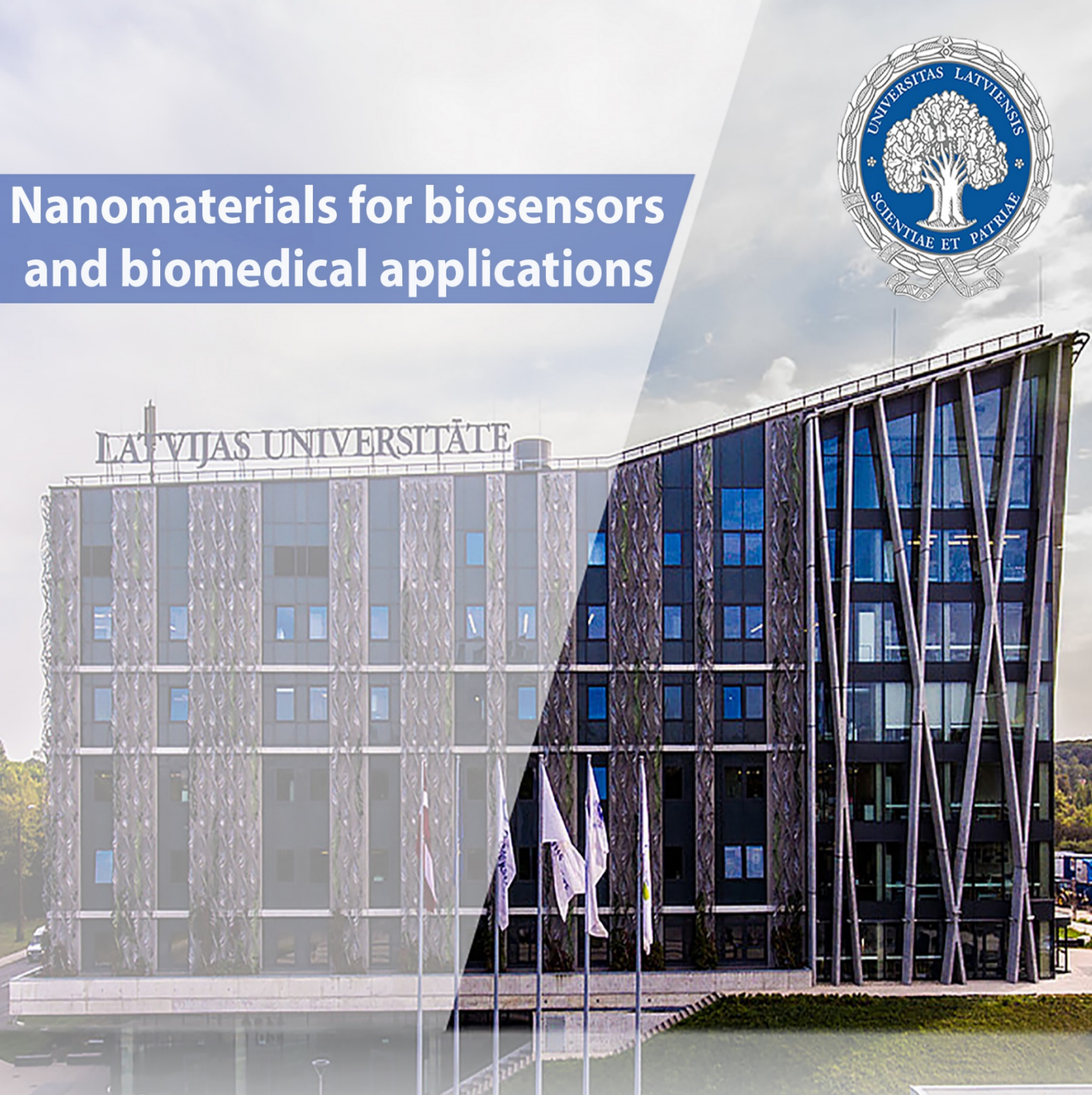
# Nanomaterials for biosensors and biomedical applications




## Book of Abstracts

# International Conference

## July 2-4, Jurmala, Latvia

CANBIOSE

NANOSURF

HORIZON 2020

# NANOMATERIALS FOR BIOSENSOR AND BIOMEDICAL APPLICATIONS

International conference

## Book of Abstracts

Jurmala, Latvia

2-4 July, 2019

The conference is supported by the University of Latvia under the ERDF project **No. 1.1.1.5/18/I/016** and European Union's Horizon 2020 research and innovation programme under grant agreements No **778157-CanBioSe** and No **777926-NanoSurf**

## THE MAIN TOPICS OF THE CONFERENCE:

- fabrication and properties of functional nanomaterials for sensors and biomedical applications (dentistry, surgery, etc.)
- new phenomena in nanomaterials which can be applied in sensors
- optical sensors and biosensors
- microfluidics for biosensing
- polymer-nanoparticle composite materials
- nanomaterials for antibacterial coatings
- antifouling surface
- methods for surface nanopaterning
- nanomaterials for 3D printing
- in-vivo and in-vitro tests of functional nanomaterials for biomedical applications
- biocompatibility of functional nanomaterials for biomedical applications.

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# LIST OF INVITED SPEAKERS:

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**Prof. Małgorzata Szczerska,**
Gdansk University of Technology,
Poland

**Dr. Bernhard Singer,**
LeukoCom GmbH, Germany

**Dr. Saad B Quasim,**
Oslo University, Norway

**Dr. Simona Sbardelatti,**
FONDAZIONE DEMOCENTER-SIPE,
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**Prof.Sigitas Tamulevičius,**
Kaunas University of Technology,
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**Pasquale del Gaudio**
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**Stefan Gassman**
Jade University of Applied,
of Applied Sciences,
Germany

**Samuel Lara Avila**
Chalmers University
Sweden

# PROGRAMM

## *International conference*
## *"Nanomaterials for biosensors and biomedical applications"*
## *Jurmala, Latvia, Hotel Jurmala Spa, July 2-4, 2019*

# July 2

### 8.30-14.30 Registration & morning coffee (8.30-9.00)

| | |
|---|---|
| **Plenary Section**<br>**Co-Chairs Assoc. Prof. D. Erts, Dr. R. Viter** | |
| 9.00-9.10 | Opening of the conference |
| 9.10-9.55 | **Invited**<br>Prof. Bernhard B. Singer, HopQ mediated interaction of Helicobacter pylori to distinct CEACAMs are crucial risk factors involved in the development of a variety of gastric diseases |
| 9.55-10.40 | **Invited**<br>Assoc. Prof. Jaime García-Rupérez, Novel approaches for the development of high sensitivity photonic biosensors |
| **Coffee break** | |
| **Microfluidics Section**<br>**Chair Dr. Mikhael Bechelany** | |
| 11.00-11.45 | **Invited**<br>Prof. Stefan Gassmann, Microfluidics - Basics, Application and Education |
| 11.45-12.05 | Dr. Leandro Lorenzelli, 3D Microelectrodes arrays (3D-MEAs) for 3D neurons' electrophysiological activity mapping |
| 12.05-12.25 | Dr. Georg Pucker, WGM resonator based integrated optical circuits for lab-on-chip sensors at ~0.85 micron |
| **Lunch** | |
| **Materials Section**<br>**Chair Assoc. Prof. Jaime García-Rupérez** | |
| 13.30-14.00 | Dr. Mikhael Bechelany, Design of nanomaterials and interfaces for biosensors and biomedical applications |
| 13.00-14.30 | Prof. Wojciech Simka, Oxide coatings formed on Zr alloys via PEO process |
| 14.30-14.50 | Dr. Oleksiy Gogotsi, MXenes for biosensors and biomedical applications |
| 15.00 | **Excursion** |
| **19.00** | **Dinner** |

# July 3

## 8.30-17.00 Registration

| | |
|---|---|
| **Plenary Section**<br>**Chair Prof. Wojciech Simka** | |
| 9.00-9.45 | **Invited**<br>Prof. Malgorzata Szczerska, Fiber-optic sensors and biosensors with nanomaterial coatings |
| 9.45-10.30 | **Invited**<br>Prof. Sigitas Tamulevičius, Diamond like carbon thin films and nanostructures for sensor applications |
| **Coffee break** | |
| **Biomaterials Section**<br>**Chair Prof. Stefan Gassman** | |
| 10.50-11.35 | **Invited**<br>Assoc. Prof. Pasquale Del Gaudio, *In situ* gelling polysaccharides submicrometric particles: a novel weapon to improve wound care armamentarium |
| 11.35-11.55 | Dr. Stefano Linari, Electro spinning applications in tissue engineering' |
| 11.55-12.15 | Ms. Hafsah Akhtara, Next Generation Oxide Containing Bioactive Scaffolds for Craniofacial Vascularisation & Bone Regeneration |
| 12.15-12.35 | Mr. Liam A. Boyle, Primary Cilia Elongation Enhances Mechanosensitivity |
| **Lunch** | |
| **Biomaterials Section**<br>**Chair prof. Malgorzata Szczerska** | |
| 14.30-14.50 | Dr. Mehmet Turemis, Integration of the photonic 1D ZnO nanorods to optical transducer for bio/sensor applications |
| 14.50-15.10 | Prof. Marek Piątkowski, Novel chitosan-based biomaterials for skin tissue regeneration with ferrimagnetic properties |
| 15.10-15.30 | Tugba Cebe, Nano and Microfibers to Investigate the Collagen Microstructure of Osteogenesis Imperfecta on Polycaprolactone Scaffolds |
| 15.30-15.50 | Mrs. Julia Radwan-Pragłowska, Novel hemostatic agents for biomedical applications |
| 15.50-16.10 | Dr. Viktoriia Holubnycha, Tetrapodal ZnO-CuNPs composites: cell toxicity and antibacterial effect |
| 16.10-16.30 | Mr. Łukasz Janus, Novel hybrid polymer-carbon quantum dots for biomedical applications |
| 16.45-17.45 | **POSTER SECTION**<br>**Chair Prof. Maksym Pogorielov**<br>**drinks and snacks, best poster competition** |
| 19.00 | **Dinner** |

## 9.00 – 16.00 Mid term meeting

## Horizon 2020 project “Novel photonic metal oxide nanostructures for early stage cancer detection” No. 778157-CanBioSE

# July 4

## 8.30-12.00 Registration

| | |
|---|---|
| **Plenary Section**<br>**Chair Prof. Arunas Ramanavičius** | |
| 9.00-9.45 | **Invited**<br>Dr. Samuel Lara-Avila, Sub-ppb gas detection with atomically thin platinum layers |
| 9.45-10.30 | **Invited**<br>Dr. Saad B Qasim, Effect of cross-linking and drug loading efficiency on freeze casted biomimetic templates for periodontal engineering |
| **Coffee** | |
| **Materials and Sensors Section**<br>**Chair Dr. Pasquale del Gaudio** | |
| 10.50-11.35 | **Invited**<br>Dr. Simona Sbardelatti, Development of biomedical device: a new approach for a productive collaboration with companies |
| 11.35-11.55 | Prof. Arunas Ramanavičius, Conducting polymers in Affinity sensors |
| 11.55-12.15 | Dr. Igor Iatsunskyi, Multifunctional nanocomposites produced by ALD |
| 12.15-12.35 | Prof. Sualieva Oksana, Tumor immune microenvironment: factors affecting it and role in prognosis of cancer |
| **Lunch** | |
| **Materials and Sensors Section**<br>**Chair Dr. Igor Iatsunskyi** | |
| 14.30-14.50 | Dr. Viktoriia. Korniienko, Time-depending antibacterial effect of chitosan sponges against different bacterial strains |
| 14.50-15.10 | Mr. Octavio Graniel, Au-covered hollow urchin-like ZnO nanostructures for surface-enhanced Raman scattering (SERS) sensing |
| 15.10-15.30 | Ms. Margarita Baitimirova, Structure and optical properties of Bi2Se3/ZnO and graphene/Bi2Se3/ZnO heterostructures |
| 15.30-15.50 | Dr. Juris Prikulis, Application of anodic aluminum oxide membranes for plasmonic nanoparticle assembly in optically active arrays |
| 15.50-16.10 | Dr. Violeta Martin-Gil, Use of Nanofibers produced by Electrospinning for Medical Applications. |
| **Coffee** | |
| **Materials Treatment Section**<br>**Chair Prof. Sigitas Tamulevičius** | |
| 16.30-16.50 | Prof. Tomas Tamulevičius, Laser imposed micro and nano patterns: from nanoparticles and hydrophobic surfaces to anti-counterfeiting applications |
| 16.50-17.10 | Prof. Maksym Pogorielov, Ti implant laser treatment - influence to cell viability and antibacterial properties |
| 17.10-17.30 | Prof. L. Orazi, Laser surface nano-patterning for biomedical and industrial applications |
| 17.30-17.50 | **Conclusions, Conference closing** |

**Mid term meeting**

**9.00 – 16.00 Horizon 2020 project “Nanostructural surface development for dental implant manufacturing” No. 777926 –NanoSurf**

## HopQ mediated interaction of *Helicobacter pylori* to distinct CEACAMs are crucial risk factors involved in the development of a variety of gastric diseases

Bernhard B. Singer[1], Verena Schmitt[1], Julia Suttorp[1], Jonas Germer[1], Marc Reschke[1], Thomas Reck[1], Gunther Wennemuth[1], Markus Gerhard[2,3], Steffen Backert[4] and Alexej Schmidt[5]

*[1]Institute of Anatomy, Medical Faculty, University Duisburg-Essen, Essen, Germany, [2]Institute for Medical Microbiology, Immunology and Hygiene; Technische Universität München; Munich, 81675, Germany, [3]German Center for Infection Research, Partner Site Munich, Munich, Germany, [4]Friedrich Alexander University Erlangen, Department of Biology, Division of Microbiology, Erlangen, Germany, [5]Department of Medical Biosciences, Pathology, Umeå University, Umeå, Sweden.*

Gastric cancer is the second most common cause of cancer-related deaths in the world and far more than half of all cases of stomach cancer are linked to *Helicobacter pylori* (*H. pylori*) infection. *H. pylori* is a gram-negative bacterium that establishes a life-long infection in humans and is estimated to inhabit the stomach lining of more than half the world's population. Although *H. pylori* infection does not cause illness in most infected humans, it remains the major risk factor for peptic ulcer disease and is responsible for the majority of ulcers of the stomach and it was recognized as an important cause of gastric cancer and gastric mucosa-associated lymphoid tissue (MALT) lymphoma.

Recently, we identified various members of the human carcinoembryonic antigen-related cell adhesion molecule family (CEACAMs) as novel receptors of *H. pylori* and identified HopQ as the outer membrane protein that specifically binds to human CEACAM1, CEACAM3, CEACAM5 and to some extend CEACAM6. The HopQ - CEACAM interaction is pH-independent and is located at defined amino acids in the N-domain. Binding of *H. pylori* weakens the protective forces of the host by inducing CEACAM mediated signaling, thereby inhibiting the pro-inflammatory reactions of certain immune cells, namely NK and CD8-T cells. Furthermore, the HopQ-CEACAM interaction is required for the translocation of the virulence factor CagA into host cells by the *H. pylori* type IV secretion apparatus (T4SS). Thus, CEACAMs seem to be responsible for the fact that *H. pylori* is a type I carcinogen. Consequently, targeting the HopQ-CEACAM interaction is likely to lead to novel therapeutic strategies to combat *H. pylori*-caused diseases such as gastric cancer.

## Novel approaches for the development of high sensitivity photonic biosensors

Jaime García-Rupérez[a]

[a] *Nanophotonics Technology Center, Universitat Politècnica de València, Valencia, Spain*

Photonic technology is one of the main candidates to create the core transduction elements of future high-performance analysis devices since it provides significant advantages such as high sensitivity, compactness and high integration level, short time to result, label-free detection, and use of very low sample volumes. These advantages will allow deploying compact and low cost analysis systems able to simultaneously detect hundreds/thousands of analytes in few seconds/minutes using simply a couple of drops of the sample to be analyzed. Therefore, this type of technology will be crucial for the development of high performance analysis sytems for their application in fields like medical diagnosis, environmental monitoring, food control or biological/chemical safety.

However, despite being very high, the sensitivity provided by photonic technology is sometimes not enough to detect very low concentrations of the target analytes or to detect target analytes with a very low size and/or molecular weight. Within this context, we present different approaches being developed in our group for increasing the sensitivity of nanophotonic-based sensing devices. These approaches are based on different concepts such as the use of integrated photonic structures able to provide a higher interaction with the target substances/analytes (e.g., photonic bandgap (PBG) structures [1] or subwavelength grating (SWG) based interferometers [2]), the use of porous materials where the target substances/analytes can infiltrate inside the photonic structure and where the surface-to-volume ratio is significantly increased (e.g., for the case of porous silicon [3,4] or electrospun polymer nanofibers [5]) and the use of alternative bioreceptors able to magnify the biorecognition event in order to obtain a higher sensing signal (e.g., using nanoparticle-labelled molecular beacon probes [6]).

**References**

[1] Á. Ruiz-Tórtola, et al., "High sensitivity and label-free oligonucleotides detection using photonic bandgap sensing structures biofunctionalized with molecular beacon probes", *Biomed. Opt. Express*, Vol. 9, pp. 1717-1727 (2018).

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## Microfluidics - Basics, Application and Education

Stefan Gassmann

*Jade University of Applied Sciences, Department of Engineering, Wilhelmshaven, Germany*

**Abstract:**

The research area of microfluidics already exist since 4 decades. A lot of research has been carried out to develop technologies for creating the needed functionalities. Based on that applications in various fields have been investigated. However, many very clever solutions did not leaved the laboratory and could not hit the market. In the author's opinion, this has two reasons: 1st the knowledge about the usage of microfluidics needs to be spread out. More researchers in other disciplines needs to be informed about the possibilities and about the possible traps. Intensive hands on training, workshops and the democratization of the knowledge are a possible solution. The 2nd problem might be the handling of the microfluidic devices. Special care needs to be taken to design an easy to use macro-to-micro interface. The talk will address both problems.

The basics of microfluidics will be briefly introduced and examples of microfluidic research in the ocean science area will be presented. The author will highlight the two aspects mentioned above. The handling and macro to micro interface will be presented in detail. And a teaching concept and the experiences with an intensive course of microfluidics for interdisciplinary students will be presented.

## Fiber-optic sensors and biosensors with nanomaterial coatings

Malgorzata Szczerska
*Gdańsk University of Technology*

In the last decade, fiber-optic sensors gained popularity as sensing devices. It became possible because of the design and the integration of new materials into fiber-optic technology.

Application of the nanomaterials coatings in fiber-optic sensors technology give us an oportunitty to use it as protective coatings, reflective layers and/or as sensing media,what makes it possible to construct new sensor or tune the metrological paramteries of the known one, e.g. by expanding the measuring range.

Until know, many carbon-based and metal-based materials, such as nanocrystalline diamond (NCD) [1], boron-doped nanocrystalline diamond (B-NCD) [2], nitrogen-doped diamond (N-NCD)[3], zinc oxide (ZnO), titanium dioxide ($TiO_2$) [4-6], aluminum oxide ($Al_2O_3$) [7] were successfully applied during the construction of fiber-optic. Nanocrystalline diamond and boron-doped nanocrystalline diamond coatings were synthesized by the Chemical Vapor Deposition (CVD) methods, while oxide and nitride based coatings were produced using Atomic Layer Deposition (ALD).

The construction of fiber-optic sensors and biosensors with nanomaterilas coatings as well as their ability to perform measurements will be presented.

**References**

[1] Milewska D., Karpienko K., Jędrzejewska-Szczerska M., 2016, *Application of thin diamond films in low-coherence fiber-optic Fabry -Pérot displacement sensor*, Diamond and Related Materials, vol.64, 169-176

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[5] Majchrowicz D., Hirsch M., Wierzba P., Bechelany M., Viter R., Jędrzejewska-Szczerska M., 2016, *Application of Thin ZnO ALD Layers in Fiber-Optic Fabry-Pérot Sensing Interferometers*, SENSORS, vol.16, 416

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[7] Hirsch M., Majchrowicz D., Wierzba P., Weber M., Bechelany M., Jędrzejewska-Szczerska M., 2017, *Low-Coherence Interferometric Fiber-Optic Sensors with Potential Applications as Biosensors*, Sensors, vol.17(2), 261

## Diamond like carbon thin films and nanostructures for sensor applications

Sigitas Tamulevičius[a, b]

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Diamond-like carbon (DLC) films is the subject of considerable attention due to their extraordinary properties such as low friction coefficient and high wear resistance; high corrosion resistance and chemical inertness; high electrical resistivity; infrared-transparency and high refractive index. Many applications of DLC films have already been implemented for practical use such as mechanical elements, optical components or biomaterials. Metal nanoparticle containing DLC films showing excellent potential in various practical applications attract much attention as well. The nanocomposite films containing the nanometer range sized noble metal nanoparticles of silver, gold or other metals like copper, embedded in a matrix such as amorphous carbon have been studied intensively, since such type of films exhibit antibacterial properties, they demonstrate surface plasmon resonance (SPR) and are promising materials for developing the elemental base of laser physics, opto- and micro-electronics devices.

In this work we present a short review on technology of deposition, structure and optical properties of DLC and DLC based silver nanocomposites grown by reactive magnetron sputtering [1], nanostructuring techniques and novel applications of this material including leaky wave optical sensors [2] for the real time monitoring of bioprocesses. Plasmonic properties as well antibacterial properties [3] of thin films composed of silver nanoparticles embedded in a diamond like carbon matrix are discussed versus concentration, size of nanoparticles.

**References**

[1] S. Tamulevičius, Š. Meškinis, T. Tamulevičius, H.-G.Rubahn,. Diamond like carbon nanocomposites with embedded metallic nanoparticles // Reports on Progress in Physics. 2018, Vol. 81, iss. 2, art. 024501, p. 1-31. DOI: 10.1088/1361-6633/aa966f.

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# *In situ* gelling polysaccharides submicrometric particles: a novel weapon to improve wound care armamentarium

Pasquale Del Gaudio[a], Donatella Di Pietro[a], Paola Russo[a], Rita P. Aquino[a]
[a] *Department of Pharmacy, University of Salerno, Italy*

**Introduction**

Non-healing wounds affect more than 2% of the population in Western countries. Management of such wounds require good knowledge of their complexity in terms of both stage and severity. Stimulation of wound healing is essential in the treatment of severe wounds. The use of dressing containing active agents to both support and stimulate tissue rebuilding is becoming critical to reduce wounds healing time. In order to improve wound care treatments, a composite submicrometric powder using high manuronic content alginate and high amidated pectin has been developed to obtain an *in situ* forming hydrogel with enhanced would healing activity able to stabilize active biomolecules, while controlling its release at the wound cavity.

**Methods**

Polysaccharide blends particles were produced by supercritical assisted atomization (SAA) in the form of dry powder processing different aqueous alginate/pectin/liquid $CO_2$ feed solutions. Fluid uptake ability, fluid loss and transpiration properties were studied using simulated wound fluid (SWF). SWF was also used to conduct in vitro release studies. HaCaT cell line (Human immortalized keratinocytes) were used to asses formulations ability to promote wound healing.

**Results**

Particles size, as well as, particle size distribution of the particles is mainly related to the total concentration of the processed feeds, while alginate-pectin ratio lead to slight differences in particle size. Particles diameter ranged between 580 and 890 nm, depending on both feed concentration and polymers ratio. Complete gelling of the formulations is always very fast, between 10 and 15 min depending on pectin relative amount. Encapsulation of a peptide, Ac2-26, used as model drug was very high, about 90%, with a reduction to 86% after 3 months storage at r.t. conditions for the best formulation. Total release of AC2-26 is achieved between 24 and 36 hours depending on alginate pectin ratio that define the properties of the in situ formed gel. *In vitro* wound healing tests on HaCaT cells shows an acceleration of wound closure for both Ac2-26 loaded formulations and blank polysaccharides particles, compared to the control. These promising results suggest that submicrometric alginate/pectin particles loaded with the peptide Ac2-26, obtained by SAA, might have potential application as dressing for wound healing and could represents a new weapon to improve wound care armamentarium.

## Sub-ppb gas detection with atomically thin platinum layers

Samuel Lara-Avila[a,b], Kyung Ho Kima, Hans Hea, Rositsa Yakimovac, Marius Rodnerc, Jens Erikssonc, Ivan Shtepliukc, Karin Larssond, Alex Zakharove, David Serratef, Marten Piantekf, Sergey Kubatkina

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*b National Physical Laboratory, Teddington, UK*

*c Department of Physics, Chemistry and Biology, Linkoping University, Linkцping, Sweden.*

*d Department Chemistry-Angstrom Laboratory, University of Uppsala, Uppsala, Sweden*

*e MAX IV Laboratory and Lund University, Lund, Sweden.*

*f Instituto de Nanociencia de Aragyn and Laboratorio de Microscopиas Avanzadas, Universidad de Zaragoza, Zaragoza, Spain.*

Atomically thin materials are attractive platforms for the detection of chemical species with ultra-high sensitivity [1]. Two-dimensional crystals have been demonstrated sensitivities down to the single-molecule level but in practice, however, this class of materials is fragile towards operation at high temperature, or to chemical functionalization to fine tune their selectivity [2]. Covalent interactions between 2D crystals and chemical species disrupt the 2D crystal lattice, alter their band structure and correspondingly, compromise the prospects for ultra-high sensitivity. We present the detection of chemical species with atomically thin Pt layers, which are electrically conducting starting from single-atom thickness when deposited on the carefully graphitized surface of SiC. The robustness of the metallic Pt bond and the strong interaction of monolayer platinum layers with gases, manifesting as changes in their electrical resistance, allows us to fabricate chemiresistors with sub-ppb detection limit for benzene and NO2. This high sensitivity is particularly interesting air quality (AQ) assesment [3], in the detection of toxic pollutants in living environments, due to their potentially hazardous effects on life over long-term exposure even to trace concentrations.

**References**

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## Effect of cross-linking and drug loading efficiency on freeze casted biomimetic templates for periodontal engineering

Saad B Qasim

*Department of Biomaterials, Institute of Clinical Dentistry. University of Oslo, Norway*

Chitosan templates have been extensively utilised for periodontal tissue engineering applications. One of the most widely investigated areas in periodontal engineering is formulating Guided tissue regenerative membranes. Functional gradients in membranes have been incorporated by adding different bioactive molecules such as growth factors and drugs. The aim of the current study was to formulate freeze casted chitosan templates in different concentrations and load doxycycline hyclate after cross linking the porous scaffolds with different concentrations. Specimens were prepared at 2, 4 and 6 wt % of chitosan and cross-linked with 0.1, 1 and 3 wt % of glutaraldehyde. The acquired specimens were characterized by Scanning electron microscopy and nano computed tomography for pore size, diameter and porosity percentage. Chemically characterization was performed using Fourier transform infrared spectroscopy which showed signs of cross linking with glutaraldehyde with peak shits in intensity for the glycosidic region. Finger print region showed peaks correlating with doxycycline structure. Swelling and drug entrapment efficiency was also performed. Drug uptake was by surface grafting. Drug release studies showed that more cross linked specimens had some effect on drug release. Moreover, this method can be adapted to formulate gradient templates with either hydroxyapatite and other growth factors for treating periodontal defects.

## Development of biomedical device: a new approach for a productive collaboration with companies

Simona Sbardelatti
*Democenter-Sipe Foundation, Italy*

Tecnopolo “Mario Veronesi” (TPM) of Mirandola is a Research centre, located in the Mirandola biomedical district, one of the most important medtech industrial site. **Thanks to the skills of its researchers and the use of the most advanced equipment, TPM performs Feasibility Studies and realizes medical devices prototype**s (from disposable components to complex electromechanical systems).

TPM is particularly effective in problem solving of highly complex issues related to products or materials, through biological and biocompatibility tests, performance analysis, **specific and tests tailored on the companies’ need**. TPM adopts protocols that protect the confidentiality and the intellectual property of the projects or researches involved. TPM is certified ISO 1348.

TPM defines a new approach to help Biomedical companies find out a brand new solution for their products. In fact, the biomedical market has as core business the production of plastic devices for the circulation of biological (eg. Blood and gaseous matrices) and other fluids (eg. dialysate and drugs), typically of disposable nature.

Two examples of our work, which will be discussed during the presentation:

-NANOSENSE4LIFE, where new approaches to transform the plastic devices for biomedical use into cheap disposable sensors have been developed. The developed nano treatments will allow to functionalize the plastic devices making them able to make an optical-chemical transduction for non-contact measurement of specific analytes of interest present within the fluid in the extracorporeal circulation and assisted respiration [2];

-TECNO-EN_P, focus on the development of **new medical devices constituted by smart materials** to optimize filtration systems and make them more performing in isolation / depletion of the target elements [3].

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# 3D Microelectrodes arrays (3D-MEAs) for 3D neurons' electrophysiological activity mapping

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**Abstract**. The combination of microfabrication-based technologies for bio-MEMS (bio-Micro-Electro-Mechanical Systems) and microelectronics, with cell biology has generated in the last two decade innovative devices for analyzing, in vitro, cell cultures under physiologically relevant conditions. Electrochemical and optical sensors, for monitoring the main biological parameters of cells, microfluidic modules for cell handling and micromachined structures for cell culture guidance, during long-term assays, constitute the main building blocks for this class of devices. Moreover, miniaturized systems for providing single-cell transfection have been explored to delivery biomolecules of interest (e.g. DNA, RNA, proteins) into cells and evaluating the synthesis of proteins. With such complex systems, real time in-vitro investigations of the physiological state of a cell population in a broad area of biomedical applications [1]-[2], ranging from basic research to various fields of pharmacological analyses have been performed. More recently, with the advent of novel approaches in the development of 3D cell models and organoids, the development of new methods for assessing the cell connectivity and monitoring the cell activity at 3D level in such complex cellular structures has lately become an important research objective that requires innovative platforms and fabrication approaches [3]. In the present talk, we address recent lab-on-a-chip developments for cell analysis. We will focus the attention in microfluidic devices to overcome most of the challenges associated with for the precise regulation of culturing conditions, while simultaneously monitoring relevant parameters using embedded sensory systems. The state-of-the-art lab-on-a-chip platforms for in vitro assessment of cell cultures is presented and their potential future applications discussed.

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## WGM resonator based integrated optical circuits for lab-on-chip sensors at ~0.85 micron

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Whispering gallery mode based optical circuits in silicon nitride and/or siliconoxynitride represent an interesting alternative to more common silicon based ones for realization of evanescent field photonic biosensors. Indeed, both material systems allow for the realization of transparent low loss waveguides in the 800nm to 900nm range where low-cost VCSEL lasers can be used as light source and silicon can be used itself for realization of homogeneous integrated detectors. The technological platform developed in FBK allows for the realization of sensor chips for different type of lab-on-chip applications. Recent progress in fabrication of these type of optical sensors will be presented together with a detailed review of the properties of the waveguides, directional couplers, and integrated detectors. The optical circuit allows to measure refractive index changes smaller than $10^{-6}$ refractive index units (RIU). Finally, we will review results on the use of these sensors for sensing of Aflatoxin M1 in milk, a potent carcinogen obtained in the EU-FP7 project Symphony. Aflatoxin M1 is a metabolite of Aflatoxin B1, produced by the ubiquitous fungus Aspergillus flavus, which can contaminate feedstock. Fast sensing of Aflatoxin is important for diary industry to avoid destruction of large batches of milk and dairy products. The lab on chip sensor allowed the sensing of Aflatoxin M1 down to ~10 nanomolar, which means that in principle it is possible to sense aflatoxin M1 in milk for the limits required by european regulations, after sample preparation and some preconcentration.

# Design of nanomaterials and interfaces for biosensors and biomedical applications

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Nanostructure science and technology are a broad and interdisciplinary area of research and development that has been exponentially growing in the past few years. Engineered nanomaterials are resources designed at the molecular (nanometer) scale to take advantage of their small size and novel properties which are generally not seen in their conventional bulk counterparts. The two main reasons why nanomaterials can have different properties are: (i) the increase of relative surface area and (ii) the quantum confinement effects leading to novel optical, electrical and magnetic behaviors. In order to apply these nanomaterials in biofields and to increase the throughput of biobased nanostructured materials and devices for energy, environmental and health applications, an efficient immobilization of the biomolecules is needed by the control of the interfaces between the nanostructures and the immobilized biomaterials.

Here, we used different synthesis techniques such as atomic layer deposition (ALD),[1] electrospinning, 3D printing and the exfoliation of Graphene and BN like Graphene etc. as the main tools for the creation of controlled nanostructured materials and interfaces in which the geometry can be tuned accurately and the dependence of the physical-chemical properties on the geometric parameters can be studied systematically in order to investigate their performances in energy, environmental and health applications. We will show examples of how these methods can be used to create biofuel cells, [2] single nanopores for sensing, membrane for gas purification, osmotic energy harvesting [3] and water treatment, optical sensors and biosensors [4, 5], and bionanocomposites materials for packaging, drug delivery and tissue engineering [6] in which the performance varies with the nanostructures/interfaces.

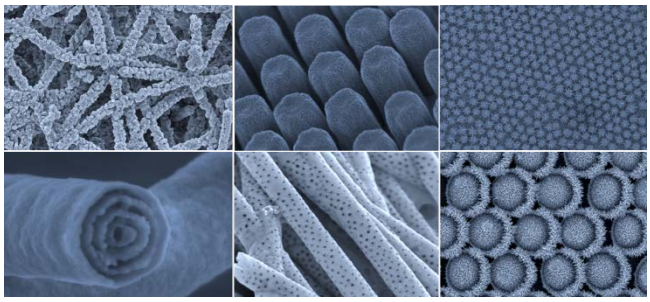

**Fig. 1: Design of bionanomaterials for energy, environmental and health applications**

**Keywords:** Atomic Layer Deposition, Electrospinning, 3D printing, Graphene, bionanocomposites, tissue engineering, drug delivery, biosensing, biofuel cells, DNA sensing

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## Oxide coatings formed on Zr alloys via PEO process

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Plasma electrolytic oxidation (PEO) is an effective method for surface modification of valve metals. With use of the PEO bioactive, antibacterial, corrosion resistive can be formed. A chemical composition of the oxide coatingd depends of proces paremeters and mainly of type of compounds present in an electrolyte. The electrolyte can be composec of Ca, P, Si as well as nanoparticle compounds.

The aim of this work was to obtain the oxide layers enriched in Ag and Cu nanoparticles on Zr alloys with use of PEO proces.

Zr-2.5Nb and Ti-50Zr were used. PEO process was performer in a solution of calcium hypophosphite with Ag or Cu nanoparticles. A morphology, chemical composition, wettability, and biological responce of obtained oxide layers were investigated.

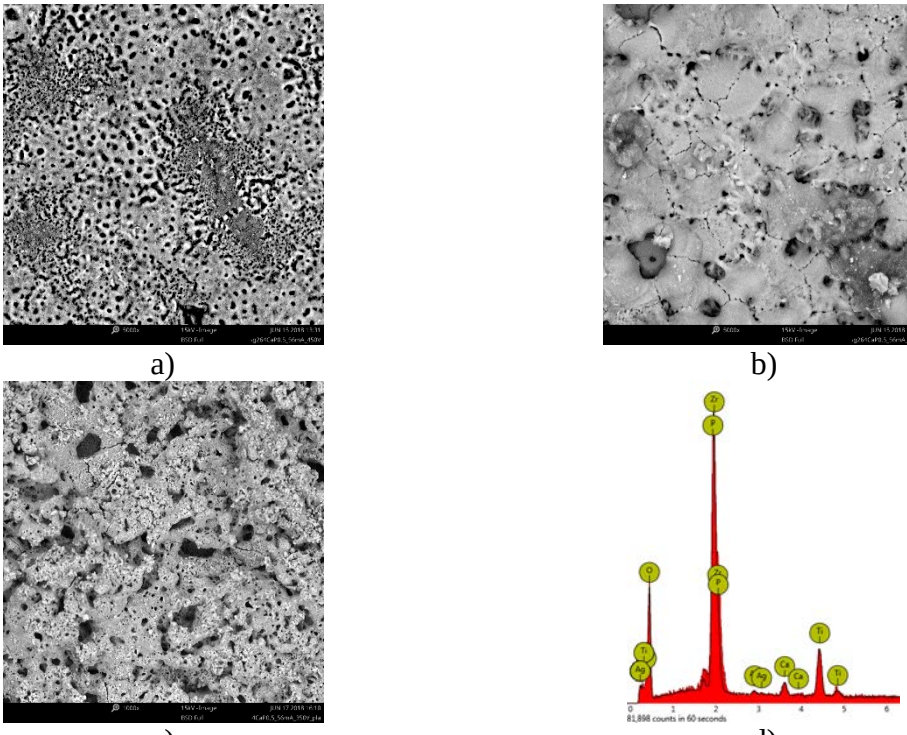


Fig 1. The SEM images of Zr-2.5Nb anodized at 450 (a) and 500 V (b), Ti-50Zr anodized at 350 V (c) and EDX spectra of Ti-50Zr anodized at 350 V (d)

The morphology and chemical composition of oxide coatings formed on Zr-2.5Nb and Ti-50Zr strongly depends of anodizing voltage and type of electrolyte. Ag and Cu nanonarticles were introduced in oxide layers at higher voltages. Coatings with Ag and Cu nanoparticles showed an antibacterial effect.

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# MXenes for biosensors and biomedical applications

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2-Dimensional transition metal carbides and nitrides (MXenes) - discovered at Drexel University [1] hold tremendous potential as new materials for biomedial applications. MXenes are produced by selective etching of the A elements (mostly Al) from their ternary layered 3D $M_{n+1}AX_n$, phase counterparts, where M is an early transition metal, A is an A-group element, X is C and/or N, and n = 1 to 3 [2]. In contrast to raw $M_{n+1}AX_n$ phases, the MXene sheets are oxygenated (═O, −OH) and fluorinated (–F) for preferential sorption of target biomolecules. Beyond the characteristics shared by all 2D materials, MXenes stand out in several ways. They are: i) conductive, with high density of states at the Fermi level and metal-like carrier densities; ii) hydrophilic, and thus processable in eco-friendly and sustainable ways; iii) extraordinarily and readily tailorable at multiple levels. MXenes have already shown promising performance in many applications including drug delivery and photothermal therapy [3], antibacterial activity [4], electrodes and sensors for medicine [5, 6], selective sorption of small molecules such as urea removal in wearable dialysis systems [7]. Moreover, cytotoxic tests show no significant effect on cell viability during 24 h incubation with 3T3 fibroblast cells by the titanium carbide MXenes [7]. This kind of MXenes sorbents offer open accessible surfaces fully available for proteins and can also be used in treatment of a broad range of conditions ranging from radiation disease and drug overdose to Ebola, Crohn's disease, Ankylosing Spondylitis and other conditions related to cytokines or toxin in blood.

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# Next Generation Oxide Containing Bioactive Scaffolds for Craniofacial Vascularisation & Bone Regeneration

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**INTRODUCTION:** Craniofacial bone is highly vascularized tissue and its repair and regeneration is challenging especially when the network of blood vessels is disrupted due to pathology or fracture, which makes healing extremely difficult. Traditional scaffold implantation does not induce angiogenesis (formation of blood vessels), instead it relies on an inflammatory healing response that results in insufficient oxygen and nutrient supply, hence, resulting in non-uniform cell differentiation and cell death [1,2]. This project investigated a tailored chemistry approach to obtain nano ceramics with added functionality. The aim of this project was to assess the potential of cerium doped ZnO for improved cell viability and vascularisation.

**METHODS:** A continuous Hydrothermal Flow System was used to synthesize cerium doped ZnO and chemical characterisation was performed. Human Osteosarcoma Cells MG63 were used for Cell viability and VEGF release assays. 10,000 cells/cm$^2$ were seeded in 24 well plates and were allowed to attach for 24 h, followed by the introduction of nanoparticle suspensions. 21-day study was performed; cell viability was analyzed at culture days 1, 7, 14, and 21.

**RESULTS:** Chemical characterization suggested successful synthesis of cerium doped ZnO. A 21-day cell viability study demonstrated no adverse effects on cells. Furthermore, increased cellular activity was observed in the presence of 3 Ce-ZnO 5 & 10 [3 mole% Cerium incorporated ZnO].

**DISCUSSION & CONCLUSIONS:** The preliminary data illustrated the non-cytotoxic nature of cerium doped ZnO. It also revealed promising results to initiate vascularization, which is the pre-requisite for bone regeneration. Further investigations on release mechanisms and biocompatibility are in progress which will lead to additional understanding of future potential for craniofacial bone regeneration and vascularization.

**ACKNOWLEDGEMENTS:** Financial support was received from Doctoral Academy, University of Sheffield; Nanoparticle synthesis process was funded by Clean Materials Technology, University College London.

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# Primary Cilia Elongation Enhances Mechanosensitivity

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## Introduction

Deflection of primary cilia (PC) is one mechanism behind how cells sense mechanical stimuli. PC have been shown to regulate their length in response to increased and continuous mechanical loads, reducing their sensitivity to stimuli. We therefore hypothesised that elongating PC in osteogenic progenitors would enhance mechanosensitivity.

## Methods

The effects of PC elongation on mechanosensitivity were assessed in 2D and 3D cell culture using lithium chloride (LiCl), a chemical known to affect PC length. Human embryonic stem-cell derived mesenchymal progenitor cells were cultured in well plates or on polyurethane foam scaffolds. 1 mM LiCl was applied for 24 hours and PC prevalence and length measured. Cells were subjected to oscillatory fluid flow using a rocking platform or an Ibidi perfusion pump. Osteogenic markers, alkaline phosphatase (ALP) activity and matrix mineralization were evaluated on day 14 and 21 respectively.

## Results

PC prevalence was similar in both 2D (55%) and 3D (53%) culture. However, in 3D culture PC of untreated controls were 63% shorter (1.3 µm compared to 3.5 µm). LiCl treatment significantly increased PC length by 43% (5 µm) and 62% (2.1 µm) in 2D and 3D respectively. In 2D or 3D culture fluid flow stimulus alone did not increase ALP activity but did increase mineralisation in 2D. When PC were elongated with 1 mM LiCl, mineralisation and ALP activity increased in response to mechanical stimulation.

## Discussion

Elongation of PC resulted in enhanced responses to mechanical loading in both 2D and 3D cell culture. These results demonstrate the significant role PClength plays in mechanosensitivity. Increases were seen in both early (ALP activity) and late osteogenic markers (mineralisation). The increase in mineralisation with PC elongation in 3D culture shows potential for tissue engineering bone constructs in vitro in a more efficient manner.

## Integration of the photonic 1D ZnO nanorods to optical transducer for bio/sensor applications

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Design and development of miniaturized optical and electrochemical devices are beneficial to get maximum response in bio/sensor systems employs 1-D metal oxide nanostructures. Herein, newly designed chamber was developed and used to hold sensing layer, excitation light and detectors to collect maximum photoluminescence response. Acetic acid was selected as standard model compound and sensitive monitoring was conducted using a nanocomposite of 1D ZnO nanorods and polyaniline (1D-ZnO/PANI) or polypyrole as the sensing material. At the first stage, 1D ZnO nanorods and nanowires were synthesized and conducting polymers of polyaniline (PANI) and polypyrrole (PPy) was formed by solution polymerization method. Interaction between ZnO nanoparticle and conducting polymers has been studied using X-ray diffraction (XRD), SEM and photoluminescence spectroscopy. The acetic acid gas sensing behaviors of the ZnO/PANI and ZnO/PPy composites were examined at various ambient conditions. The acetic acid sensor changes its photoluminescence when the sensing film adsorbs or desorbs acetic acid in gas status. An optical fiber is employed to measure variations in photoluminescence of the ZnO-conducting polymer in the presence of acetic acid vapor. Compared with those obtained on the composite of 1D ZnO nanorods and polypyrole (1D-ZnO/PPy), the photoluminescence signal response to acid vapor are significantly enhanced on the 1D-ZnO/PANI nanocomposite coated ITO glass. Experimental results show that the sensitivity of the acetic acid is about 0.4 ppm at operating temperatures ranging from 25 to 40°C in air with a linear range 0.5-100 ppm. The response time was very short, which was 3.5 s when the target gases switched from 0 ppm to 1 ppm, and 10 s for regeneration of initial signal for subsequent measurements. The results suggest that this novel ZnO/PANI composite based nanosensor shows great potential in the field of mobile monitoring and could also be modified by different sensitive materials to detect various molecules or ions in the future.

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# Novel chitosan-based biomaterials for skin tissue regeneration with ferrimagnetic properties

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Chitosan is a chitin derivative which may me obtain from shrimps, lobsters and crabs exoskeleton. An alternative are fungi which cell walls are rich in this polymer. Chitosan is known of its biocompability and biodegradability. Thus, it has many applications in medicine and pharmacy [1-2].

The main goal of the following research was to obtain polymeric scaffolds for skin tissue engineering using fungal chitosan as a raw material. To enhanced its properties the biomaterials were modified with ferrimagnetic nanoparticles. The polymeric matrixes were obtained under microwave-assisted conditions using propanodiol as a solvent and bicarboxylic acids as crosslinking agents. The ready products were characterized by FT-IR/ATR method over their chemical structure. The morphology was investigated using SEM microscope. The water vapor permeability and swelling capability were determined. The cytotoxicity was studied using human dermal fibroblasts primary cells.

The results showed that the proposed synthesis pathway resulted in the formation of three-dimensional scaffolds doped with the $Fe_3O_4$ nanoparticles. The highly porous biomaterials were characterized by interesting properties. Their high water vapor transmission rate as well as swelling abilities show that they can be successfully applied in the treatment of extensive burn wounds. The cell culture study confirmed their biocompability and positive impact on fibroblasts proliferation activity.

The research was supported financially by the Sonata project National Science Centre, Poland, Grant no. 2017/26/D/ST8/00979.

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# Nano and Microfibers to Investigate the Collagen Microstructure of Osteogenesis Imperfecta on Polycaprolactone Scaffolds

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**INTRODUCTION:** Osteogenesis imperfecta (OI) is a heritable disorder of bone matrix formation, usually caused by mutations in the type I collagen genes, *COL1A1* and *COL1A2*, which leads to increased bone fragility, and deformity [1]. It is characterized by poor bone quality, mass, and strength. In this project, we aimed to create a 3D model of extracellular matrix production using electrospun polycaprolactone (PCL) scaffolds [2] to investigate OI effects on *in vitro* collagen production in order to better understand how type 1 collagen mutations alter early collagen formation processes.

**METHODS:** PCL pellets were dissolved in dichloromethane, non-aligned and aligned fiber scaffolds were fabricated by electrospinning. Primary fibroblasts and controls were collected from human donors under informed consent from Sheffield's Children Hospital. For this project, cell-secreted collagen was analyzed using a laser scanning confocal microscope fitted with a Ti: sapphire multiphoton laser. Samples were illuminated and second harmonic generation (SHG) signals were detected.

**RESULTS:** SHG is a powerful imaging tool capable of elucidating collagen structure. SHG has been utilized to assess collagen deposited by fibroblasts in 2D and 3D [3]. As expected, collagen secreted by fibroblasts from healthy donors aligned in the direction of the electrospun PCL fibres of the substrate scaffold (3D). Notably, collagen secreted by OI fibroblasts cultured on aligned fibres produced very low SHG signals suggesting decreased collagen deposition or presence of immature procollagen. Conversely, OI fibroblasts cultured on both non-aligned fibres and tissue culture plastic (2D) produced stronger SHG signals.

**CONCLUSION:** Our results demonstrate that fibrous scaffolds traditionally used for tissue engineering can be used to create in vitro human cell-based, patient-specific models of matrix deposition in 3D. This will be a powerful tool to better understand the mechanisms behind diseases of extracellular matrix production such as OI.

**ACKNOWLEDGEMENTS:** Marie Skłodowska - Curie Actions: H2020 – MSCA – RISE - 2017 (777926) TC is funded by Republic of Turkey Ministry of National Education.

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## Novel hemostatic agents for biomedical applications

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Massive blood loss is a one of the most common death causes. To maintain hemostasis various methods may be applied. A very effective way to stop a hemorrhage is the use of hemostatic agent in the form of granules, patches or dressings. Such biomaterials can be prepared from both inorganic (kaolin) and organic raw materials, especially polymers such as cellulose, fibrin, thrombin and chitosan[1-2].

The main goal of the following research was to obtain chitosan-based hemostatic sponges with bioactive properties. The biomaterials were prepared under microwave-assisted conditions as a result of crosslinking reaction using *L*-aspartic and *L*-glutamic acid as crosslinkers. Ready products were investigated over their chemical structure, porosity and density. Their susceptibility to biodegradation as well as antioxidant properties were examined. Finally, the sponges were evaluated over their hemostatic properties using human blood samples. The research confirmed obtainment of anti-bacterial materials with excellent biological activity.

The research was supported financially by the Preludium project National Science Centre, Poland, Grant no. 2016/23/N/ST8/01273 and H2020-MSCA-RISE grant number 777926 NanoSurf.

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## Tetrapodal ZnO-CuNPs composites: cell toxicity and antibacterial effect

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Currently, there is a huge rise of interest to using metallic micro- and nanoparticles as an alternative to conventional antibiotic agents [1]. Among broad spectrum of metallic particles Cu and ZnO are the most interesting due to their antimicrobial activity, biocompatibility and reasonable price. However, an aggregation of nanoparticles and its potential toxicity may hinder its final application [2]. A way to increase antibacterial activity and decrease toxicity is combination of different metals or their oxides in one solution. Purpose of our study was to examine the influence of tetrapodal ZnO -CuNPs composites on bacteria and human cells.

**Material and methods.** ZnO particles were produced at Kristian Albrechts University (Kiel, Germany). Cu NPs were prepared at NanoBioMedical Centre Adam Mickiewicz University (Posnan, Poland). In-vitro investigation of the antimicrobial agent's activity against *E. coli* and *S. aureus* was performed by tube serial dilution method with determination of the minimal inhibitory concentration (MIC) at Sumy State University Bacteriological lab (SSU, Sumy, Ukraine). Cell toxicity was determined on primary culture of rat dermal fibroblast at Cell culture lab (SSU, Sumy, Ukraine).

**Results.** Pure T-ZnO particles demonstrated antimicrobial activity against *E.coli* and *S.aureus* at concentration 4.4±0.59 mg/ml and 1.5±0.28 mg/ml respectively. Combination of T-ZnO with Cu nanoparticles causes dramatic drop T-ZnO MIC to 1.68±0.27 ($p=0.0001$) mg/ml in case of E. coli as well as it does not influence on T-ZnO antibacterial activity against *S. aureus*.

Cell toxicity of pure T-ZnO particles and composition of T-ZnO with Cu NPs was depended of T-ZnO amount. Concentration of pure T-ZnO higher than 1 mg/ml was absolute toxic. Combination of the T-ZnO with Cu nanoparticles did not demonstrate increasing of cell viability.

**Conclusion.** Combination of T-ZnO particles with Cu NPs led to rise of its antibacterial activity against gram negative microorganism, however it does not decrease their toxicity corresponding to human cell.

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## Novel hybrid polymer-carbon quantum dots for biomedical applications

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Carbon quantum dots are nanomaterials with carbon core with the size below 10 nm. Due to their unique properties they are extensively studied by numerous scientists. These fluorescence nanomaterials can penetrate cell membranes and are of low-cytotoxicity [1-2].

To prepare the nanomaterials in the first step poly(lysine) was obtain during polycondensation reaction of lysine hydrochloride under microwave-assisted conditions. As a high boiling solvent propylene carbonate was used. The obtained precursor was further carbonized using sulphuric acid in the Prolabo synthewave microwave reactor. The ready products were further purified on CMC membranes to remove the side-products such as oligomers and low molecular weight substances. The nanomaterials solutions were investigated over their chemical structure using FT-IR method. Then, the luminescence properties were determined. Moreover, the correlation between solution pH vaule and fluorescence quantum yield was evaluated. Finally, to investigate nanomaterials biological properties, XTT assay on human dermal fibroblasts. The obtained results showed that proposed strategy enabled preparation of polymer-carbon qauntum dots with interesting luminescence properties and lack of cytotoxicity. Furtheremore, the nanomaterials were well-soluble in water solutions.

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# Conducting polymer based nanomaterials for biosensors and biomedical applications

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Biocompatibility of conducting polymer polypyrrole [1,2] opens new directions for various biomedical applications of these nanoparticles. Therefore some advanced studies of these nanoparticles were performed. In previous our research works we have proposed enzymatic synthesis of conducting polymer layers [3] and conducting polymer based nanoparticles [4,5,6,7]. Polypyrrole [1-5,7] and polyaniline [7] based nanoparticles were synthesized by this method up to this moment. Molecularly imprinted polymer (MIP) based sensors are interesting because of their relatively low costs and good selectivity towards imprinted analyte. Electrochemical [8] and chemical [9] polymerization enables deposition of thin layers of Ppy over electrodes, which could be applied in the design of sensors suitable for the determination of high molecular weight [10,11] and low molecular weight [12-14] analytes. In this research affinity and dielectric properties of molecularly imprinted conducting polymer – polypyrrole (MIP-Ppy) based thin films were evaluated. Films of polypyrrole molecularly imprinted with theophylline, caffeine and some other compounds (MIP-Ppy) and non-imprinted polypyrrole (NIP-Ppy) were evaluated and the efficiency of Ppy to bind theophylline was determined.

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## Multifunctional nanocomposites produced by ALD

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The development and tailoring of new materials is an important issue to develop novel composites with advanced properties. It is well known that the large surface area of nanomaterials, their porosity, topography, morphology and surface features improve their physical and chemical properties.

Nanocomposite materials have been intensively applied in different fields, such as in catalysis, sensor, Li ion batteries, sensing, and optics, due to their superior properties induced by quantum confinement effects. Due to the nano size of grains and important role of boundary zones surrounding individual grains, the nanocomposite materials demonstrate different properties from bulk materials. New unique physical and functional properties of the nanocomposites are driving the rapid development of these materials especially in bio-photonics and electronics.

There are many methods to produce nanocomposites. However, the most preferable method is Atomic Layer Deposition (ALD) technique. It does not depend on substrate geometry and can be applied for both planar samples, 3D patterned substrates and other multidimensional media (1-, 2- and 3D nanostructures). This method allows controlling the thickness of nanolayers or size of nanocrystallites and the chemical composition by controlling the ALD parameters.

In this research, we have applied ALD to produce multifunctional and multidimensional nanocomposites. The most important results of this research: (i) Development of production conception for multidimensional (1D, 2D and 3D) nanocomposites based on metal oxides and establishing of their optimal parameters synthesis; (ii) Evaluation of structural, chemical, electrical and optical properties of obtained nanocomposites, and development of physical models based on their properties; (iii) Establishing the correlation between the structure of nanocomposites and their electr-optical and sensors properties; (iv) Application of produced nanocomposites in (bio)sensors and energy (solar water splitting).

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## Tumor Immune Microenvironment: Prognostic And Predictive Value For Different Cancers

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The current system of tumor staging (AJCC/UICC-TNM classification), based on the assessment of tumor extension (T), regional lymph nodes (N) and distant metastasis (M), is the most reliable guidelines for the routine prognosis of clinical outcomes in different malignancies. However, it is recognized that the clinical outcome can vary widely among patients of the same stage. Plenty of approaches to distinguish different subtypes of various cancers have been proposed, including histology, molecular pathways, mutation status and gene expression-based stratification. Deep genetic alterations assessment in tumor cells provided great progress in understanding cancer biology and profoundly clarified the genomic landscape of human malignancies. Nevertheless, tumor molecular profiling provides information mostly about tumor biology but does not consider the host reactions. Recently, identification of tumor immune checkpoints has created a new era of cancer treatment that is focused on targeting immune checkpoints to reinvigorate the host immune system and restore anti-tumor immune reactions. However, the biology of the tumor immune microenvironment (TIM) determining immune check-points expression is incompletely established though it plays the crucial role in tumor progression. This study is focused on the following questions:

1) Tumor-immune cells interplay: who is chief?
2) Theoretically molecular features of tumor and host immune reactions are related. What are the networks modulating TIM?
3) TNM-staging and TIM subtypes: shaping the future classification of malignancies for precise prognostication and prediction of therapy effect.
4) Metabolic reprogramming of cancer cells and TIM: tumor metabolic synergy mechanisms and possible perspectives.

Finally, combined studying TIM and tumor genetic landscape is important to better understand the biology of different cancers and possible targets for feature therapies.

# Time-depending antibacterial effect of chitosan sponges against different bacterial strains

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**Introduction.** Chitosan is a natural polymer which can be processed into hydrogels, membranes, nanofibers, beads, scaffolds and sponges. Nevertheless, it is still required materials with high effectiveness and excellence antibacterial properties.

**Aim.** The aim of the following research was to obtain novel chitosan derivatives in chemical crosslinking process and time-depending antibacterial properties assessment.

**Materials and methods.** Chitosan with 85%, 90% and 95% deacetylation rate was used for following three-dimensional aerogels obtaining by chemical crosslinking reaction under microwave-assisted conditions with L-aspartic and L-glutamic acids as crosslinking agents: 95Ch-Asp, 90Ch-Glu, 95Ch-Glu, 95Ch-1Asp:5Glu, 90Ch-1Asp:1Glu, 95Ch-1Asp:1Glu, 95Ch-2Asp:1Glu, 95Ch-5Asp:1Glu [1].

**Methods.** In vitro antimicrobial susceptibility testing was conducted to assess the rate of killing of a bacterial inoculum determining the colony count at different time-intervals (2, 4, 6 and 24 h). Gram-positive (Staphylococcus aureus) and Gram-negative (Escherichia coli) bacteria were used in experiment.

**Results.** All sponges prevented bacterial growth within 2 hours after incubation with S. aureus. 95Ch-1Asp:1Glu aerogel retained the same effect in 4 and 6 hours. The most effective samples against E.coli were 95Ch-Glu, 95Ch-2Asp:1Glu and 95Ch-5Asp:1Glu sponges caused total media decontamination in 2 hours. Sponges 95Ch-Glu and 95Ch-1Asp:1Glu showed noticeable bactericidal activity against S. aureus and all germs were killed in 2 hours of incubation.

**Conclusion**. Investigated sponges possess antibacterial activity against both Gram positive and Gram negative bacteria strains. Accordingly, proposed biomaterials are promising alternative to commercially available biomaterials and can be used for preparation of the biomaterials with unique biological properties.

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## Au-covered hollow urchin-like ZnO nanostructures for surface-enhanced Raman scattering (SERS) sensing

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Au-covered hollow urchin-like ZnO nanostructures were prepared with controlled size by combining nanosphere lithography (NSL), atomic layer deposition (ALD) [1], electrodeposition, and electron beam (e-beam) evaporation. The influence of the Au film thickness on the surface-enhanced Raman scattering (SERS) capabilities of the substrates was investigated. The optimized structures were used to detect thiophenol molecules with a limit of detection (LOD) of $10^{-8}$ M. Additionally, adenine can be detected with a concentration as low as $10^{-6}$ M. The excellent uniformity and batch-to-batch repeatability of the substrates makes them excellent candidates for reliable SERS sensing and biosensing.

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## Structure and optical properties of $Bi_2Se_3$/ZnO and graphene/$Bi_2Se_3$/ZnO heterostructures

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Zinc oxide is known as a n-type semiconductor with good transparency and strong pholuminescence at room temperature. The recent studies showed the possibility to enhance ZnO photoluminescence by surface plasmon resonance existence on the interface between ZnO and metal/metal alloy, carbon nanotubes and graphene. Due to coupling between spin and charge excitations resulting from the locking of the spin and momentum, the spin-plasmon mode existence theoretically predicted on the surface of topological insulator (TI) materials. The research [1] experimentally showed the photoluminescence enhancement by placement of mechanically exfoliated TI $Bi_2Te_3$ flakes with thicknesses below 200 nm on the surface of ZnO.

This work is devoted to study of structure and optical properties of $Bi_2Se_3$/ZnO and G/$Bi_2Se_3$/ZnO heterostructures, that were fabricated by the ZnO layers deposition on TI material $Bi_2Se_3$ nanostructured coatings consisting from differently oriented nanoplates, which were obtained by catalyst-free physical vapour deposition method [2, 3] on quartz and graphene substrates, respectively. The ZnO nanolayers of 10-100 nm thicknesses were deposited on top of $Bi_2Se_3$ nanostructured coatings by atomic layer deposition method. The growth orientation, crystallite size and lattice strain of ZnO nanolayers were investigated using XRD technique. Absorbance and photoluminescence spectra depending on $Bi_2Se_3$ nanostructured coating structure and thickness of ZnO layers are investigated and discussed. $Bi_2Se_3$/ZnO and G/$Bi_2Se_3$/ZnO heterostructures may find applications in optical, optoelectronic devices and biological sensors.

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## Application of anodic aluminum oxide membranes for plasmonic nanoparticle assembly in optically active arrays

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Noble metal nanoparticles, Au and Ag, support localized surface plasmon resonances (LSPR) in the visible and near-infrared spectral region and can act as antennas, which couple optical radiation to local fields near particle surface. This property is very useful for various sensor applications including refractometric LSPR sensors or surface-enhanced Raman scattering (SERS) detection schemes. Ordered nanoparticle arrays can further enhance some optical properties such as directionality or narrow spectral linewidths for improved sensitivity. However, production of ordered nanostructure arrays typically requires lithography, which may not be scalable to production volumes.

Here we present a study of self-assembly of different types of Au and Ag nanoparticles on anodic aluminum oxide (AAO) templates using capillary force assisted colloid deposition [1] and test their applicability for LSPR and SERS sensor substrates. The assembly process is truly lithography free and can be performed at room temperature and atmospheric pressure. The actual optical system is an Aluminum–AAO–nanoparticle array multilayer, which supports Fabry–Pérot (FP) like resonances. Using variable thickness AAO [2] we find the optimal AAO thickness for tuning the FP resonances within the visible wavelength range.

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## Use of Nanofibers produced by Electrospinning for Medical Applications.

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On one hand, nanofibers present several advantages such as nanoscale fiber diameter, high surface area, high spatial ratio, easy functionalization of the fibers, or controlled drug release. On the other hand, electrospinning is a very versatile production method that allows the fabrication of nanofibers from different materials like polyvinyl alcohol (PVA), polylactic acid (PLA), polycaprolactone (PCL), polyvinylidene difluoride (PVDF), etc.

The electrospinning method consists of two electrodes where one of them is connected to a feed system. This electrode can be a needle, wire, slit electrode or specially shaped electrode. Then, a high voltage is applied to the electrodes and the polymeric solutions forms the so-called Taylor cone where the nanofibers are produced and collected in on the opposite charged collector where an unwound fabric captures the produced fibers. There are many different parameters can be adjusted to obtain the desired properties of the nanofiber mats, like voltage different, feed flow, work distance between electrode and collector etc.

Regarding the materials, adapting different solution parameters like polymer concentration, blending of polymers, pH, conductivity… we can modify the properties of the produced nanofiber mat and adjust it to the final applications.

The main advantages of the production of nanofibers is that they can be adapted to the final applications requirements by choosing the type of polymer, fiber diameter, porosity of the mat, fiber alignment and encapsulation and loading of active ingredients like drugs, vitamins, low or high molecular weight substances, nanoparticles, growth factors, etc.

In medical applications, there are a few parameters crucial for the good performance of the final medical device. The first one is the degradation of the nanofibers, for that purpose polymers with different degradation time can be chosen. And the second very important parameter is the biocompatibility and cell-migration. In this case, choosing the right electrospinning parameters to obtain an opened and connected porosity which promote the cell-migration.

## Laser imposed micro and nano patterns: from nanoparticles and hydrophobic surfaces to anti-counterfeiting applications

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Conventional lithography methods like UV mask lithography, electron beam lithography and other clean room processes are well established and widely used patterning technologies. Besides their advantages like assured <100 nm resolution, they are also facing some challenges including necessity of the flat surfaces, limitations of the available materials, etc. Use of intensive coherent monochromatic light enables new horizons for surface micro and nanomachining because it can overcome most of the bottlenecks faced by the conventional cleanroom processes.

In this work we are showcasing a range of promising laser patterning applications including holographic lithography, direct laser interference patterning (DLIP), focused laser beam ablation and femtosecond laser assisted chemical etching (FLICE). Main advantage of the interference based pattering is sub-wavelength resolution that scales together with the applied wavelength of the laser light. Use of the ultra-short pulses enables micro-machining of virtually any material. Application of DLIP for origination of anti-counterfeiting applications was demonstrated [1]. Tightly focused laser beam scanning or sample translation with respect to the laser beam enables down to micrometer lateral resolution. Material from the surface can be effectively removed tailoring the laser processing parameters resulting in volume structures like scaffolds for stem cells [2], microfluidic devices [3] or it can be used for gentle modification of the surfaces imposing nanoparticle size modifications or even formation of surface ripples resulting on the local variations of the surface free energy. Laser ablation of 2D materials like graphene was also shown to be a versatile patterning method [4].

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## Ti implant laser treatment - influence to cell viability and antibacterial properties

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More than 1 million arthroplasty performed annually in EU and projections indicate that the number of primary and revision joint arthroplasties will grow significantly in coming years. However, a need of revision as high as 17.5% after bone replacement surgery is reported. Incomplete osteointegration and microbial infection represent the major contributions in implant failure. Microbial populations use cell attachment to solid substrates to survive, forming biofilms. An efficient approach to prevent the biofilm formation consists in depositing a bactericidal layer on the material's surface. However, depending on the application, this approach is not completely satisfactory because of its limited efficiency, toxicity or due to its role in the emergence of multiresisting pathogens.

In the present work the surface of Titanium samples was patterned with Laser Induced Periodic Surface Structures in order to improve biocompatibility, increase tissue ingrowth and decrease bacterial adhesion and inflammatory response for applications in dental and orthopedic implants. Polished and sandblasted Ti discs 10 mm in diameter were treated generating LIPSS under two different parameters sets. The surface morphology and chemistry were investigated both by secondary electrons imaging, EDS analysis and Atomic Force Microscopy. Primary rat osteoblast culture (2nd passage) was used to assess cell toxicity and biocompatibility. The adhesive properties of the differently processed disks were assessed on gram-positive bacterium (S. aureus, strain B 918).

Formation of linear periodic surface structures on Ti-alloy surface increase osteoblast cell adhesion and proliferation, spatially on polished implants. Proliferation rate significantly increases in all (polished and sandblasted) LIPSS surface type that could enhance osteoitegration ability of medical implants. LIPSS-1 regime prevents bacterial cells adhesion within first 6 hours after co-cultivation and does not affect osteoblast cell adhesion that can be used for development of high effective implant surface with osteogenic/antibacterial properties.

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## Laser surface nano-patterning for biomedical and industrial applications

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Laser texturing is one of the most interesting technique to modify surfaces from the point of view of morphology and microstruture. Despite some interesting aspects like the absence of chemical contamination the use of laser does not normally permit to generate features at the nanoscale due to diffaction limits.

In this study, an innovative approach of ultrashort laser processing is employed: highly-regular laser-induced periodic surface structures (HR-LIPSS) [1,2] that overcome the diffraction limits and permit to generate surface nanostructure. Such nanostructures preserve quality of nanostructures over significant area of nanotextured surface area at an unprecedented treatment rate near 3 m/s. The method can be applied for industrial applications to improve tribological performance, modulate wettability and optical properties and, for biomedical applications in order to enanche cells adesion and control bacteria proliferation [3]

The proposed method permits a better control of the surface modification with respect chemical etching and mechanical treatments.

Cell proliferation assays and analysis of nanostructured implants confirm that uniformity, robustness and high reproducibility of the HR-LIPSS delivered by this low-cost and high-speed method have extremely high potential to improve cell response. This result opens a broad prospective for LIPSS applications in optimized of surgery and dental implants.

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**P #1**

## Effect of CuNPs for cell toxicity and antibacteria properties of metal alloy after PEO

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Metallic biomaterials as the materials of choice for orthopedic implants improved the quality of life and longevity of human beings. Titanium and titanium alloys are of particular interest due to the passive titanium oxide layer that forms readily on their surface when exposed to the atmosphere providing corrosion resistance and chemical stability [1]. Copper nanoparticles (CuNPs) widely used as an effective antibacterial agent but required some additional treatment to decrease cell toxicity [2].

The aim of our study was to study the influence of copper nanoparticles on cellular toxicity and antibacterial properties of Ti metal alloy after PEO.

**Materials and methods.**

PEO of Ti alloy (cylinders with 6 mm diameter) was provided with following parameters (Table 1):

Table 1. Concentration of substances and plasma electrolytic oxidation parameters

| Sample | $Ca(H_2PO_2)_2$ | KOH | CuNPs | Parameters of PEO | | |
|---|---|---|---|---|---|---|
| | | | | Voltage | Current density | Time |
| **№ 1** | 0.5 Mol/L | | | 300 | 200 mA/ $cm^{-2}$ | 5 min |
| **№ 2** | 0.5 Mol/L | 10 g/L | | 350 | 200 mA/ $cm^{-2}$ | 5 min |
| **№ 3** | 0.5 Mol/L | 10 g/L | 5 g/L | 300 | 200 mA/ $cm^{-2}$ | 5 min |

All samples were sterilized by autoclaving and assessed using osteoblast cell culture (cell toxicity) and S. aureus, strain B 918 (bacterial adhesion test).

**Results.** Alamar blue assay shown from 37±3.56 to 43.8±5.2% osteoblast adhesion in day 1 with no significant difference between groups. On day 3 we can see significant lower cell proliferation in group with CuNPs addition ($p=0.023$). Further cultivation have shown significant higher osteoblast proliferation on sample 1 compare the rest ones.

Bacteriological test confirmed less S. aureus adhesion in 2 hours to samples after PEO in pure $Ca(H_2PO_2)_2$ solution and with addition of CuNPs compare the sample after PEO with addition of KOH. Next cultivation have shown progressive bacteria growth in samples 2 and 3 and low bacteria growth rate in sample 1.

**Conclusion.** Addition of KOH and CuNPs did not provide advantages for Ti alloy surface modification due decreasing cell proliferation and increasing in bacteria adhesion.

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**P #2**

## Liposomal Nanoparticles for Pediatric Leukemia Therapy

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**Introduction.** Two main forms of acute leukemia – acute lymphoblastic leukemia (ALL) and acute myeloid leukemia (AML) occupies approximately 30% among of the pediatric malignancies. Average incidence of leukemia's in Ukraine in 2016 is 3.77 per 100 000 child population (in Sumy region – 2.87). Based on the results of the last event-free *survival* analysis of ALL children (n = 763) who were treated at the centers of the Ukrainian Cooperative Group according to the protocols ALL IC BFM 2002 and ALL IC BFM 2009, the overall recovery rate was 71%.

**Aim.** Overview the novel therapeutic strategies for pediatric patients with leukemia to reducing long-term negative impact of therapy, decrease frequency of refractive to current therapy cases and increase overall recovery rate to 80% for patients with ALL.

**Results.** Selective delivery of anti-cancer agents to cancer cells without harming the healthy cells is a major goal of novel nanoparticle-based pediatric leukemia therapy. Some studies are show that lipoprotein receptors (especially the HDL receptor) are highly active on the surface of malignant leukemic cells, that's why may be used as conduits for the delivery of anti-cancer agents [1]. Liposomal vincristine sulfate was the first nanoformulation to get approval by the FDA to treat Ph+ ALL in adults [2]. Children tolerate 2.25 mg/m$^2$/dose of weekly liposomal vincristine sulfate with evidence for clinical activity without dose-limiting neurotoxicity [3]. Liposomal doxorubicin and pegylated (polyethylene glycol coated) liposome-encapsulated doxorubicin has an impressive safety profile, particularly regarding acute cardiac toxicity, in childhood leukemia [4]. Pegylated formula of L-asparaginase decreases immunogenicity, increases circulating half-life and can be used in patients with hypersensitive to un-pegylated products [5].

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**P #3**

## Whispering gallery mode resonators covered by ZnO

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The exceptional ability of the whispering gallery mode resonators (WGMRs) to confine light within make them interesting for sensing applications. The small size and high values of quality (Q) factors (106-108) of the WGMR can be combined with a broad range of supporting optical elements. The surface of the resonator can be coated to enhance desired attributes.

ZnO is well known materials for different optoelectronic applications, such as sensors, biosensors and optical coatings. Number of techniques has been developed for ZnO deposition, such as chemical bath deposition, pulsed laser deposition, spin coating, atomic layer deposition, etc. However, among these methods, dip coating was chosen to provide complete coverage of ZnO and with minimal waste. In our previous work we showed that ZnO thickness is an important parameter, influencing crystallisation, grain size, band gap and defect concentration. It was shown that the optimal thickness of functional coating on WGMR is 10-100 nm and further increase of the coating thickness resulted to light attenuation[1]. ZnO microstructures (spheres, rods, etc.) have been used as WGMRs for laser and sensor applications due to high refractive index (important for light coupling) [2], biocompatibility and functionality of the surface. However, it is expected that ZnO nanolayers will limit Q factor of WGMRs, but it protects the surface from dust and moisture and decreases Van der Vaals forces due to screening of surface charge of WGMR.

WGMRs were fabricated from an optical telecommunication fiber under hydrogen flame, characterised using the scan method with a 780 nm ECDL to obtain the quality factors and then vertically dip-coated in the ZnO nanoparticles suspension by means of a specifically made dip coater system and characterised again for comparison. Further, an impact of ZnO presence for a WGMR glucose sensor is being investigated.

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**P #4**

## Modification of TiZr implant using plasma electrolytic oxidation in Ca/P and Ca/P-KOH solutions

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TiZr alloy is most popular materials for implant due to its biotorelance and good mechanical properties such as the lowest Young's modulus. It is widely used in different medical implant but requires surface modification to increase biocompatibility and effectiveness. Plasma electrolytic oxidation (PEO) is one of effective method to obtain specific coatings with biocompatibility and bioactivity properties. Thermodynamically stable nature oxide layer is formed on the implant surface during PEO. It may have variation of thickness and porosity that is necessary for further medical application. Incorporation different elements into oxide layer take new properties for implants such as antibacterial that can to deter pathogens adhesion.

The aim of our study was to investigate influence of KOH to formation of oxide layer on TiZr alloy after PEO in Ca/P solution.

The cylindrical samples of TiZr were obtained from Osteoplant R&D (Dębica, Poland) with 6 mm diameter and a height of 6 mm. Anodization was performed under a constant current of 0.1 A $cm^{-2}$ and up to final voltage of either 500 V for 5 min in electrolytic bath, which contained of $Ca(H_2PO_2)_2$ (0,5 Mol/L) and addition KOH. The obtained coatings were characterized by SEM and contact angle measurement. Biological properties assessed by SBF immersion test, osteoblast cultivation and bacteriological experiment.

Addition of KOH did not influence to surface structure but decrease level of Ca according EDX measurement. PEO in standard Ca/P solution have high hydrophilicity (CA-$25.2\pm3.9^0$) that extremely decrease after addition of KOH (instant drop adsorption). Both samples shown relatively high osteoblast adhesion with fast proliferation of KOH-free surface. On day 3 and 7 cell slow proliferate on surface after PEO in KOH contained solution. High hydrophilicity of KOH-contained samples leads to progressive bacteria adhesion within 24 hour compare the standard KOH-free sample.

**Conclusion.** Addition of KOH to standard PEO solution leads to extremely decreasing on contact angle with no surface morphology change. New surface did not support cell proliferation and favorable to bacteria adhesion that make unable their medical application.

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**P #5**

## Different approaches in immobilization of monoclonal antibodies on ZnO-polyacrylonitrile nanofibers surface for biomedical application

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Last decade zinc oxide (ZnO)-based nanostructures owing to their unique physical properties, biocompatibility and other multifunctional characteristics attract attention as building blocks for biosensor development including cancer cell, toxins and proteins detection. These properties of ZnO help retain biological activity of the immobilized biomolecules and help in achieving enhanced sensing performance. Despite the number of challenges, the surface biofunctionalization is still one of the most significant problem in the development of efficient and robust biosensing platforms which must be investigated more deeply.

In this work, we study the effect on various types of functionalization on the efficiency and stability of biosensing platforms based on 1D ZnO nanostructures. We report a detailed investigation of the optical and structural properties of ZnO-polyacrylonitrile (ZnO-PAN) nanofibers after their functionalization by 3-aminopropyltriethoxysilane (APTES)/glutaraldehyde (Ga) and immobilization of monoclonal antibodies (Mab) using different approaches. It was tested the following biosensing platforms: ZnO-PAN/APTES/Ga/Mab; ZnO-PAN/APTES/Ga/ProteinA/Mab and ZnO-PAN/APTES/Ga/ProteinG/Mab. Also, it were used the various types of Mabs – fluorescent labeled: anti-CD5-FITC, anti-IgG1-FITC, anti-IgG2a-FITC ($\lambda_{ex/em}$=488/525 nm), anti-CD19-PE ($\lambda_{ex/em}$=488/578 nm), anti-CD5-APC ($\lambda_{ex/em}$=633/661 nm), anti-CD19-APC-Cy7 ($\lambda_{ex/em}$=633/785 nm) and unlabeled: anti-CD5, anti-CD19, anti-IgG1, anti-IgG2a. All these studies were conducted in order to increase the sensitivity and selectivity of ZnO-based immunosensing platforms for the determination of human T-and B-lymphoblastic cells.

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**P #6**

## Testing of the one-dimensional (1D) zinc oxide nanowire platforms for biosensor creation

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One-dimensional (1D) nanostructures such as nanotubes, nanowires, nanorods have attracted attention due to their potential use as a building blocks in fabricating nanoscale devices or sensors. So, it was an important goal to find an oxide semiconductor nanostructure which is chemically stable and has a high specific surface area, capable of detecting clinically important biomolecules with a high sensitivity and reproducibility and zinc oxide-based nanostructures became one such material. Early, we show ZnO nanorod based immunosensing platform for the determination of human leukemic B-cells where physical absorption was used as method for ZnO surface biofunctionalization.

Now, we demonstrate the possibility of a fluorescent detection of human B- and T-leukemic cells using covalent coating of biomolecules on zinc oxide nanowire (ZnO NW) surface. For this, 1D ZnO NWs were growth on glass by low-temperature water-chemical method, aminated using procedure of silanization, activated by aging in glutaraldehyde vapors and finally specialized monoclonal antibodies (Mab) were immobilized. Human cell lines MOLT-4 and IM-9 derived from the patients with acute lymphoblastic leukemia and multiple myeloma, correspondingly, are used for testing constructions glass/ZnO NW/anti-CD5-FITC and glass/ZnO NW/anti-CD19-FITC.

It is shown that B- and T-lymphoblasts bind to Mab targeted ZnO NWs with high selectivity and photoluminescent signal in fluid system significantly increase. Furthermore, rise of ZnO NWs photoluminescence intensity correlated with the amount of CD5 and CD19-positive cells in the investigated populations (controlled using flow cytometry). Using scanning electron microscopy, the structural properties of formed platforms before and after lymphoblasts immobilization are investigated. So, 1D ZnO NWs exhibit an optical property useful for effective monitoring of fluorescent signal from biological system ZnO NW/Mab/cells.

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**P #7**

## Binding kinetics of monomeric analyte and dimeric derivatives of analyte linked by different spacers to granulocyte colony-stimulating factor based synthetic receptor

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Evaluation and modelling of protein – protein binding kinetics is an important issue during the modeling and development of immunosensors. In this research binding kinetics for several protein models constructed by protein fusion technology has been performed. Three different variants of granulocyte colony-stimulating factor (G-CSF) based homo-dimeric derivatives, which differed by linker length and by chemical composition of linker were constructed. Binding kinetics of these different recombinant granulocyte colony-stimulating factor based homo-dimeric derivatives was evaluated by total internal reflection ellipsometry. It was clearly observed that both (i) affinity and (ii) binding kinetics depends on the length and structure of linker, which is interconnecting two G-CSF proteins. The structure of linker, which is the most suitable for the design of G-CSF-based medications, was determined from ellipsometry based measurements and from calculations of interaction of G-CSF-based homo-dimeric derivatives with immobilized G-CSF-receptors, which were able to bind G-CSF.

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## P #8

# Synthesis, characterization and properties of nanodispersed amorphous carbonated calcium phosphates obtained by different methods

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Hydroxyapatite (HAp) and other calcium phosphates nowadays are widely used synthetic biomaterials in implantology and biomedicine. Although various substituted HAp with different stoichiometry have been obtained and implemented during the last century, synthesis method development and optimization remains important with the aim of achieving even better implant properties. There is a great emphasis on carbonate-containing HAp synthesis due to presence of relatively high amounts of carbonates in biological HAp [1] and the largest source of complications comes from poorly predictable and controllable reaction product composition which is determined by two possible ways of carbonate incorporation in a HAp molecule called A- and B-type substitution.

In current study a series of amorphous calcium phosphate syntheses were performed using different reaction conditions (see *Table 1*), products obtained are characterized by FTIR, XRD, DTA, BET and Ca/P analysis. Investigation conducted is a first preparatory step for further analytical method development for total carbonate amount quantification in carbonate-substituted HAp.

*Table 1.*

**Reaction conditions used in amorphous calcium phosphate syntheses**

<table>
<tr><th rowspan="2">Synthesis No.</th><th rowspan="2">Sample No.[a]</th><th colspan="4">REACTION CONDITIONS</th></tr>
<tr><th>Buchner funnel diameter, cm</th><th>$Ca^{2+}$ ion molar excess</th><th>Stirring time, min</th><th>Sonification</th></tr>
<tr><td>1</td><td>1; 2</td><td rowspan="3">9</td><td rowspan="3">50%</td><td>10</td><td rowspan="6">Used</td></tr>
<tr><td>2</td><td>3; 4</td><td>20</td></tr>
<tr><td>3</td><td>5; 6</td><td>40</td></tr>
<tr><td>4</td><td>7; 8</td><td>20</td><td rowspan="4">0%</td><td rowspan="5">10</td></tr>
<tr><td>5</td><td>9; 10</td><td rowspan="4">9</td></tr>
<tr><td>6</td><td>11; 12</td><td rowspan="3">Not used</td></tr>
<tr><td>7</td><td>13; 14</td></tr>
<tr><td>8</td><td>15; 16</td><td>50%</td></tr>
<tr><td>9</td><td>17; 18</td><td>20</td><td>0%</td></tr>
</table>

[a]water-washed samples are with odd number, ethanol-washed – with even number

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**P #9**

## Synthesis and photoelectrochemical properties of 1D Si/$TiO_2$/ZnO nanocomposites

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A complex Si/$TiO_2$/ZnO nanostructure has been synthesised by application of atomic layer deposition (ALD) technique to one-dimentional silicon nanopillar arrays (SiNP)[1,2]. The morphological properties of mesoporous SiNP have been tuned by means of metal-assisted chemical etching. Thin layers (approxomately 5nm) of $TiO_2$ and ZnO were deposited by ALD method, which leads to formation of complex SiNP/$TiO_2$/ZnO nanocomposite structure with superior photoelectrochemical properties in comparison to SiNP/$TiO_2$ and SiNP/ZnO nanocomposites. Superior efficiency of one-dimensional Si/$TiO_2$/ZnO nanostructure has been confirmed by photoelectrochemical (PEC) investigations such as electrochemical impedance spectroscopy and photocurrent measurements.

Owing to favorable electronic band structure the synthesised SiNP/$TiO_2$/ZnO nanocomposite facilitates efficient charge separation, transfer and low recombination rate. Additionally, narrow band gap of silicon as well the high charge carriers mobility of metal oxide layers allow facile occurrence of water photooxidation chemical reactions, known as water-splitting process. These properties can be applied for producing of stable,selective and sensetive sensor to gaseous, liquid and biological species.

**Acknowledgements**

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## P #10

# Influence of different solvent to hemostatic activity of chitosan sponge

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Massive bleeding is still a terrible complication during an accident, military action or surgery. Chitosan is a biopolymer which, due to its favorable properties and synthesis features, can serve as an effective hemostatic agent.

**Materials**

Chitosan aerogels were obtained under microwave-assisted conditions using a household microwave according to Green Chemistry principles. For the synthesis 0.5g of chitosan with 95% deacetylation degree (DD) was dissolved in the aquatic solution of aminoacid: L-Aspartic, L-Glutamic and the mixture of thereof. After 30 min, 10 mL of propylene glycol was added. Ready homogenous solution was subjected to microwave radiation until complete water evaporation. Then, crosslinking reaction was performed for 2 min (power = 900W), where propylene glycol served as high boiling solvent. Obtained hydrogels were lyophilized and transformed into aerogels.

**Blood clotting tests**

The strips of chitosan material weighted 40 mg were placed in individual Becton Dickinson Vacutainers® each filled with 2 ml of human blood. During next 10 minutes vacutainers were shaken constantly in order to provide the interaction between sponge and blood. All samples were removed, weighted and blood sorption (BS) rate was calculated. Remained blood was proceeded to complete blood count (CBC) test for the study of thrombocyte adhesion and aggregation. Following parameters were evaluated: Platelet count (PLT, $x10^9$/L), Platelet distribution width (PDW, %) and Mean platelet volume (MPV, fL).

**Results**

95Ch-1Asp:1Glu showed high sorption properties whereas 95Ch-Asp and 95Ch-Glu no significant difference. PLT concentration after blood clotting test was significantly lower than control with no difference within all groups ($p \leq 0.0001$). MPV and PDW are parameter that depended of PLT shape that will change during the blood clotting process. Interaction of chitosan sponges with blood lead to significant increasing of both parameters (ANOVA, $p \leq 0.0001$).

**Conclusions**

Chitosan-based aerogels can adhere and activate PLT after interaction that is necessary for reliable hemostasis. 95Ch-1Asp:1Glu will be more efficient due to its high sorption properties.

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**P #11**

## Cell toxicity of AgNPs and chitosan-AgNPs complex

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**Introduction.** Silver nanoparticles (AgNPs) separately and in combination with chitosan showed good antibacterial properties [1], but their use in clinical practice is difficult because of their possible toxicity. The aim was to investigate cell toxicity of AgNPs and chitosan-AgNPs complex, using dermal fibroblasts.

**Materials and methods.** Silver nanoparticles, 10-65 nm in size, synthesized by the polyol method and 2% solution of chitosan (molecular weight 300 kDa) in acetic acid were used to determine their cytotoxicity.

Dermal fibroblast cells adhesion at 24 hours and cell proliferation was assessed by the Alamar blue colorimetric assay, which is used to measure cell viability. The cells were grown in standard conditions: 5% a humidified $CO_2$, 37ºC air temperature and medium renewal for every 2–3 days in tissue culture flasks. After removing medium fibroblasts were seeded on each sample and positive control wells at a cell density of $2\times10^4$ cells per well. Alamar blue (invitrogen) was added in an amount equal to 10% of the volume to each well. The plates were incubated for 4 hours at 37°C, in the dark. The absorbance of the medium was measured using a Multiskan FC plate reader at wavelengths of 570 nm and 600 nm. The cells were quantified on the 3rd day of cultivation. The percentage of Alamar blue reduction was performed as Equation according to the manufacturer's protocol.

**Results.** Allowable non-toxic AgNPs concentration is 3.13 µg/ml, non-toxic chitosan-AgNPs complex concentration is 1.63 µg/ml. These concentrations of solutions are much higher than their minimum inhibitory concentrations (MIC) can be used in combination with the effect of low-frequency ultrasound on bacteria while maintaining the antibacterial effect of nanoparticles. For comparison, the MIC of AgNPs ranges from 0.012 to 0.78 µg/ml and the MIC of chitosan-AgNPs complex ranges from 0.006 to 0.2 µg/ml depending on the pathogen.

**Conclusions.** AgNPs and their combination with chitosan are not toxic provided they are used in combination with ultrasound and are promising for clinical application.

**Acknowledgments.** This research was supported by H2020 MSCA, grant NanoSurf 777926 and Ukraine MES grant #0118U003577

**Keywords:** silver nanoparticles, chitosan, cell toxicity

**References:**

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## P #12

# Optical biosensors based on porous silicon and gold decorated porous silicon nanomaterials suitable for the detection of mycotoxins

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Porous silicon is the one of the most popular and essential material in applied science. The high surface to volume ratio allows increasing a number of adsorbed biomolecules resulting in enhanced sensitivity comparing with planar Si surfaces. The deposition of noble metal such us Au layers over PSi and formation of PSi/Au structure can partially prevent PSi from oxidation and contamination. Selectivity of PSi and PSi/Au to target analyte can be achieved via (bio)functionalization, such as bioselective layer for target biomolecules (e.g. antigen – antibody interaction). Until now, PSi-based nanocomposites has recommended it self as a efficient platform for phatogens, bacterias, viruses detection as well as in food inspection (pesticides and mycotoxins control), etc.

Mycotoxins are toxic secondary metabolites produced by some fungal species. They have been classified as a possible carcinogen for humans and it is highly important to detect even the smallest concentration of mycotoxins in food and beverages. Aflatoxin B1 (AfB1) and Ochratoxin A (OTA), produced by different fungal (Aspergillus, etc.) are the most dangerous among all mycotoxins and the most-abundant food-contaminating mycotoxins.

In present research we reported about fabrication of the PSi and PSi/Au as a platforms for photoluminescence (PL)-based AfB1 and OTA detection [1], [2]. PSi samples were fabricated by metal assisted chemical etching, PSi/Au nanocomposites were fabricated by to approaches – chemical and electocemical deposition. It was set that both platforms shown good biosensors properties with limit of detection 2,5-4,4 pg/ml. The results shown that sensitivity of fabricated biosensors platform was very similar to sensitivity that can be measured by expensive ELISA analysis.

**Acknowledgements**

This work was supported by the European Union's Horizon 2020 research and innovation programme "CanBioSe" (grant agreement no. 778157).

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**P #13**

## Evaluation of the interaction between human cluster of differentiation 5 protein and monoclonal antibodies against it by surface plasmon resonance analysis

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**Introduction.** Now the urgent task is to create new sensitive biosensors using antibodies for the early diagnosis of cancer, in particular for the diagnosis of chronic lymphocytic leukemia (CLL). CLL is characterized by the accumulation of clonally derived mature B cells with high level of CD5 protein on their surface. Thus, estimation the degree of binding between CD5 protein and antibodies against it is important for B-CLL monitoring. The aim of this study was a quantitative determination of recombinant human CD5 protein that is binding with anti-CD5 antibodies by surface plasmon resonance (SPR) analysis.

**Materials and methods.** To solve this problem the method of surface plasmon resonance was used. The following molecular structure was created: a gold chip with 11-mercaptoundecanoic acid + protein G (platform) + anti-CD5 or anti-IgG2α (ligand) + CD5 protein (analyte in different concentrations). All measurements were carry out on Autolab SPR ESPRIT analyzer (Metrohm Autolab, Netherlands).

**Discussion of results.** After the initial immobilization of protein G we obtained that it surface concentration was in average 1,4 –2,4 ng/mm$^2$. Therefore after immobilization of the antibodies on the protein G we obtained a surface concentration of anti-CD5 in average 0,6 ng/mm$^2$, whereas level of anti-IgG2a was about 0,2 ng/mm$^2$. At the final step we estimate a value of the specific binding of CD5 protein in concentration range from 10 to 100 ng/ml and found that it was about 42 – 125 pg/mm$^2$, whereas nonspecific binding of anti-IgG2a with maximal concentrations of CD5 protein were determined less than 8 pg/mm$^2$. Comparison of anti-CD5 and anti-IgG2a molecular weights had a good correlation with concentrations obtained by this method.

**Conclusion.** According received data for this type of construction it was shown a possibility of obtaining the relatively stable results in the investigated range of analyte concentrations. In the future it is necessary to modify the immobilization methods of the target proteins to obtain a stable response and higher sensitivity at determination of the analyte concentration.

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**P #14**

## Formation of the coatings containing Ca and P on the surface of ZrNb and TiZr alloys in the presence of Cu nanoparticles by plasma electrolytic oxidation: surface structure and XRD studies

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Plasma electrolytic oxidation (PEO) is a method by which an oxide coating can be obtained on light metals like Ti, Al, Mg and others. This techniqe first was employed to produce surface hardening and improve the corrosion resistance of the materials. But the complex mature of the process where plasma microdischarges in solution take place resulting in complex and mutually dependant chemical and physical processes on the surface makes it necessary to investigate empirically the formation of the coatings on the target material (metal or alloy) in the chosen electrolytic media with different regimes of voltage and current. Moreover, in recent times the interest is emerging to conduct the PEO process in very complex media containing not only ions, but molecular species and nanoparticles which can significantly influence the coating formation and could be incorporated in the coatings.

In this work we present the part of research program aimed at the development of PEO coatings on the surface of implants to be used in dentistry and other fields of biomedicine. The TiZr and ZrNb alloys were chosen as implant materials. Electrolytes containing Ca and phosphate ions have been prepared and used as PEO baths in different regimes of current and volatges. In case of ZrNb nanoparticles of Cu has been added to the electrolyte bath. After PEO process, the surface analysis has been performed by scanning electron microscopy and X-ray diffraction study (Bragg-Brentano geometry). The coating layer is thicker when PEO process is cinducted at higher voltages in both cases. In the case of ZrNb crystallic oxide phase is present in the coatings after PEO process, in the case of TiZr no crystal phase corresponding to Ti or Zr oxides have been found. In both cases neither calcium phosphate nor copper form the crystal phases in the coating in the amount detectable by the XRD technique applied.

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**P #15**

## Investigation of photoinduced processes in one dimentional ZnO/polydopamine nanostructures

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Development of polydopamine (PDA) based composite nanomaterials is an actual subject. PDA is a biocompatible synthetic polymer, which has strong affinity to a wide range of surfaces due to the existence of multiple functional groups, which can be attached to organic and inorganic materials [1].

Among a number of different inorganic functional materials, ZnO is well known and interesting due to its structure, electrochemical and optical properties.

The combination of ZnO with PDA layers could improve optical, electronic and sensitive properties of ZnO/PDA towards target molecules [2].

In the present work, 1D ZnO nanowires (ZnONWs) were coated with PDA film via chemical bath deposition.

Structure, optical and electronic properties of ZnONWs/PDA core/shell nanostructures were analyzed by TEM, XRD, Raman and FTIR spectroscopy, photoluminescence measurements, and diffuse reflectance spectroscopy. The TEM measurements confirmed the conformal coating of PDA with different layer thicknesses. To confirm the PDA formation EELS was performed.

Correlation between structural and optical properties of the prepared nanostructures was shown. The obtained results were discussed.

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## P #16

# Optimization of porous anodic aluminum oxide surface treatment for improved adhesion of nanoparticle arrays

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Porous anodic aluminum oxide (PAAO) enables lithography free production of nanostructure arrays, such as colloidal nanoparticle assembly [1] or nanohole array formation in thin metal films [2]. Such arrays are expected to be useful in localized surface plasmon resonance (LSPR) based sensing [3], however uniform coverage of large areas with nanoparticle arrays remains challenging.

Here we analyze effects of surface treatments, including plasma etching and salinization, to achieve uniform pore filling with metal nanoparticles. The PAAO was produced using electrochemical oxidation of high-purity aluminum sheet in oxalic acid electrolyte solution [2]. The PAAO samples were etched in oxygen plasma and subsequently silanized in various silanes: (3-Aminopropyl)triethoxysilane, (3-Mercaptopropyl)trimethoxysilane, (3-Glycidyloxypropyl) trimethoxysilane, 1H, 1H, 2H, 2H - Perfluorodecyltrichlorosilane, phenyltrimethoxysilane, tetramethylorthosilicate and tetraethylorthosilicate. The silanized samples were analyzed with a Fourier-transform infrared spectroscopy and contact angle measurements. The obtained samples with different surface adhesion and hydrophilicity were tested for colloidal nanoparticle deposition in capillary force assisted assembly.

**Keywords:** porous anodic aluminum oxide, plasmonic, silanization.

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**P #17**

## Evaluation of photoluminescence and plasmonic scattering of Zinc oxide nanorods with noble metal nanoparticles

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Integration of simultaneously active components such as plasmonic or fluorescent nanostructures is a challenge for design of biosensing systems for modern optical detection technologies. Application of nanomaterial-based composites such as ZnO nanostructures and noble metal nanoparticles may potentially lead to development of new biosensors. [1-2]. The technique used for deposition of noble metal nanoparticles on the ZnO nanorods is developed and perspectives for biosensor applications of the structures is investigated. In current research, we examine effects of Au and Ag nanoparticles of various sizes on the ZnO nanowires using a colloid deposition method [3]. The evaluation of morphological and optical properties of obtained ZnO-metal assemblies is monitored using scanning electron microscopy (SEM), photoluminescence and localized surface plasmon resonance (LSPR) scattering. The experimental results show that individual and small Au and Ag nanoparticle arrays onto the ZnO are deposited without formation of large aggregates and are distributed uniformly on the surface. The evaluation of the LSPR effect of different material nanoparticles can be easily detected spectroscopically in reflection mode measurements. Further, the presence of metal nanoparticles selectively alters the photoluminescence spectra of ZnO nanorods.

***Keywords:*** *ZnO nanostructures, plasmonic nanoparticles, templated deposition, dip coating.*

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**P #18**

## WGMR coated with Au NPs to enhance the sensitivity

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One of the important properties of whispering gallery mode resonators (WGMRs) is the sensitivity to changes in the surrounding medium. Any perturbation to the optical path of the coupled light inside the WGMR results in the shift of the resonance spectrum. This make them interesting for sensing applications. The sensitivity of WGMRs is directly related to its quality factor (Q factor). Silica microsphere WGMRs have a very high Q factor of $10^7 – 10^8$.

The surface of the resonator can then be fuctionalized to further increase sensitivity. On the one hand, coating the microspheres with any type nanoparticles through deposition on the surface will lead to the degradation of the Q factor. It is crucial that the coating is homogeneous and very thin, in the range 10–100 nm [1] which is below the evanescent penetration depth. On the other hand, the benefits these particles may bring could outweigh the limitations of the Q factor by improving other surface properties of the WGMR. A known method to extending the evanescent field tail penetration depth into the media is combining the WGMRs localized surface plasmon (LSP) nanostructures to enhance the sensitivity using metal nanoparticles [2]. The LSP in gold nanoparticles (Au NPs) has been intensely researched. The Au NPs have the ability to amplify the electromagnetic field at nanometric distance from the metal surface while being highly chemically stable and photo-stable.

WGMRs were fabricated using standard telecommunication fiber and a hydrogen flame, characterized using the scan method with a 780 nm ECDL to obtain the quality factors and then coated with Au NPs using dip coating method and characterized again for comparison. The deposited layer was investigated using SEM. Further, an impact of Au NP presence for a WGMR glucose sensor is being investigated.

**Acknowledgments**

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**P #19**

## SILANIZATION OF ZnO NANOWIRES FOR THE IMMOBILIZATION OF BIOMOLECULES

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An optical biosensor is a compact analytical device containing a biorecognition sensing element integrated with an optical transducer system. Optical biosensors offer great advantages over conventional analytical techniques, because they enable the direct, real-time and label-free detection of many biological and chemical substances [1]. Due to unique optical properties ZnO nanostructures can be used in the desing of optical biosensors. The changes in ZnO nanostructures photoliuminascence intensity can be measured as analytical signal for biomolecules determination [2]. Important step of biosensor design is formation of stable bioselective layer based on ZnO surface pre-modified with biomolecules. Silanization of ZnO surface and folowing covalent binding of bioselective molecules allow to ensure a sensitive detection of analyte [3, 4].

In this work ZnO nanowires deposited on indium tin oxide (ITO) coated glass were functionalized by 3-aminopropyltriethoxysilane (APTES). The silanization procedure was performed from vapor phase. Functionalization of ZnO nanowires was assessed using contact angle measurements. Furthermore, influence of experiment conditions on silanization quality was studed.

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**P #20**

## Production of optical biosensor substrates using porous aluminum oxide templates

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The development of new selective and sensitive optical methods for monitoring of various diseases are necessary in the fields of biomedicine and biotechnology. However, reliable, reproducible, and cost-effective production of the substrates for optical sensors is still challenging. Self-organized porous anodic aluminium oxide (PAAO) as template [1] for nanofabrication has many advantages; relatively simple fabrication process, hexagonally ordered pores, pore diameter and interpore spacing can be tuned by changing anodization potential and electrolyte solution.

In our study, we use thin PAAO membranes (200 – 300 nm, pore diameter 40 – 50 nm) on Al surface as a template for capillary force assisted colloidal gold nanoparticle assembly [2, 3]. The density of nanoparticle arrays was controlled by the withdrawal speed (0.1 – 10 μm/s range). The obtained Au nanoparticle arrays on PAAO-Al substrate have a strong scattering in the visible spectral range. Applicability of Au nanoparticle arrays for refractive index sensing is demonstrated.

PAAO membranes were used also as templates for zinc oxide and titanium dioxide nanorod array preparation by atomic layer deposition. Photoluminescence of obtained hybrid Al-PAAO-ZnO, Al-PAAO_$TiO_2$ nanomaterials and free standing, ordered ZnO, $TiO_2$ nanorod arrays were analysed.

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**P #21**

## Site-directed antibody immobilization using 3-aminophenylboronic acid and oligosaccharide moieties present in antibody structure

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The sensitivity, stability and regeneration ability of an immunosensor are directly dependent on the type and amount of immobilized antibodies, on the remaining activity of antigen binding sites after immobilization and on the proper orientation on the sensing surface [1]. The site-directed immobilization of antibodies is an important step in the development of immunosensors sensitive for various analytes, such as different proteins, drugs or cells [2,3]. The most commonly used methods for the site-directed antibody immobilization are based on employing antibody binding proteins, antibody fragments or oligosaccharide moieties present in antibody structure.

In this work antibodies against human growth hormone (anti-hGH) were immobilized in a site-directed manner using 3-aminophenylboronic acid modified self-assembled monolayer and oligosaccharide moieties present in antibody structure. Efficiency of anti-hGH immobilization and the ability to directly detect human growth hormone were investigated by surface plasmon resonance analyser.

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**P #22**

## Silver nanostructures for SERS applications

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Colloidal metal nanoparticles (NPs) are emerging as key materials for catalysis, plasmonics, sensing, and biomedicine [1]. Within these applications, the control of the size and shape provides the functionality and sensitivity. Promising applications of Ag polyhedron nanostructures drive further studies of their synthesis to achieve more uniform shapes and sizes [2]. Polyol synthesis is a versatile chemical synthesis method to produce high monodispersity Ag nanostructures of predefined linear dimensions. These reactions are usually performed at elevated temperatures with the polyol serving as both solvent and reducing agent and the dissolved silver salt as the source of silver [3].

In the present research, silver NPs were synthesized employing modified polyol method [4]. Scanning electron microscopy analysis has revealed that synthesized Ag NPs had predominant cubic form and the size (edge length) varied in a range of 20 – 40 nm. The surface enhancement of the Raman scattering (SERS) was investigated using colloidal solution and NPs deposited on the template. 2-naphthalene thiol ($10^{-3}$M – $10^{-4}$M concentration) was used as an analyte material. In both cases the SERS enhancement was observed in the latter case the molecule destruction was less prominent.

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**P #23**

## Thin implant made from different alloys - Finite Element Analysis

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Lately the use of small-diameter implants has become more popular in some clinical situations. In conditions of bone tissue deficit with thin alveolar ridge, restoration of a small-diameter tooth in a confined interdental space with small-diameter implants allows to avoid additional intervention associated with bone augmentation and to avoid some complications associated with it. Many researchers use small-diameter implants with great caution, since these constructions were introduced to the market not long ago. However, technical failures, such as screw or implant fracture, screw loosening occur regularly in 30-41% within 5 years of implant service.

The aim of current research was3D modelling of mechanical loads to small-diameter implants made from different metal alloys to determine the material with optimal fatigue and strength characteristics. Solid Edge ST software were used to to reproduce the implants' geometry classical methods of geometric modelling in CAD systems were used. The form of an implant screw manufactured by Osteoplant was reproduced in the simulation model. Three-dimensional created models were represented as polygonal surface, or a set of multilines, which were saved in STL and IGS formats. Generated datasets were imported in the Solid Edge ST software environment, where we performed further steps of creation of solid-state virtual models and combination of heterogeneous models of bones with pre-established models of dental implants in assembling mode.

Beta titanium-zirconium alloy shows the maximum reversible deformations, which reduces the likelihood of a critical (destructive) stress at the points of their concentration. When comparing the materials, beta-titanium-zirconium alloy behaves biomechanically similar to the bone tissue and is optimal for implants manufacturing.

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**P #24**

## Whispering gallery mode resonators covered by ZnO

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The exceptional ability of the whispering gallery mode resonators (WGMRs) to confine light within make them interesting for sensing applications. The small size and high values of quality (Q) factors ($10^6$-$10^8$) of the WGMR can be combined with a broad range of supporting optical elements. The surface of the resonator can be coated to enhance desired attributes.

ZnO is well known materials for different optoelectronic applications, such as sensors, biosensors and optical coatings. Number of techniques has been developed for ZnO deposition, such as chemical bath deposition, pulsed laser deposition, spin coating, atomic layer deposition, etc. However, among these methods, dip coating was chosen to provide complete coverage of ZnO and with minimal waste. In our previous work we showed that ZnO thickness is an important parameter, influencing crystallisation, grain size, band gap and defect concentration. It was shown that the optimal thickness of functional coating on WGMR is 10-100 nm and further increase of the coating thickness resulted to light attenuation[1]. ZnO microstructures (spheres, rods, etc.) have been used as WGMRs for laser and sensor applications due to high refractive index (important for light coupling) [2], biocompatibility and functionality of the surface. However, it is expected that ZnO nanolayers will limit Q factor of WGMRs, but it protects the surface from dust and moisture and decreases Van der Vaals forces due to screening of surface charge of WGMR.

WGMRs were fabricated from an optical telecommunication fiber under hydrogen flame, characterised using the scan method with a 780 nm ECDL to obtain the quality factors and then vertically dip-coated in the ZnO nanoparticles suspension by means of a specifically made dip coater system and characterised again for comparison. Further, an impact of ZnO presence for a WGMR glucose sensor is being investigated.

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