structures. The properties of LC allow developing systems in PDMS, e.g., the lens with different focal lengths depending on the polarization of light or multiplexers are proposed. Appropriate control of LC molecules orientation is a crucial element in creating tunable systems. The motivation of the research is the proper arrangement of the electrode array to control the orientation of liquid crystal molecules and thus the refractive index. The performed tests allowed to determine the initial parameters to produce LC:PDMS structures with the periodic orientation of LC molecules. As the channel sizes have to be of micrometer-scale, a proper electrode arrangement has to be developed. The materials from which electrodes could be created are also limited due to PDMS properties and the size of the channels. The plan is to create a tunable LC:PDMS structure with periodic reorientation of the LC molecules, which would allow the system to function as a tunable Bragg grating. It would be the first achievement of this kind, and it would open up new possibilities for the combination of liquid crystal and PDMS in photonic systems.

This work was supported by the FOTECH-1 project “Electrically-driven waveguiding systems in LC:PDMS structures” granted by the Warsaw University of Technology under the program Excellence Initiative: Research University (ID-UB).

P6. Development of Functional Receptor Layers Based on DNA-Directed Immobilization for the Spri Immunosensing of Viral Infection Biomarkers

Sylwia Karoń, Marcin Drozd, Elżbieta Malinowska

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The viral ability of fast adaptation and spreading has led to the most significant health struggle of the world in the past 100 years - the outbreak of pandemics. Therefore, reliable immunodiagnostics of viral infection and immunological methods that enable rapid adjustment and development of receptor layers for detecting the viral biomarkers are critical in the case of future needs. The research aims to design a microarray for immunodiagnostics and profiling of the human response to viral infections. One of the basic and at once the most challenging steps in forming the microarray is an effective immobilization of the receptors, which is crucial to obtain the robust receptor layer.

In the presented study, immobilization was based on DNA hybridization. Model biomarkers of viral infections (recombinant SARS CoV-2 nucleoprotein antigen and monoclonal antibody against human C-reactive protein) were conjugated with DNA oligos (ssDNA anchors) to obtain functional conjugates, capable of the facile assembly via "click-biology" approach, called DNA-directed immobilization [DDI]. DNA-protein conjugates were purified through ionic chromatography and immobilized on the gold surface covered with complementary sequences of DNA or its analogues (peptide nucleic acid, PNA, and zipped nucleic acid, ZNA). Surface plasmon resonance imaging [SPRi] measurements were chosen to assess the efficiency of DNA-directed immobilization as well as the performance of the obtained immunoassay. Basic parameters influencing the properties of receptor layers, e.g., the length and the type of nucleic acid used as an immobilization probe, the surface density of the layer, and kind of anti-fouling agent, were assessed in terms of the immunoplatform stability and sensitivity as well as the capability to preventing non-specific adsorption.

This research is supported by the project "ImGen" funded by the National Centre for Research and Development in Poland (grant no. POIR.01.01.01-00-0638/20).

P7. Miniaturized Immunoplatforms Supporting the Diagnosis of Lung Cancer Biomarkers and Immunotherapies

Marcin Drozd[1, 2], Polina Ivanova[1, 2, 3], Sylwia Karoń[1, 2], Adrian Duszczyk[1, 2], Katarzyna Tokarska[2], Elżbieta Malinowska[1, 2]

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Immunotherapy is an innovative strategy of cancer treatment that activates the immune system, which enables natural anti-cancer defense mechanisms. Although the large-scale use of immunological treatment remains hope for the future, immunotherapy already plays a practical role in the cancer treatment. Lung cancers have been selected as the main subject of interest. The aim of the presented research is to explore innovative methodology for rapid determination of protein antigens by means of miniaturized immunosensing platforms. One of the key elements of such diagnostic approach is the determination of PDL1 and/or HER2 expression directly on cancer cells or in biofluid samples. As a principle, the developed method should act as a support or alternative to assessment of tissue sections after immunohistochemical staining or classical ELISA assays. The idea covers the utilization of biosensing platforms based on flexible substrates, e.g., poly(ethylene terephtalate) foils or antibody-binging membranes made of nitrocellulose/PVDF for sensitive detection of lung cancer biomarkers. As a result, it would be possible to globally assess the occurrence of biomarkers (e.g., PDL1 epitopes). The detection process consists of instrumental readout using optical techniques (spectrophotometry or fluorometry).
Main specific goals of the presented research will be: i) characterization of antibody–protein antigen interactions and selection of the best immunosensing formats; ii) selection of the most attractive epitopes as sensing targets; and iii) characterization of the analytical performance of the developed immunosensing platforms for the detection of PD-L1 and/or HER2 biomarkers. Taking into account the benefits, we put forward the thesis that proposed research will allow us to broaden the knowledge about cancer diagnostics and allow us to propose a quantitative methodology for determining various epitopes of cancer cells.
This research was funded by IDUB BIOTECHMED-1 project granted by Warsaw University of Technology under the program Excellence Initiative: Research University (IDUB).

P8. Nanozyme-Based Electrochemical Immunodetection of Genetic Biomarkers of SARS Cov-2

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Recently, the need for a detection of SARS-CoV-2 has increased greatly. Methods used for this purpose should be fast, sensitive, selective, and user friendly. One of the most popular methods of detection of genetic biomarkers is based on a Real-Time Polymerase Chain Reaction (RT-PCR). Enzyme-linked immunosorbent assay (ELISA) in a sandwich format seems to be an interesting alternative with a low limit of detection, high sensitivity, and selectivity, and can be used for labelled amplicons specific for SARS CoV-2, obtained in PCR amplification process. Horseradish peroxidase (HRP) is a commonly used enzyme label in such assays. However, multifunctional nanozymes can replace natural enzymes, especially for such assays, as numerous types of noble metal nanoparticles can mimic the activity of HRP. Nanozymes are more stable in wide range of pH and temperature, cheaper to produce, and do not require special storage conditions in comparison to HRP.

In this work, we present multimetallic nanoparticles-based platform which can be used for electrochemical immunodetection of genetic biomarkers of SARS CoV-2. Magnetic nanocore was decorated with platinum and gold nanoislands forming nanoparticles, in which Pt promotes HRP-like catalytic activity and Au facilitates conjugation with antibodies. Multimetallic nanozymes give us an opportunity to combine peroxidase-like activity, capability of bioconjugation with specific antibodies and susceptibility to magnetic separation. As a result, nanoparticle-based ELISA was constructed using multifunctional nanoparticles as reporters. The developed, versatile platform can be also functionalized with various immunoreceptors and thus adapted for the electrochemical or optical detection of other, relevant antigens.

This work is implemented as a part of Operational Project Knowledge Education Development 2014–2020 co-financed by European Social Fund, Project No POWR.03.02.00-00-I007/16-00 (POWER 2014-2020).

This research is supported by the project "ImGen", funded by the National Centre for Research and Development in Poland (grant no. POIR.01.01.01-00-0638/20).

P9. A Fully Integrated Microfluidic-Based POC Device for COVID-19 Testing

Katarzyna Tokarska[1], Kamil Zukowski[1], Marcin Drozd[1], Kasper Marchlewicz[1], Polina Ivanova[1], Mariusz Pietrzak[1], Adam Nowiński[2], Zbigniew Brzozka[1,3], Elzbieta Malinowska[1,3]

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Since the severe acute respiratory syndrome (SARS-CoV-2) was revealed in Wuhan in 2019, it has rapidly spread around the world causing severe mortality, economic crisis, and bringing challenges to the public health, diagnostics, and medicine. The shortage of diagnostic facilities, insufficient number of test kits and laboratory supplies have highlighted an urgent need of microfluidic-based point of care devices for the detection of COVID-19.
POC devices, especially utilizing microfluidics, are portable, sensitive, selective, and cost-effective platforms which eliminate sample transport to the centralized clinical laboratories. Herein, we present a fully integrated microfluidic-based POC device which enables testing COVID-19 in terms of active viral infection and serological (antigens/antibodies) detection. The presented system consists of microfluidic reusable cassette and reader device. The construction of the cassette is multi-layered and assumes the use of PET foils. Each layer of the cassette includes CO2 laser-cut network of microfluidic channels/chambers which have different functionalities. The bottom layer of the cassette is custom-made screen-printed layer with electrodes responsible for the voltammetric measurement. The next layer is the substrate for the immobilization of antibodies/antigens. The remaining layers enable the transport of the fluids to reaction and detection zones to finally reach the waste reservoir. The sample along with all necessary reagents is stored in special tanks placed in the cassette cap, which represents its upper part. After placing the sample into the disposable cassette, all operations are performed automatically by a micromechanical module placed in the reader device.
Using the developed diagnostic system, the determination of SARS-CoV-2–related analytes was possible. The presented microfluidic-based platform is characterized by high versatility. It can be simply adjusted to determine various entities by selecting the appropriate immobilization materials and technology. At the same time, the production technology is characterized by high efficiency at a low unit cost.

P10. Studies on Recombinant Insulin Analogs Interactions with Partner Cell Membrane Receptors Using the SPR Technique

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The rapid progress in the field of chemical sensors made it possible to carry out quick, accurate, and precise monitoring of interactions between biological compounds, enabling the development of models describing the processes occurring at the cellular level. Measurement techniques utilizing biosensors coupled with optical detection play a special role in this type of research. Label-free techniques, such as surface plasmon resonance, are particularly useful for studying intermolecular interactions in real time and for determining thermodynamic parameters characterizing them.

The study presented in this work concerns the use of the surface plasmon resonance (SPR) technique for the evaluation of biological activity and potential mutagenicity of recombinant insulin analogs exhibiting prolonged time of action (compared to human insulin)—innovative drug candidates for the treatment of diabetes. The aim of the project was achieved by the analysis of kinetic parameters describing interactions of cell surface receptors with a wide range of recombinant proteins with amino acid sequences that differ from the natural hormone in only a few positions.

The presented results include the construction of the receptor layer with immobilized membrane receptors, obtained by their covalent conjugation with -COOH terminated SPR chips. The selection of appropriate parameters of the conjugation process with the use of carbodiimide chemistry allowed to obtain good-quality layers with a sensitivity enabling direct monitoring of the interactions of the receptor with insulin and its analogues. The research covers the optimization of the receptor layer to reach high ligand surface density. The results of molecular modelling with the use of the obtained kinetic curves for the interaction of insulin and long-acting analogues were also shown. Determined kinetic parameters (especially KD) became the starting point for the comparative characteristics of interaction of studied proteins with insulin receptor.

P11. Evaluation of Thermo-Optical Properties of Selected Liquids By Photonic Crystal Fiber Based Sensor

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Thermo-optical properties of liquid materials are very important in many practical applications. Temperature dependence of the refractive index (RI) is usually sufficient to fully characterize a given material, however, for some applications an extinction coefficient (EC) temperature dependence has a great influence on the optical properties of the sensor's transducer. Our previous studies have shown that light wave propagation properties in a large mode area (LMA) photonic crystal fiber (PCF) partially filled with liquid strongly depend not only on its RI, but also on the state of matter - either liquid or solid - which also determines its EC. Therefore, high absorption of the filling material significantly reduces intensity of light passing through the PCF. In the presented work we studied commercial PCF (LMA-10) partially filled with liquid paraffin. Recorded light transmission within the temperature range of 20 °C - 120 °C allowed us to observe changes in the propagation conditions of such hybrid PCF transducer, when the light transmission was supported either by index-guiding and bandgap-guiding mechanisms, depending on the paraffin's RI. Furthermore, as the RI of the paraffin approached the RI of the PCF, we observed lack of the transmission and then the propagation changed between the index-guiding and the bandgap-guiding conditions. The transmission in the bandgap-guiding region was reduced in comparison with the transmission in the index-guiding region. This can be caused by the difference of EC of paraffin in the two guiding regions. In our numerical simulations we analyzed the influence of this parameter on the transmission losses by changing values of the EC to match them with the experimental results. Hence we were able to obtain its value, which was not previously reported. The presented studies provide not only an insight into material properties of paraffin, but also pave the way for PCF-based RI sensors.

P12. Development of 3-Axis Fibre-Optic Seismograph for Direct and Autonomous Monitoring of Rotational Events

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The era of optical fiber sensors began over 50 years ago with the non-contact vibration monitoring sensor based on bifurcated fibre bundles (U.S.03327584; 1967). The first single-mode optical fibres have appeared a decade later which raised possibility to design interferometers which promised immense engineering benefits compare to their free space precursors bolted on optical tables. Immunity to electromagnetic interference, minimal invasiveness and lightweight belong to a wide range of the optical fibre sensors benefits. The fibre-optic gyroscope (FOG) based on the Sagnac interferometer is today arguably the most successful fibre sensor technology. The Sagnac effect makes it possible to obtain directly information about the component of the angular movement perpendicular to the sensor plane.

The paper presents historical perspective of the fibre-optic seismographs designed and constructed in the Institute of Applied Physics at Military University of Technology, Poland based on the so-called the minimum configuration of FOG where the Sagnac effect produces a phase shift between two counter-propagating light beams proportional to the measured rotation speed as well as specific electronic solutions which calculate and record rotational events data. The briefly presented history which has been originated in the nineties by the system named GS-13P laid solid foundations for construction of the 3-Axis Fiber-Optic Seismograph. The presented system meets all technical requirements of rotational seismology in terms of measurement parameters (measuring range from several dozen nrad/s to 10 rad/s and frequency from 0.01 Hz to 100 Hz) and utility parameters (mobility, autonomy, power independence, environmental stability). The presented device provides universal application both for research in engineering applications (high buildings, chimneys, wind towers) and in seismological research.

P13. CMOS Delay-Line-Based Smart Temperature Sensor

Jiou-Yi Yang [1], Chih-Hui Liu [2], We-Ting Kuo [1], Chun-Chi Chen [1]

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A delay-line-based smart temperature sensor (STS) in the all-digital CMOS circuit is presented. With the tremendous growth in the thermal monitoring and management for the consumer electronics industry, the market of CMOS STSs has grown substantially. Time-domain STSs with a temperature-to-time generator and a time-to-digital converter (TDC) were invented to substantially reduce circuit complexity and cost compared with voltage-domain STSs with an analog-to-digital converter. First, an inverter-based delay line or oscillator generated a temperature-sensing time proportional to absolute temperature (PTAT). Then, a complex pulse-shrinking unit for high time resolution or a complicated time amplifier for time amplification was used to achieve satisfactory sensor resolution. In this abstract, a concise structure only using a CMOS delay line and a counter-based TDC is proposed to fulfill the extremely simple STS with good circuit area, resolution, and inaccuracy. A long channel length of the MOS transistor is helpful to obtain a sufficient PTAT time. Further, the typical 3-input NAND gate instead of the original inverter used in the delay line is adopted to improve circuit area and temperature-sensing time. Thus, the presented NAND-based delay line is good enough as the temperature-to-time generator. By using a reference clock and a simple AND gate as the TDC, the generated PTAT time can be converted into the digital value. The all-digital STS was implemented in a 0.35-µm TSMC CMOS process and occupied a layout area of nearly 0.11 mm2, which achieved an area improvement of 25% compared with the inverter-based version. With a resolution of 0.25 °C, the maximal inaccuracy was simulated to be around 1.5 °C for a range of 0-80 °C. With such a simple structure, the CMOS STS functions successfully with satisfactory performance while fully synthesizing for future VLSI integration.

This work was financially supported by Ministry of Science and Technology (MOST) of Taiwan for Grant MOST 110-2221-E-992-094 and Shu Zen Junior College of Medicine and Management for Grant SZM11008027. The authors would like to express their appreciation to Taiwan Semiconductor Research Institute (TSRI) for supporting EDA tools.

P14. Time Degradation Analysis of Organic Solar Cells Based on ITO / PEDOT:PSS / P3HT:PCBM / Al Structure

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Nowadays, energy consumption has increased exponentially over the last decades. This fact reflects on the price of the electrical energy. Consequently, the scientific community has concentrated on generation procedures from renewable sources. In this sense, the efficiency of conventional photovoltaic cells and the emergence of new organic and hybrid materials have substantially improve photovoltaic generation and its Power Conversion Efficiency (PCE).

The interest in organic cells has been justified by their beneficial properties: ease of processing, low cost, flexibility and low weight. Recently, the increasing PCE evolution has been higher than that of the classical technologies, reaching values up to 17.5%. Notwithstanding that, there are still several challenges to deal with. Amongst them, there is the timelife of these devices. In certain contexts, the fabrication conditions and their associated parameters constraint the time degradation of the physical properties of the organic device.

This study assesses how time degradation affects organic cells, in which certain fabrication parameters were varied. In particular, this work evaluates cells with the following structure: ITO / PEDOT:PSS / P3HT:PCBM / Al. The analysis focused on parameters such as: PEDOT:PSS solution volume, P3HT:PCBM solution ratio, solution temperature and layered dopants. The results obtained in terms of PCE, V_{oc} and I_{sc}, provide insights on the possible dependences for the timelife degradation. Finally, in light of the results, this work proposes several analytical models that aid in the fitting of the degradation curves for the studied materials and their fabrication parameters.

P15. Sensor Actuator Network for in Situ Studies Of Antarctic Plants Physiology

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The poster presents, in details, a custom implementation of a sensor actuator network for in situ studies of antarctic plants physiology. At the beginning our work talks about the importance of the studies, of the antarctic plants, in the context of the ongoing climate change, where the plants are considered to be bio indicators of this process. The goal of those studies is to simulate the future climatic conditions by means of usage of special, greenhouses and to measure the plants physiology under the altered conditions. The greenhouses, also called OTC (Open Top Chamber) elevate the temperature inside the chamber a few degrees of Celsius during the daytime (in reference to the outside air temperature). During the nighttime the same effect can only be achieved using some external heat source and this is the moment, where the idea of our system arises. In the technical part we speak about the system architecture and topology of the proposed solution: a distributed sensor actuator network, which consists of 90 infrared sensors and 30 thermal actuators, which monitor and alter the plants temperature. In last part we present some data collected during the antarctic summer in the seasons 2019-2022 in the vicinity of the Polish Antarctic Station “Arctowski” situated on King George Island, South Shetlands.

P16. Theoretical Study of the Effect of Stresses on the Effective Masses in the Inas/Inassb Type-II Superlattice

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A^3B^5 materials used in the construction of a superlattice have a properties enable the design of devices optimized for use in infrared detection. These devices are used in the military, industry, medicine and in other areas of science and technology.

The paper presents the theoretical assessment and analysis of the impact of stresses in InAs/InAsSb type-II superlattice (T2SL) grown on GaSb buffer layer on the band gap energy and on the effective masses at the temperature 150 K. The theoretical research was carried out with the use of the commercial program "SimuApsys" (*Crosslight*). The method kp 8·8 (k = 0.06) was adopted in T2SL modeling. Luttinger coefficients (γ_1, γ_2 and γ_3) were assessed assuming the Kane coefficient F = 0. The band gap energy of InAsSb ternary materials was determined assuming that the bowing parameter for the above-mentioned temperature is b_g=0.75 eV. The cut-off wavelength values have been estimated on the basic of theoretically determined absorption coefficients (α). The energy gap energy was calculated according to the following formula: . From the analysis of theoretical results, it can be concluded that the stresses in T2SL cause the E_g shift, which also has an impact on the influence on the change of the effective masses m_e and m_h, which play an important role for the optical and electrical parameters of the detection structure. The simulated theoretical parameters T2SL at 150 K are comparable to those measured experimentally.

P17. Comparison of the Properties of PMMA Layers Containing an Organic Dye and Cdse Quantum Dots for Sensor Applications

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In recent years, fiber optic sensors have been increasingly used in a wide variety of industries. Compared to traditional electronic sensors, they have numerous advantages which make them preferable to specific applications. First of all, they ensure much greater sensitivity, resolution and dynamic range. Due to the extremely small size of the active part, it is possible to produce sensors of very small dimensions. The matrix with the active part can be applied to the front of the optical fiber, then the sensor works by using the wave reflection phenomenon (external sensors) or by covering the side surface and using the evanescent wave (internal sensors). Layers were made of PMMA polymer as a carrier for the active dye (methyl red) and CdSe quantum dots. The smallest quantum dots can be obtained by precipitating semiconductor crystals from a solution in a liquid. Usually, compounds of elements from groups II and IV as well as groups III and V are used for the production of quantum dots. By manipulating the shape and size, one can influence their properties, including the phenomenon of luminescence in a specific way needed for a given application. They are characterized by high quantum efficiency, extremely narrow bands of photoluminescence emission. Compared to standard organic dyes, they have a long fluorescence lifetime, very high stability and resistance to photobleaching.

Quantum dots will be synthesized using the colloidal method, and then introduced into the liquid polymerization mixture, from which, after polymerization, a uniform layer should be formed. The indicator dye will be directly added to the polymerization mixture, placed in the ultrasonic bath and deposited on the slide. The paper presents the absorption and emission spectra of the produced structures as well as optical characteristics of the produced polymers.

P18. A *Body-On-A-Chip* Microfluidic System for the Analysis of Inflammatory Processes in the Cancer Microenvironment

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Metastasis of cancer cells to various organs in the human body is a significant oncological problem. The mechanisms that activate the invasion of cancer cells, are not well understood. The research on the processes of cancer invasion is limited under laboratory conditions, because there are still few biotechnological solutions developed to conduct advanced, three-dimensional (3D) cell cultures *in vitro.* It is necessary to develop new tools for cell engineering that will allow the study of the processes related to cancer metastases and that will enable the analysis of interactions between non-malignant and cancer cells.
In this work, a new *Body-on-a-chip* microfluidic system was designed. The microsystem was made of two layers of biocompatible poly(dimethylsiloxane) (PDMS) and a thin, porous PDMS membrane, which was the surface of cells growth. The developed microsystem enabled 3D culture of several types of non-malignant and cancer cells under microfluidic conditions. Four types of cells were cultured simultaneously in the microsystem: non-malignant lung cells (MRC-5), breast fibroblasts (HMF) and co-culture of ovarian fibroblasts (HOF) and ovarian cancer cells (A2780). Additionally, the use of cellular co-culture allowed the imitation of the physiological structure of cancer tissue, composed of a cancerous parenchyma and a non-cancerous stroma.
The multi-organ cell culture model was characterized by viability tests: AlamarBlue assay and differential fluorescence staining with propidium iodide and calcein-AM. The changes in the morphology of lung cells and breast fibroblasts because of interaction with ovarian cancer model were also observed using microscopic methods. The cancer cells can create new inflammatory disease outbreaks as a result of interaction with the microenvironment created by non-malignant cells. Therefore, in the next stage of research, the *Body-on-a-chip* system will be used for analyzing the invasion of ovarian cancer cells by monitoring pro-inflammatory factors in the microenvironment created by non-malignant cells of other organs.

P19. Electrochemical Detection of SARS-Cov-2 Genetic Markers Using DNA Biosensor Based on Stem–Loop Probe

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Nowadays, fast, reliable, and cost-efficient molecular diagnostic tests which could be performed outside laboratories are mostly still only in the research phase. Early detection of diseases allows for fast therapeutic intervention, which is the key to successful treatment. Assays based on nucleic acid detection turned out to be an effective approach for such a challenge. The presented research is focused on the development of fast and versatile “on-off” signaling electrochemical genosensor for detection of SARS-CoV-2 specific nucleotide sequences (RdRp, E and N). The DNA molecular beacon probe was immobilized onto gold electrodes in its folded state through the alkanethiol linker at the 5’-end, while the 3’-end was labeled with methylene blue redox molecule. As the sensor response was significantly dependent on the stem-loop architecture, the three different hairpin probes were investigated for each of detected gene sequence. During the research, the best sequences of DNA probes for genetic targets were selected. The human β-actin gene was used as a reference for appropriate swab taking. It was confirmed that properly designed DNA receptor layers are able to selectively distinguish real samples after amplification with the asymmetric PCR technique in terms of the presence of genetic biomarkers. The sensors were developed using two different blocking agents (mercaptohexanol and diethyldithiocarbamate). As was already shown in our previous studies diethyldithiocarbamate is an interesting alternative in the construction of DNA biosensors exhibiting some advantages over broadly used mercaptohexanol.

P20. Point Measurements of Soil Moisture Using TDR Technique - Comparison of Probes

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There are many methods and techniques for measuring soil moisture. These methods are divided into direct and indirect ones. Direct methods, although characterized by high accuracy, are usually time consuming. Nowadays, when precision farming is more and more common, indirect methods are used, which determine soil moisture by measuring other soil parameters. The most commonly used methods are time domain and frequency domain reflectometry.

In order to achieve satisfactory performance in a given application, choosing an appropriate measurement technique and a suitable probe is necessary. There are many types of probes available on the market. The most common are two-rod probes, although single-rod, antenna-type probes [1], as well as multiple-rod probes that are also known from the literature. Apart from the rod probes, there are also other constructions, such as dagger probes [2]. Each of the mentioned constructions have appropriate measuring or mechanical properties. Another issue to consider is the sensitivity zone of the probe. Although, in the case of measurements of homogeneous materials, it does not matter much, in the case of soil moisture measurement, especially in field conditions, it may be a critical parameter determining the usefulness of the probe.

The paper compares three types of TDR soil moisture measuring probes: dagger, antenna, and a two-rod probe. Based on the results obtained, the applicability of the probes in the field conditions was evaluated.

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P21. Humidity and CO_2 Sensing by Graphene Film Based Sensor Obtained by Liquid Phase Exfoliation

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Detection of humidity levels is a very important and ubiquitous process in the many fields of human activity. Medicine, various types of industry, weather forecast and everyday life require humidity sensing as an important information for decision making and monitoring of future trends. In this presentation we will show our work in the development of humidity sensor based on ultra-thin graphene layer obtained by liquid phase exfoliation. The fabricated sensor showed very good responsivity on various humidity levels, at the same time having very short response and recovery time. The sensor was also capable of detecting human finger proximity thus opening the possibility to be used in touch screen applications. Detection of CO_2 levels was achieved by the sensor made out of sulfonated polyaniline (PANI)-functionalized graphene layer. The sensor was capable of detecting low CO_2 levels, between 300 ppm and 10 000 ppm, while at the same time showing a full dynamic range, from zero to 100% CO_2 in the atmosphere at the normal conditions (1 bar, 20 °C). In the same development we have applied a specially devised numerical analysis by which it was possible to obtain a real-time read-out of the adsorption based sensor. This will be shown in this presentation.

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P22. 5-hexadecanoyloxyoctadecanoic Acid (5-PAHSA) as a Potential Therapeutic Agent in Diabetes? - Preliminary Studies Using the Newly Developed, Fully Functional Islet-on-Chip Model

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Diabetes mellitus is a group of metabolic diseases characterized by hyperglycemia resulting from a defect in the production or function of insulin secreted by β cells of the pancreatic islets. Pancreatic islets are spherical cells aggregates (100-200 μm) which consist of several cell types. The most important for improving research in the field of diabetes is developing a model that reflects in vivo conditions. Here, we present a study based on Islet-on-a-chipsystem, which was designed to create fully functional pseudoislets (three-dimensional aggregates of α- and β-cells).
This PDMS/PDMS Islet-on-a-chip system consists of two elliptical cell culture chambers. In each of the chambers, there are 15 round microtraps (280 μm x 280 μm), each of them composed of 7 circular micropillars, which force cells aggregation by limiting the growth surface. We designed this device to facilitate the screening of potential therapeutic agents, so here we examined the effect of the newly discovered compound named 5-PAHSA on the developed model. Due to the appropriate design of the microfluidic system, it was possible to simultaneously culture, observe and analyze the cell proliferation, viability, and hormone expression after incubation with selected concentrations of 5-PAHSA. It was noticed that after incubation with 5-PAHSA, the degree of proliferation increased both in relation to the control and the previous day of incubation. After analysis of the fluorescence intensity levels, the highest expression of insulin was observed after 48h incubation with 100 μm 5-PAHSA. These observations were confirmed by analyzing the amounts of secreted insulin under low (LG, 2.5 mM) and high (HG, 16.5 mM) glucose conditions using the ELISA test. Based on these results, it can be concluded that 5-PAHSA has potential properties as a therapeutic agent in diabetes, and the developed microsystem can be used for rapid drug screening.

P23. Electrochemical Aptasensors as an Ultra-Sensitive Tool for the Detection of Antibiotics after Cattle Antibiotic Therapy

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Currently, the bovine mammary gland (mastitis) has become a multifactorial disease characterized by high clinical and economic significance. Studies show that excessive antibiotic treatment has resulted in the greater resistance of mastitis pathogens. So, the development of technologies for detection of antibiotics able to use on-site, in the field diagnostics of bovine mastitis are very desirable and would permit for rapid intervention to stop and prevent mastitis. Therefore, it is very important to develop a very sensitive, simple, cheap, and selective antibiotic detection tool applicable for therapy effects in order to perform a large amount of analyses in a short time. Electrochemical biosensors meet such requirements.

To date, several systems have been developed for the electrochemical detection of antibiotics. However, simultaneous detection of many antibiotics during one measurement cycle, on single working electrode using redox markers is a big challenge and has not been presented so far. Herein, we report on the development electrochemical systems allowing detection of at least two antibiotics on a single measurement electrode. For the construction of these systems, we used aptamers as the receptor elements. Aptamers are single-stranded DNA or RNA oligonucleotides, which can specifically bind to target molecule, such as nucleic acids, proteins, metal ions, and other small molecules with high affinity, selectivity, and sensitivity are of particular interest. The idea of aptasensors evolved from the applications of oligonucleotide probes modified with redox active markers (such as ferrocene, anthraquinone, thionine, methylene blue) for covalent attachment to the gold electrode surface. The changes in the efficiency of electron transfer between the electrode and redox label underlie the principles of the mechanism of analytical signal generation. The electrochemical aptasensors were successfully applied in milk samples.

Acknowledgements

This research was funded by the National Science Centre (Poland), Grant Number 2020/37/B/NZ9/03423.

P24. Towards to Automatic Correction of Unwanted Artifacts Observed in Digital Data Continuously Recorded by a Rotational Seismograph

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Modern optoelectronics devices use advantage digital systems for data processing directed to delivering reliable information. However, because commonly used DACs have limited accuracy, the same artefacts (signal pins with high amplitude and limited width in time) can be observed in streams of data especially in systems designed for continuum long-time process monitoring. The above situation is generally solved by applying suitable filtering techniques, which are adequate especially for time-independent data, for example, noise investigation of rotational seismographs. However for data recording in real-time there signal disturbances above meddle level are used as a moment to start their recording, artefacts existence general disturbed recording process. Although artefacts are easily recorded by human eyes even, at first sight, their automatic elimination is not so easy. In this paper, we propose a new concept of signal filtering to solve the above problem. Signal filtering is a two-step process. In the first phase, disturbance detection is performed and unwanted artefacts are distinguished from the actual measurement signal. At this stage of work, it was decided to use an algorithm based on the set of conditions with numerous parameters (e.g. window sizes, level limits, etc.) established experimentally. The second phase is the process of eliminating the disturbance in the places indicated by the algorithm - along with the immediate surroundings. Elimination consists in subtracting the model form of the disturbing impulse so as to recreate the measurement signal as much as possible.

P25. Tracking Multiple Instances of Retail Consumers from RGB and Thermal Images

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Visual tracking of multiple objects is a challenging task that has gained considerable attention recently. The process involves several steps: detection, data association, and re-identification, each with its own set of challenges. Trending methods usually combine some of these steps and report impressive results in tracking benchmarks while running at practical speeds. In this work, we develop an online, real-time multi-object tracking approach, also able to perform consumer tracking in indoor retail stores, without further tuning its design philosophy. Our model can utilize multi-modal inputs, such as RGB and thermal images when available, to improve its performance while maintaining acceptable speeds at 20FPS. Our key contribution for motion forecasting replaces the standard Kalman Filters with a LSTM network to properly model long-term dependencies and target tracking. Numerical experiments of our method on the widely used MOT16 benchmark demonstrate its effectiveness. Additionally, qualitative results in in-house retail image data confirm the methods ability for practical multi-consumer tracking. Our proposed system is part of a research project aiming to capture retail consumers' preferences, as a function of their relative position with respect to particular areas of a store that have been mapped according to the shelves which are visible for each view area of the installed RGB and thermal cameras. Additionally, the system relies on accurate estimation of consumer age and gender using only body images, in a multi-task deep learning framework in order to further taxonomize consumer preferences into age and gender groups. By these means, useful consumer meta-data can be extracted, ready to be employed for marketing campaign customization that might improve sales and consumer experience altogether.

P26. SPR Sensor Based on Tapered Optical Fiber With a Low Refractive Index Liquid Crystal Cladding

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Tapered optical fibers due to their specific optical properties are great sensing elements. During elongation of the optical fiber, a tapered waist is forming, which allows the electromagnetic wave to propagate in the whole volume of this structure, simultaneously some part of this wave leaks out of the taper as an evanescent wave. In fiber-based Surface Plasmon Resonance sensors, the evanescent field of propagating modes in a fiber penetrates a thin metal layer and thus the surface plasmons are excited at a metal/dielectric interface. Additionally, to control and strengthen the SPR effect, the liquid crystal cladding with controllable refractive indices by voltage was applied.

This research focuses on the electric field sensor based on the tapered optical fiber probe. The manufactured sensor consists of a gold and silver thin films coated tapered waist area of the optical fiber and the low refractive index liquid crystal named 3092A as a cladding. The Au and Ag layers with thicknesses from 10 to 30 nm were deposited using the sputtering method. Because of the significant influence of liquid crystal molecules' initial arrangement on light propagation, the three types of liquid crystal cells: orthogonal, parallel, and twist were considered. Measurements were performed in the room temperature and steering voltage range U from 0 to 200 V in a wide optical range. The obtained results allowed to establish resonant peaks whose depth and position depend on the used metallic layer, liquid crystal cell type, and voltage and can be controlled by the mentioned factors.

P27. Threshold Volatile Organic Compounds Sensor Based on Polymer Microtip

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The development of optical fiber sensor technology has led to interest in the use of new elements for functionalizing the fiber end face. Modification of this part of the fiber can be done by forming a polymer microtip (PM). The technology of manufacturing PMs on single-mode and multi-mode fibers is widely described in the literature. Geometry and optical properties of PMs depend on technological process parameters, optical fiber type, and monomer mixture composition. PM can be considered in the context of sensor applications as a transducer which is sensitive to refractive index (RI) changes. RI's sensors were an inspiration to explore the possibility of using PM to detect VOCs in air. Five selected volatile compounds were tested: trimethyl phosphate (TMP), 1,4-thioxane (THX), acetone, toluene, and aqueous ammonia. The principle of the sensor operation was based on the phenomenon of attraction and repulsion of the condensed VOCs. Attracted VOC molecules cover the PM surface and form a liquid film that changes the RI at the interface between the PM and the external material. The return loss level changes rapidly when the PM is introduced into the glass vial filled with the test compound. The proposed sensor acts as a threshold, showing only the presence of condensed VOC, but with no ability to determine its concentration and type of substance. Such a sensor can be used in warning systems to monitor leaks in volatile chemical transport lines, as well as monitor accumulations of hazardous liquid substances that easily transit into the vapor phase. It acts as an early warning system in the event of the condensation process of the monitored dangerous chemical agent.

P28. Research on Optical Properties in a Tapered Optical Fiber with Higher Alkanes Cladding Doped with Fe3O4 Nanoparticles

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The presented research shows the effect of mixing Fe3O4 nanoparticles with higher alkanes on the propagation of the light wave in a biconical, adiabatic optical fiber taper. Fiber optic taper makes it possible to influence directly light parameters inside the taper without the necessity to lead the beam out of the structure. The mixture of alkanes and Fe3O4 nanoparticles forms a special cladding surrounding a fiber taper which can be controlled by temperature as well as external factors like magnetic fields. Described studies show change of beam intensity as well as polarization properties like azimuth, ellipticity depending on mixture temperature and its state of aggregation of nanoparticles and different applied magnetic fields. The taper was made of a standard single-mode telecommunication fiber, pulled out to a length of 25.0 ± 0.5mm and the diameter of the tapers is around 8.0 ± 0.3μm. Such taper causes the beam to leak out of a waist structure and allows the addition of external beam-controlling cladding material. The built-in sensor containing nanoparticles operates on the on-off principle as well as change of position around the taper of nanoparticles. Nanoparticles added to the alkanes cause increase in hysteresis in a heating and cooling process. For magnetic one, it can change its position influence on light propagation and polarization parameters. Such mixture makes also a significant shift of temperature characteristic in a heating process in which the mixture change their physical state with a simultaneous slight shifting of the characteristics during cooling. Tests were carried out in a wide spectral range of 500 - 1700nm. Temperature tests for selected lengths in the visible and infrared range were determined.

P29. Compact Camera Fluorescence Detector for Real-Time PCR Devices Using a Parallel Light Lens

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Molecular diagnosis evaluates changes in molecules occurring in cells by numerical and imaging. The expression of genes and disease genes are studied to present directions for prevention and treatment for infectious diseases. The Real-time polymerase chain reaction is a technology that amplifies the amount of a small target genetic material. Real-time PCR detection technology based on fluorescence measurement detects DNA amplification and measures fluorescence brightness. Existing real-time PCR systems require complex configurations and many optical components. As a result, the size of the optical system device is large, and there are limitations in cost and assembly. In addition, imaging devices such as large and expensive high-performance cameras are required to measure fluorescence. Recently, due to the continuous development of cameras for smartphones, many cameras with small size and good performance are being developed. In this paper, we propose a low-cost compact fluorescence detection device using a parallel light lens. The proposed system has a simple optical structure, and the cost of the system can be reduced and miniaturized. This system has the same field of view using a fresnel lens. In addition, a small and inexpensive CMOS camera and LED were placed in the same direction as possible in the center of the fresnel lens. For accurate analysis, an image processing method was used to compensate. As a result of comparative experiments using double distilled water (DDW) and a reference fluorescence solution (FAM), the proposed system confirmed that stable fluorescence detection was possible.

P30. Gas chambers Shape Design for Electronic Nose

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In this work, we present different types of gas chambers designs for electronic nose devices, which has an array of many various sensors. These chambers were designed to work with metal oxide semiconductors, electrochemical, Taguchi gas sensors. In all cases, the gas was pumped to the chamber with a known velocity. Every chamber was priory designed and recalculated using COMSOL numerical simulation, with the model uses the Navier-Stokes equation and finite element analysis. This program can check gas flow in every part of the designed element. The proper design and coefficients of the equation enable to model the laminar flow of gas next to every sensor.
During simulation, we checked velocity vectors in every part of chambers volume and its change during the first seconds after starting the pump. Moreover, using a pressure change model, it was possible to determine probe gas concentration in every part of the chamber. It helps to better design the location of sensors. Our work refers to a different size and shape of the chambers, internal reflectors and even single channels connection to every sensor.
Afterwards, every optimised design was made and tested with the same sample gas. We checked the signal response time and strength in each design and compare it with numerical data.

P31. Implementation of a Smart Lifejacket for Assisting the Evacuation Process on Large Passenger Ships

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Evacuating large passenger ships is a complex and safety-critical process. During an evacuation, the passengers are assisted by exit signs, the public announcement system and the crew, the latter providing instructions for mustering and abandonment. In addition, passengers are required to wear lifejackets that are made of buoyant or inflatable material used to keep them safe in the water. The timely mustering and guidance of passengers to their embarkation stations is of the utmost importance and greatly affects the evacuation time in the case of an emergency. This is especially important in extreme conditions and hazards, such as fire and flooding. Within the context of the project SAFEPASS, a smart lifejacket is designed and implemented, which integrates indoor localization technology and a haptic navigation system that can assist passengers during evacuation. The indoor localization technology reports the passengers' location within the ship, while the navigation system can negotiate a route and navigate the passenger using vibration motors attached to the smart lifejacket. These actuators vibrate to provide haptic cues to the passenger to navigate them to their destination in low visibility conditions and in case they are left behind or lost. The smart lifejacket can also help the crew to locate stray passengers, thus increasing the safety of passengers and reducing the evacuation time as a whole.

P32. An Impedance-Based Label-Free Polymerase Chain Reaction Chip and Detection System

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In the conventional real-time polymerase chain reaction (RT-PCR) technique, DNA amplification was confirmed by quantitatively analyzing the increase in fluorescence brightness using a fluorescent label. However, when using a fluorescence label-based technology, an optical structure for accurate and expensive fluorescence detection is required, and pretreatment of the sample is required to attach a visible fluorescence marker.

In order to overcome this problem, many technologies have been studied for label-free detection using electrical sensors. Impedance has a characteristic of having a high correlation with the concentration of the sample solution and the fragment length of the DNA length. If a change in the amount of DNA can be detected by a change in impedance during the PCR process, a detection device having a small and simple structure can be implemented without including an optical detection unit.

In this paper, we propose a PCR chip and detection system based on impedance spectroscopy. Two types of chips were made using two types of flexible printed circuit boards (PCBs) with different electrode shapes, a double-sided tape, and a plastic film. The system for driving the PCR process includes a microcontroller and is configured to control temperature and process measured values.

DNA sample solutions diluted to various concentrations were injected into the two types of chips, and impedance values for each concentration were measured. The measured values were analyzed for each concentration and electrode type. As a result, it was found that although there is a difference in the size of the measured value depending on the type of chip, it is possible to distinguish by concentration.

P33. Portable, Highly Sensitive and Selective Electrochemical Biosensors for SARS-Cov-2 Detection

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Infectious diseases, such as COVID-19, continue to cause an enormous burden of death and disability in developing countries, and there is an urgent need to better understand the infectious pathogens and develop ways to control their spread. We have developed a new type of testing strategy based on electrochemical biosensing aspects, created using a microfluidic detection platform for rapid, sensitive, and specific detection of infectious SARS-CoV-2 and its variants. The target compounds, i.e., SARS-CoV-2 variants, were selected due to the current worldwide outbreak, however, the fabricated biosensing aspect may be expanded to future emerging pathogens by undemanding modifications. The biosensor platform is based on screen-printed-electrodes (SPEs) modified with nanostructured polystyrene (PS)/polyaniline (PANI)-Au NP composite. The surface of modified-SPEs is later immobilized using different representative receptor elements, i.e., specific viral antibodies. Tackling PS/PANI-Au NPs composite on the nanoscale enables to exploit its outstanding conductivity, biocompatibility, and high surface area which facilitates loading of a huge amount of viral receptor elements (Ab), thus resulting in high sensitivity, specificity, and low detection limits (i.e., at attomolar concentration levels). Such a construction is able to translate this specific covalent interaction (Ab) with its corresponding binding viral target, i.e., receptor-binding domain (RBD) of spike (S) glycoprotein) into a measurable, concentration dependent electrochemical response. By creating an electrochemical readout, data enable qualitative and quantitative analysis. The fabricated system represents a low-cost and efficient alternative to conventional assays for testing as offers a simple in-situ method of analysis in much shorter time frames. Its feasible design is easy-touse and can be operated by patients themselves using simple samples like saliva, thus allowing population scale screening.

P34. Electronic Nose Designs for Dendrolimus Pini Odour Detection

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Dendrolimus pini is one of the most popular insects that cause damage to pines in Poland and other countries of Central Europe. Especially in the places where there are monoculture cultivation of forests, those pests could be a big economical problem by consuming a significant number of pine needles.
This insect appears in cyclical gradations, causing great damage to Pinus spp. Each of the damages can cause weakening of stands, decreased annual tree growth and the death of individual trees. In order to identify the numerical state of the insect population and its trend, various prognostic works are done: searching for overwintering caterpillars in the litter, sticking and felling trees to monitoring foraging caterpillars in the upper branches of trees. These searching activities are time-consuming and not very accurate.
Therefore, foresters are looking for a good tool to monitor Dendrolimus pini and other insect species dangerous to Pinus spp. Dendrolimus caterpillars, whose behaviour is group-based, are assumed to communicate using specific scent compounds called pheromones, which could be detected in the air.
The study searched for these compounds with gas chromatography and the use of various models of artificial electronic noses. Few construction types of the e-noses were tested, some of them with and without the aroma mixing chamber. All of the devices use metal oxide semiconductors sensors. The e-nose measurements were done both in laboratory and field conditions. The development of a properly functioning detector will enable foresters to shorten the time of forecasting work, reduce its cost, and increase its accuracy.

P35. A Fully Integrated Microfluidic-Based POC Device for COVID-19 Testing

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Since the severe acute respiratory syndrome (SARS-CoV-2) was revealed in Wuhan in 2019, it has rapidly spread around the world causing severe mortality, economic crisis, and bringing challenges to the public health, diagnostics, and medicine. The shortage of diagnostic facilities, insufficient number of test kits and laboratory supplies have highlighted an urgent need of microfluidic-based point of care devices for the detection of COVID-19.
POC devices, especially utilizing microfluidics, are portable, sensitive, selective, and cost-effective platforms which eliminate sample transport to the centralized clinical laboratories. Herein, we present a fully integrated microfluidic-based POC device which enables testing COVID-19 in terms of active viral infection and serological (antigens/antibodies) detection. The presented system consists of microfluidic reusable cassette and reader device. The construction of the cassette is multi-layered and assumes the use of PET foils. Each layer of the cassette includes CO2 laser-cut network of microfluidic channels/chambers which have different functionalities. The bottom layer of the cassette is custom-made screen-printed layer with electrodes responsible for the voltammetric measurement. The next layer is the substrate for the immobilization of antibodies/antigens. The remaining layers enable the transport of the fluids to reaction and detection zones to finally reach the waste reservoir. The sample along with all necessary reagents is stored in special tanks placed in the cassette cap, which represents its upper part. After placing the sample into the disposable cassette, all operations are performed automatically by a micromechanical module placed in the reader device.
Using the developed diagnostic system, the determination of SARS-CoV-2–related analytes was possible. The presented microfluidic-based platform is characterized by high versatility. It can be simply adjusted to determine various entities by selecting the appropriate immobilization materials and technology. At the same time, the production technology is characterized by high efficiency at a low unit cost.

P36. Indirect Detection of Acrylamide Using Novel Biosensor Element

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Acrylamide (AA), C_3H_5NO, is worldwide used in the synthesis of polymers and gels for wastewater treatments and in the paper industry. Naturally it is formed in heat-treated food mostly during frying and baking of potatoes, cereals, and coffee beans. Its' presence in food is dangerous as it is a neurotoxic and genotoxic compound. Triggered by new EU regulations, there is a high demand for reliable and cost-effective sensors in food and home appliances. In the view of this electrochemical sensors show high potential in detection of toxic compounds.

In the present work, we show the development of electrochemical biosensor element, since AA is non-active molecule and direct electrochemical detection is not possible. The sensors' receptor element is based on a modified commercial screen-printed electrodes (SPE) that offer on-site and cost-efficient sensing. As an electrochemical transducer, conductive polyaniline (PANI) decorated with Au NPs was applied, which enables high sensitivity and limit of detection below 10^{-6} M range. As biological component, enzyme amidase was selected, since it is known that it catalyses the hydrolysis of acrylamide into carboxyl acid and ammonia. The ammonia is finally detected using chronoamperometry. The chemical interaction between PANI and ammonia is well-known and was used as a base for the fabrication of an amperometric sensory platform for its aqueous detection at neutral pH. Understanding AA and amidase interaction and decomposition into ammonia, PANI electrochemical synthesis and redox behaviour in acidic and neutral media was used to study the mechanism for the AA indirect detection.

Acknowledgement: The authors acknowledge the project (High performance nanostructured acrylamide sensors, ID J2-1739) which is financially supported by the Slovenian Research Agency.

P37. FBG-Based Sensing of the Back During Gait Cycle

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We report on the calibration and testing of a Fiber Bragg Grating (FBG) based 2D-shape sensing strip for real-time monitoring of the position and orientation of the human spine during gait. The strip will be evaluated for use as an input for control of an exoskeleton for patients with spinal cord injury. By measuring torsion and bending of the back the walking movement can be reconstructed.

The 3D-printed strip has nine embedded fiber bragg gratings located at specific places with respect to the vertebral column. Three FBGs are placed opposite to the thoracic vertebrae T6 -T9, these FBGs are sensitive for measuring bending of the spine during the gait cycle. Torsion is measured at two locations: at thoracic vertebra T3 and at lumbar vertebra L3. At these locations the width of the strip is reduced to have a larger sensitivity for torsion. The strain at each FBG is measured with an interrogator. This leads to a radius of curvature and torsion as a function of time. The Frenet-Serret formulas are used to calculate the shape of the strip during gait cycle.

We have calibrated this FBG-strip for curvature by bending it at known radius of curvatures. We find a linear dependence between the strain and curvature. For torsion calibration we have rotated the strip with a stepper motor at different angles and monitored the strain. We again found a linear dependence with a small hysteresis.

We have mounted the strip on a healthy test subject and monitored the gait cycle. The FBG- strip shows similar results compared to a motion capture system based on multiple cameras. Although the fixation of the strip to garment or on the back directly strongly influences the measured response, it does show a periodic and reproducible signal during gait cycle.

P38. Application of Polarization Sensing for Detection in Scattering Media

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In recent years a significant progress in polarization imaging technologies has been observed, resulting in a numerous applications of this technology in biomedical imaging, autonomous vehicles navigations, 3D surface inspection and many others. One of the most important applications of polarizing imaging is improving the image quality in scattering media. A good example is a number of R&D works on improving the quality of images in underwater vision, which have been conducted providing the impressive application results.

In this work, we are focused, however, on agriculture industry-oriented solution, addressing the challenge of high-speed, highly reliable detection of the pits in cherries. In particular, different setup configurations for polarization image analysis using LC filters were investigated, and the examination of the sensitivity of the polarization systems was performed. It should be noted here that the polarization imaging systems are usually less sensitive, and the acquired images are of insufficient quality. That's why the machine learning technology was used to enhance the object detection efficiency, and the method of extracting the details of acquired images and improving detection accuracy based on machine learning will be presented.

Acknowledgment: This work was supported by the National Centre for Research and Development, project POIR.01.01.01-00-1045/17.

P39. Well-Secured Tests of Innovative Hydrostatic Levelling System

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The auxiliary laboratory of the Space Research Center in Warsaw (SRC) was adopted for testing the non-water-based HLS (hydrostatic leveling system) developed in the ULTRAXIS start-up. The area for testing consists of three concrete pillars, plunged in the ground to a depth of 3 meters below the laboratory's floor. The concrete structure is reinforced and separated from the laboratory floor. The weight of the concrete structure with sand filling is approximately 30 tons. The objective of the sand filling is to dampen the vibrations produced by the town. Hydrostatic measuring systems, due to their simple and robust configuration, combined with high resolution, are widely used to monitor vertical movements and deformations of constructions that require precise leveling.

The tested HLS parameters are as follows: closed, double-pipe system, 3 m long, equipped with unique ultrasonic sensors to measure fluid level.

Newly constructed, thermally compensated sensors do not have any moving and elastic parts. High speed and precision of measurement is ensured by sophisticated ultrasonic methodology.

Initial observation results indicate that the sensitivity of the liquid level measurement is better than 0.01 µm, and the long-term stability is better than 1 Arcsec per year.

This gives rise to the expectation that the proposed HLS solution can be widely used in geodynamic research related to tectonic motions. Specifically, there are plans to measure the movements of the rocky blocks in the Świebodzice Depression Unit (Książ region), owing to the already-observed coincidence of tectonic activity in the Książ massif with the seismic activity of the Foresudetic Monocline.

The installation of the HLS solution at the Geodynamic Laboratory in Książ enables the cross-verification of its measurement results in comparison with the results of the existing, highly sensitive 100 m long water-based leveling system.

Non-water-based HLS should also arouse interest in the rapidly developing SHM (Structural Health Monitoring).

P40. Humidity and CO_2 Sensing by Graphene Film Based Sensor Obtained by Liquid Phase Exfoliation

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Detection of humidity levels is a very important and ubiquitous process in the many fields of human activity. Medicine, various types of industry, weather forecast and everyday life require humidity sensing as an important information for decision making and monitoring of future trends. In this presentation we will show our work in the development of humidity sensor based on ultra-thin graphene layer obtained by liquid phase exfoliation. The fabricated sensor showed very good responsivity on various humidity levels, at the same time having very short response and recovery time. The sensor was also capable of detecting human finger proximity thus opening the possibility to be used in touch screen applications. Detection of CO_2 levels was achieved by the sensor made out of sulfonated polyaniline (PANI)-functionalized graphene layer. The sensor was capable of detecting low CO_2 levels, between 300 ppm and 10 000 ppm, while at the same time showing a full dynamic range, from zero to 100% CO_2 in the atmosphere at the normal conditions (1 bar, 20 °C). In the same development we have applied a specially devised numerical analysis by which it was possible to obtain a real-time read-out of the adsorption based sensor. This will be shown in this presentation.

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P41. Cell Counting in Silicon Nanosensor for CAR T-Cell Therapy Monitoring

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Silicon nanowire sensors have demonstrated outstanding utility in biosensing, especially for small biomolecules at extremely low concentrations. However, the sensor is less commonly applied for whole-cell monitoring, such as CAR T-cell counting during cancer treatment. The patient's T-cells are modified to express chimeric antigen receptors (CAR) targeting specific tumor cells in CAR T-cell treatment. Therefore, the CAR T-cell level in blood is an essential parameter determining the immune system's reactivity to fight cancer cells. Although nanosensors are typically beneficial for early cancer diagnosis and detection, we want to expand their application and explore their usage in cancer treatment monitoring and development. Our previous works showed promising results of using nanosensors in finding the most effective immuno-therapy. In this work, we study the response of silicon nanowire field-effect transistors (SiNW FET) to the binding of CAR T-cells and discuss the benefits and limitations of the sensors in cell monitoring. The SiNW FETs are fabricated in a top-down manner have been shown superior sensitivity to IgG antibodies sensing in our previous study. A peptide with a high affinity to the designed CAR T-cells is immobilized on SiNW FETs to detect the cell binding. We observed distinguished signals following the number of cells binding to the sensing area. The results pave the way for using nanosensors in monitoring cancer treatment yet suggest some room for improvement.

P42. PPG EduKit: An Adjustable Photoplethysmography Evaluation System for Educational Activities

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Nowadays, technological solutions for education are more available than ever. These tools and resources are accessible for both students and teachers and they can range from generic online teaching tools to more specific software and hardware resources. The grown interest in healthcare applications has made biomedical engineering, which combines knowledge of living systems with engineering principles, one of the fastest growing disciplines in recent years. Photoplethysmography (PPG) has gained popularity in recent years due to its versatility for noninvasive monitoring of vital signs such as heart rate, respiratory rate, blood oxygen saturation and blood pressure. In this work, an adjustable PPG-based educational device called PPG EduKit, which aims to facilitate the learning of the PPG technology for a wide range of engineering and medical disciplines is proposed. Through the use of this educational platform, the PPG signal can be understood, modified and implemented along with the extraction of its relevant physiological information from a didactic, intuitive and practical way. The PPG Edukit is evaluated for the extraction of physiological parameters such as heart rate and blood oxygen level, demonstrating how its features contribute to engineering and medical students to assimilate technical concepts in electrical circuits, biomedical instrumentation, and human physiology.

P43. Design and Development of a Miniature Mid-IR Spectrometer for Environmental Sensing and Food Safety Applications

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In this work, we present the recent results of designing and developing a miniaturized mid-IR spectrometer designed to detect and identify specific markers, that may provide crucial information on air/water/food quality, human health, production line condition, etc.

The device is designed to operate in the spectral range of 3–5 µm or 7–9 µm, depending on the detector used, with a spectral resolution of approx. 20-100 nm, chosen appropriately for the targeted applications. Specific focus has been placed on the potential for further miniaturization and cost optimization of the device.

The heart of the spectrometer, determining its spectral selectivity, is a 32-element, thermoelectrically cooled linear detector array (LDA) and a linear-variable filter (LVF). The LDA consists of InAsSb photodiodes, which, for a temperature of 230K, offer a specific detectivity D* of the order of 10^{10} / 10^{8} $cmHz^{-1/2}W^{-1}$, for the spectral range of 3–5 µm and 7–9 µm, respectively. The LVF's spectral response changes linearly along its length—since it is placed parallelly and near the LDA, this effectively restricts the spectral response of each pixel to a narrow peak, shifted by a constant value with regard to its neighbors.

To test the applicability of the device, a standalone demonstrator was developed, consisting of a thermal light source, beam-forming optics, a light beam modulator and an optoelectronic detection setup. To prove the proper operation of this device, several tests have been performed, evaluating among others its detection limits for different substances. Various measurement configurations (transmissive, reflective, multi-pass) were tested to improve the flexibility of the developed solution.

Since the presented work is a part of a bigger project focusing on development of fully integrated micro-spectrometers, the perspectives for further miniaturization will be also discussed, with specific focus placed on the potential of photonic integrated circuits (PICs).

P44. Public Lighting Recognition System based on Colored Reflection Index and Computational Machine Learning

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Identifying which type of lamp is installed on each public lighting poles and evaluating its luminous power is important because the new LED-type models are much more economical in terms of energy, and energy distribution companies need to know the consumption of public lighting energy. In Brazil, the following types of lamps exist in street lighting: incandescent, mercury vapor, sodium vapor, "mixed" lamps (composed of a mercury vapor arc tube in series with an incandescent tungsten filament), metal lamps and moderns LED (Light Emitting Diodes) type lamps. In this article, the authors describe the experimental results of the development of an automated system for recognizing lamps for public lighting based on the light pattern of each lamp, taking into account an innovative optic method which uses the RIC phenomenon (Reproduction Index of Color) and colored cards. Data collection in the field consisted of the task of driving a vehicle through public roads and obtaining several photos of the colored cards illuminated through the lamps of the poles and also through the use of a spectrofotometer, which is already traditional for this application. Samples were obtained and used for training Classifiers that use Machine Learning in order to identify the nature of the lamps. The tests were carried out on the city's public roads at night, so resulted tables also show the noise from interfering light sources (examples: lights from windows in houses and buildings, lights in stores, etc.) scenario as realistic as possible. The performance of the Classifiers was evaluated through parameters used in Artificial Intelligence.

P45. Distributed Liquid Level Sensor Based on Brillouin Sensing and Active Thermometry

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Università della Campania Luigi Vanvitelli

Liquid level sensors based on optical fiber sensors have superior reliability and safety, especially when operating in harsh environments and aircrafts fuel tanks. Several optical fiber sensors for liquid detection have been demonstrated, some of them offering discrete measurements, other ones offering continuous level measurements. Configurations based on the presence of an active optical sensing surface in direct contact with the measured liquid, makes them inherently sensitive to contamination and fouling. Alternatively, thermo-optic level measurement methods are far less sensitive to surface contamination, as they solely rely on the difference between the thermal properties of liquid and gas, with no direct interaction between the light and the measured liquid. In these sensors, the optical fiber can be heated optically using specialty doped fibers, which absorb light at distinctive wavelengths and convert it to heat. In all these sensors, usually two separate laser sources are needed, one for heating, one for temperature sensing.

In this paper, we propose a simplified approach, where a single laser is used to measure the temperature distribution and provide optical heating. The method is based on a conventional Brillouin Optical Frequency-Domain Analysis (BOFDA) system operating at 1550 nm, and a cobalt doped fiber with an absorption of 40 dB/m. When the cobalt doped fiber is interrogated by the BOFDA sensor, its temperature increases due to absorption of the pump light. The resulting temperature distribution is significantly affected by the immersion of the fiber into a liquid. Thanks to the high spatial resolution inherent to BOFDA sensors, the liquid level position can be determined with high resolution. In our experiments, continuous liquid level is demonstrated along a 9-cm cobalt doped fiber with 5-mm resolution.

P46. Multispectral Portable Optical Fiber Reflectometer

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Multispectral optical sensors are extensively studied nowadays in non-contact and remote imaging systems. However, our previous experimental studies have shown that the changes of reflective properties of chicken eggshells allow the classification of their origin: healthy or Mycoplasma synoviae (MS) infected hens. MS is a pathogen affecting poultry that may have a significant economic impact on poultry breeding. In this work, we present the portable optical fiber reflectometer, which can be used for early MS detection in a flock by the measurement of back-reflected light of a multispectral system.

The designed reflectometer consists of control and optical modules. The control module is responsible for light sources and photodetector modulation, synchronization and power supply, as well as data recording. The main part of this module is a microcontroller used for flexibility in creating the research sequence during operation. The optical module is based on a fiber bundle with six light outputs and a single detection line. The loose end of the fiber bundle is integrated with an optical head which shapes the illuminating beam to obtain measurement conditions. The same optical head collects a back-reflected beam that propagates through the detection line to the detector. The application of optical fiber decreases the weight of the whole system and enables flexible operation of the optical head, making this system portable. In order to classify test objects, the collected data is subjected to numerical analysis by means of machine learning.


MDPI