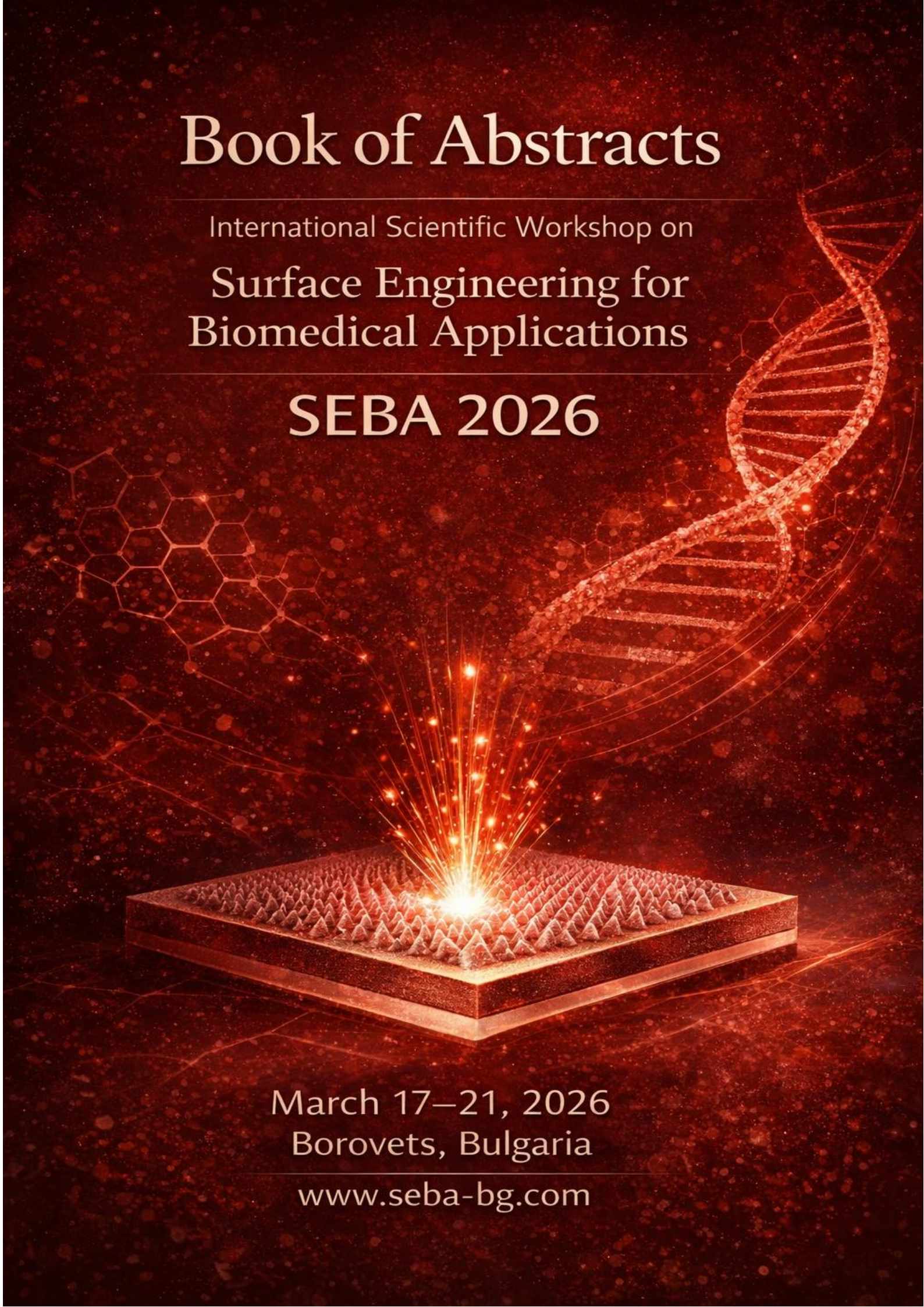
Book of Abstracts

International Scientific Workshop on

Surface Engineering for Biomedical Applications

SEBA 2026



March 17–21, 2026

Borovets, Bulgaria

www.seba-bg.com

INTERNATIONAL SCIENTIFIC WORKSHOP ON
SURFACE ENGINEERING FOR BIOMEDICAL APPLICATIONS

SEBA 2026

17 - 21 March 2026

BOROVETS, BULGARIA

PROGRAM

ABSTRACTS

Editors: Stefan Valkov, Maria Ormanova

SEBA 2026

17 – 21 March, Borovets, Bulgaria

ORGANIZED BY

INSTITUTE OF ELECTRONICS, BULGARIAN ACADEMY OF SCIENCES

CO - ORGANIZERS

MEDICAL UNIVERSITY OF PLEVEN

TECHNICAL UNIVERSITY OF GABROVO

SPONSORS

NATIONAL SCIENCE FUND
Project КП-06-МНФ/28 от 13.08.2025

Union of Physicists in Bulgaria

ВАЛЕРУС®

АКВАХИМ
AQUACHIM

MDPI

surfaces

ORGANIZING COMMITTEE

Chair:
Stefan Valkov, Institute of Electronics, BAS
Vice-Chair:
Nikolay Nedyalkov, Institute of Electronics, BAS
Secretary:
Maria Ormanova, Institute of Electronics, BAS

Members:
Christina Andreeva, Institute of Electronics, BAS
Darina Kaisheva, Institute of Electronics, BAS
Georgi Kotlarski, Institute of Electronics, BAS
Albena Daskalova, Institute of Electronics, BAS
Lilia Angelova, Institute of Electronics, BAS
Dragomir Vasilev, Technical University of Gabrovo
Teodora Valova, Medical University of Pleven
Dobromira Yaneva, Technical University of Gabrovo

INTERNATIONAL ADVISORY COMMITTEE

Chairman:
Ivan Petrov, University of Illinois at Urbana-Champaign, USA

Members:
Amelia Almeida, Instituto Superior Técnico, Portugal
Peter K. Petrov, Imperial College London, United Kingdom
Maja Dutour Sikirić, Ruđer Bošković Institute, Croatia
Aleksandar J. Krmpot, Institute of Physics, Serbia

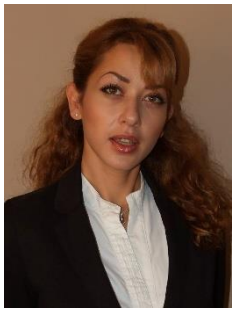
PROGRAM COMMITTEE

Stefan Valkov, Institute of Electronics, BAS
Nikolay Nedyalkov, Institute of Electronics, BAS
Slavcho Tomov, Medical University of Pleven
Katya Vutova, Institute of Electronics, BAS
Iliya Zhelezarov, Technical University of Gabrovo
Dobromir Dimitrov, Medical University of Pleven
Maria Ormanova, Institute of Electronics, BAS
Dragomir Vasilev, Technical University of Gabrovo
Tatyana Koutzarova, Institute of Electronics, BAS
Galya Stavreva-Marinova, Medical University of Pleven
Albena Daskalova, Institute of Electronics, BAS

INVITED SPEAKERS

Vera Marinova is a Professor at the Institute of Optical Materials and Technologies of the Bulgarian Academy of Sciences, where she leads a research group working on 2D materials for optical and photonic applications. She received her MSc in Optics and Spectroscopy from Sofia University and her PhD in 2000 from the Bulgarian Academy of Sciences. She has held international research positions at National Yang Ming Chiao Tung University in Taiwan and University of Antwerp in Belgium, and since 2008 has been a visiting and currently Adjunct Professor at National Yang Ming Chiao Tung University. Her research focuses on the synthesis of nanolayers and functional oxide materials for optical devices such as liquid crystal displays, spatial light modulators, and flat optical elements. She is a Fellow of SPIE and a member of Optica, Materials Research Society, and European Materials Research Society, as well as international networks supporting women in science.

Dr. Peter K. Petrov is a Principal Research Scientist at the Department of Materials and a Royce Technology Platform Lead for Diverse thin film device materials (Henry Royce Institute). He is the director of the Thin Film Device Manufacture facility, which provides the lead UK Universities and industrial partners with facilities for nano-scale thin film deposition, device patterning, and electrical characterisation. In 2024, Dr. Petrov received the prestigious Henry Royce Institute Award for Innovation by a Technical Professional. This award recognises the crucial impact that technical professionals make in advancing our technology and understanding of the material world. (The award is administered by IOM3 on behalf of the Henry Royce Institute.)



Maria Nikolova is a Full Professor of Materials Science at Ruse University “Angel Kanchev”, Bulgaria, where she coordinates the Master’s program in Technology of Materials. She obtained a BSc in Molecular Biology (2004) and an MSc in Biochemistry (2005) from Sofia University, followed by a Master’s degree in Materials Engineering (2007) from University of Chemical Technology and Metallurgy. She received her PhD in 2013 and Doctor of Science degree in 2022 in Materials Science from Ruse University. Maria Nikolova leads the laboratories for Scanning Electron Microscopy, XRD analysis, and Evaluation of Coatings and Materials, and previously served as Vice-Dean of the Faculty of Mechanical and Manufacturing Engineering. Her research focuses on surface engineering, including thermochemical treatments, PVD coatings, and nanomaterials for biomedical applications. She has extensive expertise in SEM, XRD, spectroscopic techniques, and materials characterization, and has authored more than 77 publications in Scopus- and Web of Science–indexed journals.

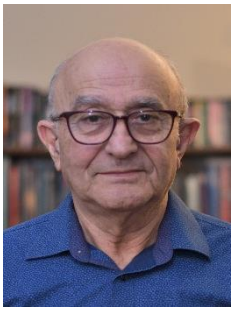
	**Bogdan Ranguelov** is a Professor at the Institute of Physical Chemistry, Bulgarian Academy of Sciences (IPC-BAS), Head of Electron microscopy laboratory and currently Director of IPC-BAS. He received MSc in Physics from Physics Department, Sofia University, and PhD degree in 2009, doctor thesis entitled „Instability of vicinal crystal surfaces – step bunching“. His research areas include phase formation and phase transitions in condensed matter; nucleation and crystal growth; epitaxy; diffusion and morphological instability of vicinal crystal surfaces; electron and optical microscopy; elemental analysis; and computer modeling of phase formation processes in solid and soft condensed matter using molecular dynamics. He has conducted research and specializations in Germany, France, and Russia, working on surface reactions, crystal growth, and epitaxial processes on silicon surfaces using advanced electron microscopy and vacuum techniques.

	**Margarita D. Apostolova** is Head of the Medical and Biological Research Laboratory at the Roumen Tsanev Institute of Molecular Biology of the Bulgarian Academy of Sciences. Her research focuses on molecular and cellular toxicology, environmental health, and proteomics, with recent work centered on nanotoxicology and the biocompatibility of nanomaterials for biomedical applications. She has conducted research in Canada, Japan, and the United Kingdom and has been involved in several EU-funded projects, including NanoREG II and ERA.Net RUS Plus. Prof. Apostolova is also a member of the Horizon Europe Programme Committee (Cluster 1) and an expert in technology transfer and innovation management. Her work has been recognized with the First Place Research Award from the Society of Toxicology, USA.

	**Cyril Popov** is a professor at the Institute of Nanostructure Technologies and Analytics (INA), University of Kassel, Germany, leading the Nano Diamond Group. He received MSc in Chemical Engineering in 1990 and PhD in 1994 from the University of Chemical Technology and Metallurgy, Sofia, Bulgaria. In the period 1995-1997 he was a Postdoctoral Fellow at the National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan and at the Central Laboratory of Photoprocesses (currently part of the Institute of Optical Materials and Technologies), Bulgarian Academy of Sciences, Sofia, working on preparation and investigation of novel materials in the ternary system B-C-N. In 1998 he joined the Institute of Nanostructure Technologies and Analytics at the University of Kassel, Germany. During his early stage career, he was granted Japan Society for the Promotion of Science (JSPS), Humboldt (Germany) and Marie-Curie (EC) Fellowships. His research interests cover deposition, characterization, nanostructuring and applications of nano- and ultrananocrystalline diamond films and monocrystalline diamond for biomedical and quantum applications.

	**Dr Tsanka Dikova** is Doctor of Science and full Professor in Materials Science at Medical University "Prof. Dr Paraskev Stoyanov" – Varna, Bulgaria. Her scientific interests are in the field of: biomaterials – dental materials and materials for implants; nanomaterials and nanocoatings; application of nanotechnologies, laser and 3D printing technologies in general and dental medicine. Dr Ts. Dikova has more than 150 scientific papers, 6 books, 4 textbooks and 6 books chapters, published in international journals. She has participated in more than 100 national and international congresses and conferences. Dr Dikova was invited lecturer on 18 international conferences in India, Turkey, Macedonia, China, Poland, France, Italy, Serbia and Australia. She gave lectures in Tokai University, Japan, Rice University, USA, and Xidian University, China.

	**Prof. Dr. Ivana Savić Gajić** is a Full Professor in pharmaceutical and cosmetic engineering at the University of Niš, Faculty of Technology, Leskovac, where she has been working since 2008. Her doctoral studies in technological engineering were completed in 2010 at the same institution. Her primary research focuses on optimizing extraction processes for bioactive compounds and modifying their properties through encapsulation in polymer carriers. She currently serves in a leadership capacity as the Vice-Dean for Education (2021–2025). Furthermore, she is actively involved in national research initiatives, coordinating significant projects like RECAP and LAMINATION under the Serbian Science Fund.

	**Prof. Ivan Petrov** is a Principal Research Scientist at the Materials Research Laboratory (1998–present), Professor of Materials Science, and 1998–2010 Director of the Center for Microanalysis of Materials at the University of Illinois at Urbana-Champaign. He is an Adjunct Professor of Physics at Linköping University, Sweden (2010–present) and served as Visiting Professor of Surface Engineering at Sheffield Hallam University, U.K. (2000–2012). Prof. Petrov earned his Ph.D. in Physics from the Institute of Electronics, Bulgarian Academy of Sciences, and received the Doctor Honoris Causa degree from Linköping University, Sweden. His research interests include nanostructural and nanochemical analyses, thin film physics, and surface science and engineering.

MAIN SCIENTIFIC TOPICS:

- Bioengineering and fundamental applications
- New materials and techniques for biomedical applications
- Application of modern engineering technologies in the medicine
- Surface modification of novel biomaterials
- Advanced thin films and coatings for biomedical applications

POSTER SESSIONS:

PS 1: Bioengineering and fundamental applications

New materials and techniques for biomedical applications

PS 2: Application of modern engineering technologies in the medicine

Surface modification of novel biomaterials

Advanced thin films and coatings for biomedical applications

ABBREVIATIONS:

PL – PLENARY LECTURE

PR – PROGRESS REPORT

OP – ORAL PRESENTATION

PS 1 – POSTER SESSION 1

PS 2 – POSTER SESSION 2

P R O G R A M

TUESDAY, 17 March

14:00	*Registration and Accommodation*	

WEDNESDAY, 18 March

10:00	***Official Opening***	
10:10 - 12:15	***Plenary Session 1***	
	Chairman: Tatyana Koutzarova	
10:10	PL-1: Vera Marinova	2D materials for biomedical applications
10:55 - 11:15	*Coffee Break*	
11:15	PR-1: Albena Daskalova	Smart, bioactive, and antiviral/antibacterial surfaces beyond the state of the art
11:50	OP-1: Georgi Prandzhev	Application of artificial intelligence for early diagnosis of cervical pre-cancer lesions
12:15	***Group Photo***	
12:30	*Free time*	
13:00	*Lunch time*	
14:00 - 16:10	***Plenary Session 2***	
	Chairman: Tsanka Dikova	
14:00	PL-2: Maria Nikolova	Multicomponent sputtered films for titanium implant functionalization
14:45	PR-2: Dimitre Dimitrov	Antibacterial performance of ALD ZnO and Al-doped ZnO
15:20	OP-2: Teodora Semova	Robotic interval debulking surgery for advanced epithelial ovarian cancer
15:45	OP-3: Evdokiya Hikova	Comparative analysis of poly-L-lysine deposition techniques for improving cell adhesion on gold surfaces
16:10 -19:00	Poster Session-1	- Bioengineering and fundamental applications - New materials and techniques for biomedical applications
19:00	*Free time*	
20:00	***Welcome Party***	

THURSDAY, 19 March

11:00 - 13:15	***Plenary Session 3***	
	Chairman: Nikolay Nedyalkov	
11:00	PL-3: Cyril Popov	Tailoring the surface of ultrananocrystalline diamond films for biomedical applications
11:45	*Coffee Break*	
12:05	PL-4: Ivana Savić Gajić	Advanced biopolymer - based systems for encapsulation and delivery of bioactive compounds
12:50	OP-4: Lyubomira Veleva	Environment-dependent morphology and interfacial stability of Pt nanoparticles for biomedical surface engineering
13:15	*Lunch time*	
14:00 - 16:10	***Plenary Session 4***	
	Chairman: Dimitre Dimitrov	
14:00	PL-5: Margarita Apostolova	Surface engineering of titanium materials for biomedical applications
14:45	PR-3: Slavcho Tomov	Simulation in medicine – challenges and perspectives
15:20	OP-5: Dimitar Dimitrov	Robotic sentinel lymph node detection with ICG in endometrial cancer patients
15:45	OP-6: Maria Todorova	Influence of silver nanoparticles on Liposomal membrane properties relevant in photothermal therapy
16:10 - 19:00	Poster Session-2	- Application of modern engineering technologies in the medicine - Surface modification of novel biomaterials - Advanced thin films and coatings for biomedical applications

FRIDAY, 20 March

10:00	***Social program***	
13:00	*Lunch time*	
14:00 - 18:20	***Plenary Session 5***	
	Chairman: Vera Marinova	
14:00	PL-6: Peter K. Petrov	Nanostructured antimicrobial surfaces based on titanium nitride nanoneedle arrays
14:45 - 15:05	*Coffee Break*	
15:05	PL-6: Tsanka Dikova	Modern dentistry - symbiosis between dentist and engineer
15:50	Companies presentations	
	Todor Todorov	AQUACHIM - 30 Years history and success stories
16:15 - 16:35	*Coffee Break*	
16:35 - 18:20	***Plenary Session 6***	
	Chairman: Stefan Valkov	
16:35	OP-7: Ognyan Petkov	Sugar-mediated modulation of the dielectric permittivity of phosphatidylcholine membranes
17:00	PR-4: Dobromir Dimitrov	Development of an automated multifunctional coaxial needle for breast biopsy: a conceptual approach
17:35	PL-8: Ivan Petrov	Control of composition, microstructure, and properties of sputter-deposited transition metal diborides
18:20	*Free time*	
20:00	***Official Dinner***	

SATURDAY, 21 March

10:00 -13:50	***Plenary Session 7***	
	Chairman: Peter K. Petrov	
10:00	PL-9: Bogdan Ranguelov	Flow-induced vesicle translocation through a narrow slit-transit time scaling relations
10:45 - 11:05	*Coffee Break*	
11:05	PR-5: Aleksandar Krmpot	Nonlinear imaging, laser nano surgery and electrophysiology on single fungal cell
11:40	PR-6: Stefan Valkov	Electron beam surface modification of metals and alloys for biomedical applications
12:15	OP-8: Velizar Georgiev	Electoranalysis of nickel-containing dental archwires in in vitro and in vivo environments
12:40	Roundtable	"Surface Engineering for Biomedical Applications"
13:50	***Closing Ceremony***	

SEBA 2026 is co-financed by the Bulgarian National Science Fund,
Project KP-06-MNF/28_13.08.2025.

ABSTRACTS

PLENARY LECTURES

2D MATERIALS FOR BIOMEDICAL APPLICATIONS

Vera Marinova[1,2,*], *Nikolay Minev*[1,2], *Blagovest Napoleonov*[1], *Vladimira Videva*[1,3], *and Dimitre Dimitrov*[1,2,4]

[1]*Institute of Optical Materials and Technologies, Bulgarian Academy of Sciences, Sofia 1113, Bulgaria*

[2]*National Centre of Excellence Mechatronics and Clean Technologies, 8 Kliment Ohridski Blvd., Blk. 8, 1756 Sofia, Bulgaria*

[3]*Faculty of Chemistry and Pharmacy, Sofia University "St. Kl. Ohridski", Sofia, Bulgaria*

[4]*Institute of Solid-State Physics, Bulgarian Academy of Sciences, Sofia, Bulgaria*

*corresponding author contacts: vmarinova@iomt.bas.bg

Abstract: Two-dimensional (2D) materials, characterized by their atomic thickness and exceptional surface-to-volume ratio, have emerged as very promising candidates in biomedical landscape. From graphene and transition metal dichalcogenides (TMDCs) to the more recently developed MXenes, these materials offer unique properties distinct from their bulk counterparts. However, the successful translation of 2D materials from the laboratory to clinical settings relies heavily on precise surface engineering to diminish toxicity, enhance solubility, and ensure biological specificity.

This work explores the critical role of controlling the thickness growth and surface modification strategies in unlocking the biomedical potential of 2D nanomaterials. We examine current methodologies designed to tune surface charge, hydrophilicity, and biocompatibility. Special attention is given to the interface between engineered 2D surfaces and biological systems, highlighting applications in high-sensitivity biosensing, drug delivery, and regenerative tissue engineering. Furthermore, we discuss the challenges of surface stability in physiological environments. This presentation aims to provide a roadmap for the next generation of 2D based biomedical devices.

Keywords: 2D materials, transition metal dichalcogenides (TMDCs), 2D biomedical devices.

Acknowledgments:
We acknowledge the Bulgarian Science Fund support under the project number FNI КП-06-Н-68/1. Financial support from the Research equipment of distributed research infrastructure INFRAMAT (part of Bulgarian National roadmap for research infrastructures) supported by Bulgarian Ministry of Education and Science is also acknowledged. Research equipment of the project № BG16RFPR002-1.014-0006 "National Centre of Excellence Mechatronics and Clean Technologies" was used for experimental work financially supported by European Regional Development Fund under "Research Innovation and Digitization for Smart Transformation" program 2021-2027.

MULTICOMPONENT SPUTTERED FILMS FOR TITANIUM IMPLANT FUNCTIONALIZATION

Maria P. Nikolova[1,], Stefan Valkov[2,3], Iliyan Tzvetkov[1], Dimitar Dechev[2], Nikolay Ivanov[2], Maria Ormanova [2,3], Tanya V. Dimitrova[4], Yordan Handzhiyski[4], and Margarita D. Apostolova[4]*

[1]*Department of Material Science and Technology, University of Ruse "Angel Kanchev", 8 Studentska Str., 7017 Ruse, Bulgaria*

[2]*Institute of Electronics, Bulgarian Academy of Sciences, 72 Tzarigradsko Chaussee Blvd., 1784 Sofia, Bulgaria*

[3]*Department of Mathematics, Informatics and Natural Sciences, Technical University of Gabrovo, 4 H. Dimitar Str., 5300 Gabrovo, Bulgaria*

[4]*Roumen Tsanev Institute of Molecular Biology, Bulgarian Academy of Sciences, Acad. Georgi Bonchev Str., Bl. 21, 1113 Sofia, Bulgaria*

* corresponding author contacts: mpnikolova@uni-ruse.bg

Abstract: Metallic materials are widely used for orthopedic and dental implants due to their favorable mechanical properties; however, their long-term performance is often limited by insufficient osseointegration, corrosion, wear, and implant-associated infections. Surface modification through functional coatings is an effective strategy to overcome these limitations. This paper focuses on the development and characterisation of copper-doped titanium oxide (Cu–TiO_2) coatings deposited on titanium-based substrates using physical vapour deposition (PVD) magnetron and glow-discharge co-sputtering techniques within the framework of the "КП-06-Н67-5/12.12.2022" project.

The study investigates the influence of deposition parameters, particularly target composition and substrate bias voltage, on the microstructure, phase composition, thickness, surface morphology, and mechanical properties of the coatings. Advanced characterisation methods, including SEM, EDS, XRD, XPS, AFM, and scratch testing, were employed to evaluate structural, chemical, and tribological properties. Special attention is given to wettability, corrosion resistance in simulated body fluids, and controlled copper ion release.

Biological performance was assessed through *in vitro* studies using osteoblastic MG-63 cells to evaluate cell attachment, viability, and cytoskeletal organization, alongside antibacterial tests against typical pathogenic strains. The results demonstrate that appropriately tailored Cu–TiO_2 coatings exhibit improved adhesion, enhanced corrosion resistance, favorable surface wettability, strong antibacterial activity, and good cytocompatibility.

Overall, the presented results highlight the potential of PVD-engineered Cu–TiO_2 coatings as multifunctional surfaces for next-generation titanium implants, contributing to improved implant integration, reduced infection risk, and extended service life.

Acknowledgments:
This research was funded by the Bulgarian National Science Fund, grant number KP-06-H 67/5 (2022).

TAILORING THE SURFACE OF ULTRANANOCRYSTALLINE DIAMOND FILMS FOR BIOMEDICAL APPLICATIONS

*Cyril Popov**

Institute of Nanostructure Technologies and Analytics (INA), Center for Interdisciplinary Nanostructure Science and Technology (CINSaT), University of Kassel, Heinrich-Plett-Str. 40, 34132 Kassel, Germany

*corresponding author contacts: popov@ina.uni-kassel.de

Abstract: Diamond is a material with quite a number of excellent properties, like extreme hardness, high elastic modulus, high wear resistance, optical transparency in a broad spectral range, controllable resistivity by the level of dopants, etc. which make it a promising candidate for different applications. Due to the outstanding electrochemical properties, superior chemical inertness and biocompatibility, artificially grown diamond has been recognized as an extremely attractive material for (bio-) chemical sensing and as an interface to biological systems. The ultrananocrystalline diamond (UNCD) films are composed of diamond nanocrystallites of up to 10 nm embedded in an amorphous carbon matrix. They are deposited by microwave plasma chemical vapor deposition from methane/nitrogen gas mixtures. The first part of the talk will describe the growth mechanism and the bulk properties of UNCD, comparing them with other types of diamond films. The second part will address the surface modifications of the UNCD films, which is the first step towards preparation of a biosensor or implant coating, including different plasma and chemical processes, the thorough characterization of the resulting surfaces by a variety of techniques (AFM, XPS, ToF-SIMS, contact angle measurements, etc.) and the possibility to pattern the surface properties. The third part will summarize the bio-properties of UNCD films, like cytotoxicity, bioinertness, non-specific interactions with biomolecules, etc., and will demonstrate examples of bio-applications, like platforms for long-term growth and investigation of neurons, coatings of bio-implants, immobilization of biomolecules (proteins, DNA) and others.

Keywords: ultrananocrystalline diamond, surface modifications, bio-properties

Acknowledgments:
The financial support by the German Research Foundation (DFG) via funded Research Training Group “multiscale clocks” (448909517/GRK 2749 “Biological Clocks on Multiple Time Scales”) is gratefully acknowledged.

ADVANCED BIOPOLYMER-BASED SYSTEMS FOR ENCAPSULATION AND DELIVERY OF BIOACTIVE COMPOUNDS

Ivana Savić Gajić and Ivan Savić*

Faculty of Technology in Leskovac, University of Niš, Serbia

* corresponding author contacts: savicivana@tf.ni.ac.rs

Abstract: The development of innovative materials and technologies for biomedical applications increasingly depends on natural, sustainable, and biocompatible sources. Among these, natural polysaccharides, such as alginate, chitosan, and cyclodextrin represent a new generation of bio-based materials capable of forming functional matrices for the encapsulation and controlled delivery of therapeutic and bioactive compounds. Owing to their unique physicochemical characteristics, including the ability to form hydrogels and inclusion complexes, these polymers provide a versatile platform for biomedical engineering. Plant-derived extracts, rich in polyphenols, flavonoids, terpenoids, and alkaloids, exhibit a wide spectrum of pharmacological activities: antioxidant, antimicrobial, anti-inflammatory, and anticancer. However, their practical and clinical use is often limited by low stability, poor solubility, and limited bioavailability. Encapsulation within polysaccharide-based carriers can overcome these challenges by protecting sensitive molecules from premature degradation, improving their chemical stability, and enabling controlled release and site-specific delivery within biological tissues. The mild processing conditions required for polysaccharide systems preserve the integrity of sensitive bioactive compounds, while allowing the design of various delivery formats nanoparticles, hydrogels, microcapsules, and thin films. Their non-toxic nature, ease of functionalization, and structural adaptability make natural polysaccharides an excellent sustainable alternative to synthetic polymers in the development of advanced drug delivery systems, wound dressings, and tissue engineering scaffolds. Overall, the integration of natural polysaccharides and plant-derived bioactive compounds offers a forward-looking approach toward safer, more efficient, and environmentally responsible therapeutic technologies. These advanced biopolymer-based strategies underline the transformative potential of natural materials in shaping the next generation of biomedical innovations.

Keywords: natural polysaccharides, plant extracts, encapsulation, biomedical materials, drug delivery.

Acknowledgments:
This research was supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (Grant No. 451-03-137/2025-03/200133) and the Science Fund of the Republic of Serbia, #17807, The Loess Plateau Margins: Towards Innovative Sustainable Conservation – LAMINATION.

SURFACE ENGINEERING OF TITANIUM MATERIALS FOR BIOMEDICAL APPLICATIONS

Margarita D. Apostolova[*]

Roumen Tsanev Institute of Molecular Biology, Bulgarian Academy of Sciences, Acad. Georgi Bonchev Str., Bl. 21, 1113 Sofia, Bulgaria

*corresponding author contacts: margo@bio21.bas.bg

Abstract: Biomaterials are engineered to interact with biological systems and play a central role in modern medical devices. Titanium and its alloys are widely used in biomedical applications, including bone tissue replacements and cardiovascular devices, owing to their favorable combination of relatively low elastic modulus, good fatigue resistance, excellent corrosion resistance, and generally acceptable biocompatibility. Despite their extensive clinical use and overall success, titanium-based implants do not fully meet all clinical requirements. Implant-related complications, including insufficient osseointegration, mechanical mismatch, and susceptibility to infection, remain clinically relevant challenges, particularly in compromised patient populations such as those with osteoporosis. These limitations have motivated sustained research efforts focused on surface modification strategies aimed at improving the biological performance of titanium implants.

In this context, tailoring the surface of titanium alloys to enhance bioactivity while simultaneously imparting antimicrobial functionality has become a major research direction in materials engineering. Numerous surface treatments and coating approaches have been developed to modify the surface topography and chemical composition of titanium alloys, thereby imparting properties better suited for specific biomedical applications.

A substantial body of research has demonstrated that micro- and nanoscale surface features can significantly influence cell–material interactions compared with conventional microrough surfaces. Nanoscale modifications often increase surface energy and alter protein adsorption kinetics, which are key determinants of subsequent cellular adhesion and behavior. In addition to topography, surface chemistry, charge distribution, and wettability play critical roles in regulating cell adhesion and spreading. Importantly, recent studies indicate that nanoscale roughness alone is insufficient to dictate osteoblast adhesion and proliferation, and that synergistic effects between surface topography and surface chemistry are required to elicit optimal cellular responses. Different surface engineering strategies for titanium-based materials intended for biomedical applications will be discussed.

Keywords: Ti, Ti-alloys, biomedical applications.

Acknowledgments:
This research was funded by the Bulgarian National Science Fund, grant number КП-06-Н67-5 (2022).

NANOSTRUCTURED ANTIMICROBIAL SURFACES BASED ON TITANIUM NITRIDE NANONEEDLE ARRAYS

*Ryan Bower[1,3], David Owen[2], Bruno Rente[1], Ming Fu[3], Thomas Smith[2], Arutiun P. Ehiasarian[2], Rupert Oulton[3], and Peter K Petrov[1,]**

[1]Department of Materials, Imperial College London, London SW7 2AZ, UK
[2]Sheffield Hallam University, Sheffield S1 1WB, UK
[3]Department of Physics, Imperial College London, London SW7 2BW, UK

*corresponding author contacts: p.petrov@imperial.ac.uk

Abstract: Antimicrobial resistance (AMR) is an escalating global health crisis, with bacterial infections becoming increasingly difficult to treat due to the diminishing efficacy of conventional antibiotics. In 2019 alone, AMR was associated with an estimated 4.95 million deaths, including 1.27 million directly attributed to resistant bacterial infections. Beyond the health implications, AMR imposes a significant economic burden through prolonged hospitalisations, increased healthcare costs, and reduced productivity.

As pharmaceutical interventions lose effectiveness, non-chemical strategies such as antimicrobial surfaces (AMSs) have emerged as promising alternatives. Inspired by naturally occurring bactericidal surfaces like cicada and dragonfly wings, nanostructured surfaces—particularly nanoneedles—have shown potential in physically disrupting bacterial cells and preventing biofilm formation. Titanium nitride (TiN) has been identified as a strong candidate for such nanostructures due to its mechanical durability, chemical stability, biocompatibility, and plasmonic properties. These characteristics suggest that TiN nanoneedles could offer enhanced bactericidal effects under light activation.

Previous work in our group successfully demonstrated the fabrication of sharp, well-defined TiN nanoneedle arrays with antimicrobial properties using electron beam lithography (EBL). However, EBL is not scalable for large-area applications. This paper, building on the outcomes of ROMANS (Robust Manufacturable Antimicrobial Surfaces) project, aimed to develop a scalable fabrication method for TiN nanoneedle arrays while preserving their antimicrobial efficacy.

The methodology, results, and implications of this work will be presented at the conference, showcasing a pathway toward the practical and large-scale deployment of AMSs in high-touch environments, such as healthcare and public transportation systems.

Keywords: Plasmonic metasurfaces, titanium nitride, antimicrobial resistance, scalable fabrication, light-activated bactericidal surfaces.

Acknowledgments:
The authors gratefully acknowledge the support of the Engineering and Physical Sciences Research Council (EPSRC) for funding this research through the Robust Manufacturable Antimicrobial Surfaces (ROMANS) grants [EP/W009501/1] and [EP/W012197/1]. We are also grateful for support from the Henry Royce Institute made through EPSRC grant [EP/R00661X/1].

MODERN DENTISTRY - SYMBIOSIS BETWEEN DENTIST AND ENGINEER

*Tsanka Dikova**

Medical University - Varna, Faculty of Dental Medicine, 84 Tsar Osvoboditel Blvd, 9000 Varna, Bulgaria

*corresponding author contacts: tsanka_dikova@abv.bg

Abstract: Last years, digital dentistry increasingly enters the clinical practice and dental laboratories and replaces conventional dentistry. Several factors define fast development of the digital dentistry: continuous development of dental materials, production processes and technologies, machines and equipment as well as the application of IT tools and systems. The aim of the present paper is to analyze the development of dentistry from ancient times to the present day, to reveal the engineering aspects of the modern dentistry and to outline the requirements to the knowledge and skills of dentists and dental technicians in the era of globalization, computerization and digitalization. The work is based on own research and is illustrated with examples of problems in dentistry solved by an engineering approach. It is clearly shown that the dentists should have interdisciplinary knowledge in the field of the image analysis, tissue engineering, materials and technologies, CAD-CAM design and production as well as excellent skills in IT and digital technologies. Nowadays, the treatment in dental clinic is synergistically dependent on the high-tech activities in the dental laboratory. The new technologies, improved world communications and globalization allow for flexibility in selecting a dental laboratory with the most suitable equipment for the production of a particular dental construction. Therefore, the profession of dental technician requires a high level of computer skills, work with specialized automated equipment and constant upgrading of qualifications. All this necessitates the transformation of the dental technician profession into a dental engineer. Mutual understanding between the dentist and the dental engineer on the specifics and limitations of both technology and clinical treatment are basis for the success in the modern dentistry.

Keywords: modern dentistry, dental engineer, tissue engineering, digital technologies, high-tech dental laboratories.

Acknowledgments:
This study is financed by the European Union-NextGenerationEU, through the National Recovery and Resilience Plan of the Republic of Bulgaria, project № BG-RRP-2.004-0009-C02.

CONTROL OF COMPOSITION, MICROSTRUCTURE, AND PROPERTIES OF SPUTTER-DEPOSITED TRANSITION METAL DIBORIDES

Ivan Petrov[1,2]

[1]*Materials Research Laboratory and Materials Science Department, University of Illinois at Urbana Champaign, Illinois 61801, USA*
[2]*Department of Physics (IFM), Linköping University, SE-581 83 Linköping, Sweden*

*corresponding author contacts: petrov@illinois.edu

Abstract: Transition metal diborides (TMB_2) typically crystallize in a hexagonal AlB2-type structure (P6/mmm, SG-191), in which the B atoms form sheets between hexagonal-close-packed TM layers. TMB_2 exhibit a unique combination of properties such as high melting points, excellent hardness, good corrosion and wear resistance, relatively low electrical resistivity, and high thermal and chemical stability. These properties, which mostly originate from the dual ceramic/metallic chemical-bonding nature of TMB_2 -- strong covalent bonding between TM and B atoms and within the B sheets as well as metallic bonding within TM layers, make them promising candidates for many applications, especially in extreme thermal and chemical environments, such as aerospace vehicles, advanced nuclear fission reactors, protective coatings, and others.

A common problem in DC magnetron sputter-deposited TMB_x layers is that the film contains excess boron with x ranging from 2.4 to 3.5. Excess B forms a tissue phase in a nanocolumnar structure which can lead to superhardness. Overstoichiometric diborides have poor oxidation resistance as oxygen and humidity attack the B-tissue phase. It is important to be able to control the B/TM ratio during film growth as a first step to synthesizing epitaxial single crystal films in order to investigate their fundamental properties. We use TiB_x as a model system and study the effect of the discharge pressure and plasma density, varied in a wide range, on the B/Ti ratio during DC magnetron sputtering of a TiB_2 target and demonstrate the ability to sputter-deposit epitaxial stoichiometric diborides. During HiPIMS deposition, it is possible to tune the B/Ti ratio in TiBx films and achieve stoichiometry by controlling the metal-ion densities in the plasma by varying the target peak current. We synthesize stoichiometric and substoichimetric single-crystal TiB_2 layers and show the atomistic arrangement accommodating B deficiency in substoichimetric diborides – B vacancies order to form Me-rich stacking faults which terminate the $[11\bar{0}0]$ prismatic planes of the crystal structure. Such nanostructure results in an increase in the hardness of substoichimetric diborides which at the same time exhibit superior oxidation resistance, compared to overstoichiometric coatings because of the elimination of the B tissue phase.

A range of metastable nanostructures are synthesized, including $Zr_{1-x}Ta_xB_2$, $Zr_{1-x}Cr_xB_2$, $Ti_{1-x}Al_xB_2$, and $Ti_{1-x}Hf_xB_2$ which all exhibit enhanced performance as protective coatings with potential savings in materials and energy resources in industrial applications.

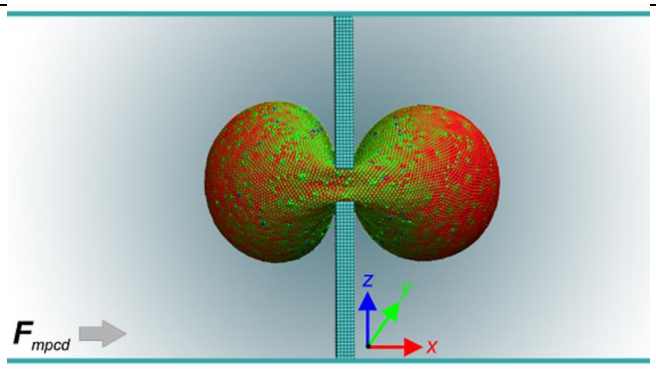
FLOW-INDUCED VESICLE TRANSLOCATION THROUGH A NARROW SLIT - TRANSIT TIME SCALING RELATIONS

Bogdan Ranguelov[1,*], *Peicho Petkov*[2], *and Andrey Milchev*[1]

[1]*Institute of Physical Chemistry, Bulgarian Academy of Sciences, Sofia, Bulgaria*
[2]*Sofia University St. Kl. Ohridski, Faculty of Physics, Sofia, Bulgaria*

*corresponding author contacts: rangelov@ipc.bas.bg

Abstract: The problem of vesicles passing through channels is pertinent to a wide range of applications such as drug delivery, nanofluidics, cell splenic filtration and hemostatis. Vesicles play an important and diverse functions in the living organisms like helping transport of materials such as proteins, hormones, enzymes, etc. both in inter- and extracellular environment. Such processes of mass transport are almost inevitably connected to a passage through obstacles and constrictions like pores or slits at different type of boundaries. Furthermore, the translocation of soft objects like red blood cells through splenic inter-endothelial slits is a major factor in blood filtration and disease progression, and plays a critical role in microfluidic devices used for separation purposes. Using extensive Molecular Dynamics simulations, we study the pressure driven flow-induced translocation of a loaded vesicle through a narrow rectangular slit whereby the hydrodynamic interactions in the channel are taken into account by means of multi-particle collision dynamics (MPCD)-algorithm. The vesicle is represented by a tethered 3D spherical membrane with M spherical monomers (vertices) enclosing athermal beads (load) of a given numerical density φ. Considering vesicles of different size and load, moving in a stream induced by a constant body force F, we demonstrate that the transit time τ of the vesicle passing through a pore with half-width H scales as $\tau^{-1} \propto FH^2$, confirming earlier theoretical predictions.



Flow-driven vesicle M = 9800 (half translocated) in a channel between parallel walls at Z = ±40 with a slit pore of half-width H = 3. Distinct colours denote the degree of bond stretching during the translocation process from blue (slightly compressed), over green (unstretched bonds) up to red (strongly stretched).

The scaling regime is bounded from below by a critical force $F^{jam}{}_{min} \propto H^{-1}$, at which the vesicle gets stuck in the pore, while above an order of magnitude larger force, $F^{open}{}_{min} \propto H^{-1}$, the transit time τ becomes independent of H. As expected, the load of the vesicle affects the transit time τ, and reveals a linear increase in τ with the concentration of fillers φ inside the vesicle volume. Evidently, this impact gets stronger with diminishing the body force F.

PROGRESS REPORTS

SMART, BIOACTIVE, AND ANTIVIRAL/ANTIBACTERIAL SURFACES BEYOND THE STATE OF THE ART

Albena Daskalova[1,], Liliya Angelova[1], Antonella Bandiera[2], Abeer Shalaa[3], Lucy di Silvio[3], Stuart Neil[3], Zhenxue Zhang[4], and Artemis Stamboulis[4]*

[1]*Institute of Electronics, Bulgarian Academy of Sciences, 72, Tzarigradsko Chaussee Blvd.1784 Sofia*

[2]*Università degli studi di Trieste/University of Trieste, Ed. C11, lab. 231, via Giorgieri, 1 - 34127 Trieste, Italy*

[3]*Faculty of Dentistry, Guys Hospital SE1, 9RT London,UK*

[4]*School of Metallurgy and Materials, University of Birmingham, Edgbaston B15 2TT, UK*

*corresponding author contacts: e-mail: albdaskalova@gmail.com

Abstract: The development of sustainable antibacterial and antiviral surfaces is essential for next-generation materials capable of outperforming conventional coatings in diverse applications. In this study, stainless steel was used as a model substrate, and femtosecond-laser surface processing was used to create periodic hybrid structures designed to modulate surface interactions and enable subsequent functionalization. Preliminary investigations employing protein–surface interactions using a number of representative protein systems deposited on untreated and laser-textured samples were performed. Microscopic and elemental analyses confirmed successful protein adherence and highlighted the strong effect of laser-induced surface morphology on protein retention and distribution. To impart antiviral properties, the laser-structured samples were additionally functionalized with silver-based nanoparticles. This modification increased surface roughness and produced a substantial change in wettability, shifting the stainless-steel surfaces from hydrophobic to highly hydrophilic. Antiviral performance evaluated according to international standards demonstrated significant reductions in viral activity on the treated surfaces, clearly surpassing the benchmark set for effective antiviral materials. Overall, the combination of laser-induced structuring, protein interaction studies, and nanoparticle-based functionalization establishes a robust and scalable approach for creating advanced pathogen free metal surfaces.

Keywords: femtosecond laser processing, antimicrobial, antiviral, sustainable.

Acknowledgments:
This work was supported by the EUROPEAN UNION'S H2020 research and innovation program under the Marie Sklodowska-Curie grant number No. 861138. The authors would like to acknowledge the European Union: Horizon Europe program under the Grant Agreement № 101057961, „Surface transfer of pathogens" (STOP).

ANTIBACTERIAL PERFORMANCE OF ALD ZNO AND AL-DOPED ZNO

Dimitre Dimitrov[1,2,3], *Maria Mladenova*[2], *and Vera Marinova*[2, 3]

[1]*Institute of Solid State Physics, Bulgarian Academy of Sciences, 1784 Sofia, Bulgaria*
[2]*Institute of Optical Materials and Technologies, Bulgarian Academy of Sciences, 1113 Sofia, Bulgaria*
[3]*National Centre of Excellence Mechatronics and Clean Technologies, 8 Kliment Ohridski Blvd., Blk. 8, 1756 Sofia, Bulgaria*

*corresponding author contacts: dzdimitrov@issp.bas.bg

Abstract: This study investigates the structural, optical, and antibacterial performance of zinc oxide (ZnO) and aluminum-doped ZnO (AZO) thin films synthesized via Atomic Layer Deposition (ALD). ZnO is a highly biocompatible, non-toxic, and cost-effective antimicrobial agent, yet traditional coating methods often suffer from poor adhesion and non-uniform coverage on complex structures. Utilizing ALD allows for the fabrication of ultra-thin, uniform coatings with superior surface coverage on three-dimensional geometries, such as personal protective equipment (PPE). Structural analysis via X-ray diffraction confirms that both pure and Al-doped films maintain a hexagonal wurtzite structure with a preferred c-axis orientation. The incorporation of Al^{3+} ions leads to a reduction in crystallite size and a transition in surface morphology. The films exhibit high visible transparency (>85%) and strong ultraviolet absorption, with Al-doping inducing a blue shift in the bandgap attributed to the Burstein-Moss effect. Antibacterial assessment against *Escherichia coli* demonstrate that Al-doping enhances biocidal efficacy. ALD-produced ZnO coatings achieved near 100% bacterial reduction, while doped films showed expanded zones of inhibition. This enhanced performance is primarily driven by the generation of reactive oxygen species (ROS), such as H_2O_2, and the release of Zn^{2+} ions. The high concentration of surface oxygen vacancies and defects in doped thin films plays a critical role in accelerating ROS production, making them ideal for coatings in medical and industrial applications.

Keywords: ALD, ZnO, Al-doped ZnO, coatings, Antibacterial activity.

Acknowledgments:
This work was supported by the Bulgarian Science Fund under the grant number КП-06-Н-58/12. Research equipment of the project № BG16RFPR002-1.014-0006 “National Centre of Excellence Mechatronics and Clean Technologies” was used for experimental work financially supported by the European Regional Development Fund under the “Research Innovation and Digitization for Smart Transformation” program 2021–2027.

SIMULATION IN MEDICINE – CHALLENGES AND PERSPECTIVES

Slavcho Tomov [1, 2, 3] *

[1]*Saint Marina University Hospital, Pleven, Bulgaria*
[2]*Medical University of Pleven, Bulgaria*
[3]*Corresponding Member of the Bulgarian Academy of Science*

*corresponding author contacts: slavcho_tomov@yahoo.de

Abstract: Simulation in medicine is a training and education approach which helps reduce errors, enhance patient safety and improve overall healthcare quality. The aim of the study is to present authors own experience with medical simulation and to share current challenges and future perspectives.

The evolution of medical imaging began with black-and-white two-dimensional images and videos, progressed through two-dimensional color images, and today has led to three-dimensional videos, augmented reality, and holographic images. Over the last decade, the following modern laboratories for contemporary training have been created and are operating at Medical University of Pleven and their university hospitals: Simulator's hall, Augmented reality training laboratory, Virtual Reality Operating Room OR 360^0, 3D Polymer-printing and 3D Bio-printing laboratories, Holographic Images Center.

One of the real challenges represents the artificial intelligence. The question is how to combine the efforts of natural and artificial intelligence and to serve better our patients. Some of the solutions are the digital surgery and the implementation of 5G technology. Since January 2026, the latest generation robotic system, da Vinci 5, has been operating at St. Marina University Hospital, Pleven. It allows real tele-surgery and tele-mentoring to be performed.

Simulation in medicine is a contemporary modern method of training and education that uses realistic scenarios to improve healthcare professionals' skills, decision-making, and teamwork.

Keywords: simulation in medicine; medical education; virtual reality; artificial intelligence; robotic surgery; patient safety.

Acknowledgments:
Not applicable.

DEVELOPMENT OF AN AUTOMATED MULTIFUNCTIONAL COAXIAL NEEDLE FOR BREAST BIOPSY: A CONCEPTUAL APPROACH

*Dobromir Dimitrov** [1,2] *and Martin Karamanliev* [1,2]

[1]*Department of surgical oncology, University Hospital Georgi Stranski, Faculty of Medicine, Medical University – Pleven, Pleven, Bulgaria*
[2]*Centre of competence in personalized medicine, 3D and telemedicine, robotic assisted and minimally invasive surgery - "Leonardo da Vinci"*

*corresponding author contacts: dobri_dimitrov@abv.bg

Abstract: Image-guided breast biopsy is a cornerstone in the diagnostic algorithm of breast cancer. With continuous advances in breast imaging, increasingly smaller and non-palpable lesions are being detected, requiring precise, safe, and minimally invasive biopsy techniques. Despite technological progress, the standard percutaneous breast biopsy procedure remains a multistep process involving local anesthesia with a separate needle, skin incision using a scalpel, followed by the introduction of a biopsy needle. This workflow is associated with prolonged procedure time, increased tissue trauma, and a higher potential risk of infection and procedure-related complications. Furthermore, operator fatigue can lead to suboptimal visualization of target lesions, especially for deep-seated or small lesions that require precise acoustic windows

To present the conceptual development of an automated multifunctional breast biopsy needle designed to integrate several procedural steps into a single device, aiming to improve safety, efficiency, and standardization of breast biopsy procedures.

The present invention addresses limitations of current biopsy needles through an innovative system that employs a novel smart coaxial needle design to enable sequential anesthesia delivery and tissue biopsy through a single insertion path, significantly improving procedural efficiency and patient comfort. By reducing the need for multiple instruments and repeated skin penetration, the concept targets minimization of procedural complexity and operator-dependent variability. The automation of key steps is intended to enhance procedural accuracy while maintaining oncological safety and patient comfort.

The integrated approach may reduce procedure duration, limit soft tissue trauma, and decrease the risk of infectious and hemorrhagic complications. Additionally, simplification of the biopsy workflow could facilitate wider adoption in outpatient settings and improve reproducibility, particularly in cases of small, image-detected breast lesions.

The development of an automated multifunctional breast biopsy needle represents a promising step toward modernization of percutaneous breast biopsy techniques. Further technical refinement and preclinical evaluation are required to assess feasibility, safety, and clinical applicability.

Keywords: Breast biopsy; Automated biopsy needle; Minimally invasive surgery.

Acknowledgments:
The support of the project BG16RFPR002-1.014-0002-C001 “CENTRE OF COMPETENCE IN PERSONALIZED MEDICINE, 3D AND TELEMEDICINE, ROBOTIC ASSISTED AND MINIMALLY INVASIVE SURGERY” funded by the PRIDST 2021-2027, co-funded by the EU is greatly acknowledged.

NONLINEAR IMAGING, LASER NANO SURGERY AND ELECTROPHYSIOLOGY ON SINGLE FUNGAL CELL

Marta Bukumira[1], Tanja Pajić[2], Katarina Stevanović[2], Nataša Todorović[3], Svetlana Savić Šević[1], Ana Senkić[4], Nataša Vujičić[4], Miroslav Živić[2], Mihailo Rabasović[1], and Aleksandar Krmpot[1,]*

[1]Faculty of Biology, University of Belgrade, Serbia
[2]Institute for Biological Research "Siniša Stanković", University of Belgrade, Serbia
[3]Institute of Physics Belgrade, University of Belgrade, Serbia
[4]Centre for Advanced Laser Techniques, Institute of Physics, Bijenička cesta 46, 10 000 Zagreb, Croatia

*corresponding author contacts: krmpo@ipb.ac.rs

Abstract: Electrophysiology studies of ion channels, in live filamentous fungi by patch clamp method are not possible due to presence of rigid chitinous cell wall that prevents patch clamp pipette to access the plasma membrane. We present laser nano-surgery of the fungal cell wall that enables patch clamp electrophysiology studies. The developed method is reproducible utilizing femtosecond lasers accompanied by two-photon excitation fluorescence (TPEF) imaging of hyphae *Phycomyces blakesleeanus* (Burgeff) [NRRL 1555(-)]. The hyphae were grown on glass coverslips with hand-etched grid, coated with a thin layer of 50% collagen type I as an immobilizer. Home built nonlinear laser scanning microscope utilizing Ti:Sa tunable fs laser was used for TPEF imaging of hyphae and the cell surgery. The latter is enabled with the custom made add-on in software. The dwell time (1s) and the laser power (4-15mW) were set with fixed repetition rate (76MHz), pulse duration (160fs) and laser wavelength (730nm). Coverslip with hyphae is transferred to another microscope setup for patch clamp, consisting of micromanipulators and precise electronics for pA current measurements. Obtained current recordings provide valuable information on fungal cell membrane ionic channels. Based on the obtained results, a new integrated instrument is developed, combining nonlinear microscope and patch clamp instrumentation. The newly developed instrument was characterized in various aspects, most notably by knife-edge techniques for resolution assessment utilizing single molecule layers (monolayers) of WS2. The samples were made by chemical vapor deposition. The new integrated instrument enables significantly shorter time for the whole imaging-surgery-patch clamping procedure, as well as reduced stress imposed to hyphae.

Keywords: Nonlinear imaging, laser cell surgery, electrophysiology, WS2 monolayer, fs lasers.

Acknowledgments:
project BioPhysFUN, program GREEN, Science Fund of the Republic of Serbia; Ministry of Science and Technological Development and Innovations of the Republic of Serbia.

ELECTRON BEAM SURFACE MODIFICATION OF METALS AND ALLOYS FOR BIOMEDICAL APPLICATIONS

Stefan Valkov[1,2,*]

[1]*Acad. E. Djakov Institute of Electronics, Bulgarian Academy of Sciences, 72 Tzarigradsko Chaussee Blvd., 1784 Sofia, Bulgaria;*
[2]*Technical University of Gabrovo, 4 H. Dimitar Str., 5300 Gabrovo, Bulgaria;*

*corresponding author contacts: stsvalkov@gmail.com

Abstract: During the last decades, electron-beam modification technologies have been widely used for surface modification of metals and alloys for the needs of the modern biomedicine. These methods are known as accurate and efficient. They have many advantages in comparison with the conventional techniques, such as very short technological process time, uniform distribution of the energy of the electron beam, which allows a precise control of the beam parameters and formed structure and properties of the materials, etc. Currently, modern trends in the surface treatment of metals and alloys for biomedical applications are based on the combination of electron-beam technologies with other methods, such as thin film deposition and others. This approach results in a significant improvement in the surface properties of the materials which opens new potential applications. This talk aims to summarize the topics related to the manufacturing and surface modification of metals and alloys by means of electron-beam technologies. The benefits of these technologies, as well as their combination with other methods for the needs of the modern biomedicine, are extensively discussed.

Keywords: Electron beam surface modification, biomedical coatings, implants.

Acknowledgments:
This work was funded by the Bulgarian National Science Fund, grant # KP-06 H 67/5

ORAL PRESENTATIONS

APPLICATION OF ARTIFICIAL INTELLIGENCE FOR EARLY DIAGNOSIS OF CERVICAL PRE-CANCER LESIONS

Georgi Prandzhev [1,2,*], *Slavcho Tomov* [1,2,3], *and Grigor Gortchev* [1,2,3]

[1]*Saint Marina University Hospital, Pleven, Bulgaria*
[2]*Medical University of Pleven, Bulgaria*
[3]*Bulgarian Academy of Sciences*

[*]corresponding author: georgi.prandzhev@gmail.com

Abstract: Cervical cancer remains a leading cause of cancer-related morbidity and mortality among women worldwide, despite the availability of effective screening methods. Early identification of cervical precancerous lesions is critical for timely intervention and prevention of invasive disease. Artificial intelligence (AI), particularly machine learning and deep learning techniques, has emerged as a promising tool to enhance the accuracy of medical diagnostics.
The present study aims to evaluate the application and clinical relevance of an in-house–developed artificial intelligence system, trained and validated using a proprietary database of colposcopic images of the uterine cervix. The system has been engineered over a four-year period, during which more than 20,000 cervical images were accumulated.

Artificial intelligence algorithms enable the automated analysis of large volumes of high-resolution colposcopic images, facilitating the detection of subtle visual patterns associated with precancerous lesions. Evidence suggests that AI-assisted colposcopy can achieve diagnostic performance comparable to experienced colposcopists. It can improve sensitivity, specificity, and interobserver agreement, while contributing to more standardized and objective clinical decision-making.

Challenges such as data quality, algorithm transparency, and clinical validation remain. Further large-scale prospective studies are necessary to confirm the reliability, safety, and cost-effectiveness of such systems. Overall, artificial intelligence represents a transformative approach in cervical cancer prevention, supporting clinicians in achieving earlier and more accurate detection of pre-cancerous cervical lesions.

Keywords: artificial intelligence; colposcopy; cervical cancer; detection; deep learning;

Acknowledgments:
N/A.

ROBOTIC INTERVAL DEBULKING SURGERY FOR ADVANCED EPITHELIAL OVARIAN CANCER

Teodora Semova[1,2,*], *Grigor Gorchev*[1,2], *K. Yaneva* [1,2], *Georgi Prandzhev*[1,2], *D. Dimitrov*[1,2], *and Slavcho Tomov*[1,2]

[1] *Medical University – Pleven, Bulgaria*
[2] *University Hospital Saint Marina, Pleven, Bulgaria*

*corresponding author contacts: teodora_semova@abv.bg

Abstract: For many years, the standard treatment for Stage III and IV ovarian cancer has been primary debulking surgery followed by platinum-based adjuvant chemotherapy. However, more recently, neoadjuvant chemotherapy followed by interval debulking surgery has emerged as an alternative option to primary debulking surgery. In women who have a response to neoadjuvant chemotherapy, it has been proposed that interval cytoreduction can be achieved using minimally invasive surgery. The objective of this study was to evaluate the impact of introducing robotic surgery for interval cytoreduction of selected patients with stage III–IV ovarian cancer.

Thirty-six patients with histologically confirmed ovarian carcinoma after neoadjuvant chemotherapy were included in the study. All patients underwent robotic–assisted surgery with the Da Vinci X Surgical System.

In the study, 61.1% of the patients had stage IIIC disease, 13.9% had stage IVA, and 2.8% had stage IVB. In 44.4% of patients, a complete clinical response to chemotherapy was observed. The average operative time is 85 minutes, and the average hospital stay is 5 days. Complete cytoreduction after surgery was achieved in 75.0% of patients included in the study

The findings from our study indicate that minimally invasive surgery (MIS) is both feasible and seems to be safe for patients with advanced epithelial ovarian cancer who undergo interval cytoreduction following neoadjuvant chemotherapy (NACT). A large, prospective, randomized, multi-institutional cooperative group trial is needed to validate the effectiveness of MIS in this patient population.

Keywords: Robotic surgery, Ovarian cancer, Interval debulking surgery.

COMPARATIVE ANALYSIS OF POLY-L-LYSINE DEPOSITION TECHNIQUES FOR IMPROVING CELL ADHESION ON GOLD SURFACES

Evdokiya Hikova[1,*], *Petar Kolev*[1], *Petar Veselinov*[1], *Anna Atanasova*[1], *Petia Genova-Kalou*[2], *and Georgi Dyankov*[1]

[1]*Institute of Optical Materials and Technologies (IOMT), Bulgarian Academy of Sciences (BAS), Sofia, Bulgaria*

[2]*Department of Virology, National Centre of Infectious and Parasitic Diseases (NCIPD), Sofia, Bulgaria*

*corresponding author contacts: evdokiyabelina@yahoo.de

Abstract: Poly-L-lysine (PLL) is a cationic polymer widely used to enhance cell adhesion on hydrophobic surfaces such as gold, a key material in biosensor technologies and pharmaceutical development. In this work, a comparative analysis of established methods for the deposition of PLL on gold surfaces is presented, with a focus on the influence of surface pretreatment on the coating efficiency. Conventional chemical approaches and established protocols, including ozonation, plasma activation and treatment with the non-ionic detergent Triton X-100, as well as thiol-based self-assembled monolayer (SAM) deposition methods were reviewed. Key parameters such as layer uniformity, coverage, long-term stability and compatibility with cell culture were evaluated.

These methods are compared with our experimental results of PLL deposition using modified laser evaporation technology (MAPLE – Matrix Assisted Pulsed Laser Evaporation) – an innovative physical approach that allows controlled and localized deposition without the need for surface pretreatment or application of embedding matrix. The aim of the review is to outline the advantages and limitations of each method, providing a basis for choosing an optimal protocol for the development of biofunctionalized gold surfaces.

Keywords: Poly-L-lysine (PLL), cell adhesion, MAPLE.

Acknowledgments:
This research was funded by the Bulgarian National Science Fund, grant number КП-06-Н78/9-14.12.2023, and by Bulgarian Ministry of Education and Science (MES), Project N◦ DO1-352/13.12.2023.

ENVIRONMENT-DEPENDENT MORPHOLOGY AND INTERFACIAL STABILITY OF PT NANOPARTICLES FOR BIOMEDICAL SURFACE ENGINEERING

Lyubomira Veleva [1,2,*]

[1]*Department of Natural Sciences, University of Shumen Konstantin Preslavsky, 115 Universitetska str., 9700 Shumen, Bulgaria*
[2] *Institute of Electronics, Bulgarian Academy of Sciences, 72 Tsarigradsko Chaussee blvd., 1784 Sofia, Bulgaria*

*corresponding author contacts: l.veleva@shu.bg

Abstract: From a biomedical perspective, these high-resolution investigations provide important insight into the design of functionalized metallic implant surfaces, biosensors, and catalytic therapeutic platforms. Nanoparticle morphology, size distribution, and crystallographic orientation critically influence catalytic activity, corrosion resistance, surface energy, and interfacial stability — key parameters governing biocompatibility, antibacterial performance. The preferential localization of Pt nanoparticles at high-energy oxide sites suggests improved adhesion and stability controlled by surface and interface energetics, offering a pathway for optimizing nanoparticle-functionalized biomedical surfaces under physiological conditions. High-resolution TEM and STEM investigations of Pt nanoparticles can demonstrate that particles are crystalline, composed of pure Pt, and exhibit morphology strongly dependent on the surrounding chemical environment. Reducing conditions favour the formation of small, rounded nanoparticles, whereas oxidizing environments promote larger, irregular clusters. The Pt nanoparticles preferentially attach to oxide edges and corners, indicating strong interfacial interactions.

Keywords: Platinum nanoparticles, surface energetics, interfacial stability.

Acknowledgments:
This research was funded by project КП-06-Н67/7.

ROBOTIC SENTINEL LYMPH NODE DETECTION WITH ICG IN ENDOMETRIAL CANCER PATIENTS

Dimitar Dimitrov[1,2,*], *Slavcho Tomov*[1,2], *Georgi Prandzhev*[1,2], *Teodora Semova*[1,2], *and Grigor Gorchev*[1,2]

[1] *Medical University – Pleven, Bulgaria*
[2] *University Hospital Saint Marina, Pleven, Bulgaria*

*corresponding author contacts: dr_dimitrov@abv.bg

Abstract: The performance of lymph node dissection in early stage endometrial carcinoma is still under discussion. The aim of this study was to assess the SLN detection rate after application of Indocyanine green (ICG) in the cervix of patients with endometrial cancer.

Eighty patients with histologically proven early stage endometrial cancer were included in this study between July 2020 to June 2023. All patients underwent robotic – assisted surgery with the Da Vinci X Surgical System with introduction of ICG and near – infrared (NIR) imaging.

The detection rate was 97 %. The incidence of SLN metastases was 7,5 % (6/80). The negative predictive value of SLN mapping was 99 %. Most patients were in FIGO IA stage (65 %), followed by IB (15 %), II (12,5 %) and IIIC1 (7,5%).

Based on the results of our study we can state that the application of ICG for identification of sentinel lymph nodes in early stage endometrial cancer is safe and effective method.

Keywords: Sentinel lymph node, Indocyanine green, Endometrial cancer, Robotic surgery.

INFLUENCE OF SILVER NANOPARTICLES ON LIPOSOMAL MEMBRANE PROPERTIES RELEVANT IN PHOTOTHERMAL THERAPY

Maria Lyudmilova[1,*], *Lyubomir Stoychev*[1], *Denitsa Yancheva*[2,3], *Stoyanka Nikolova*[4], *Mina Todorova*[4], *Charilaos Xenodochidis*[5], *Kamelia Hristova-Panusheva*[5], *Natalia Krasteva*[5], *and Julia Genova*[1,*]

[1] *Institute of Solid State Physics, Bulgarian Academy of Sciences, Tzarigradsko Chaussee 72, 1784 Sofia, Bulgaria*

[2] *Institute of Organic Chemistry with Centre of Phytochemistry, Bulgarian Academy of Sciences, "Acad. Georgi Bonchev" Str., Build. 9, 1113 Sofia, Bulgaria*

[3] *Department of Organic Chemistry, University of Chemical Technology and Metallurgy, 8 Kliment Ohridski Blvd., 1756 Sofia, Bulgaria*

[4] *Department of Organic Chemistry, Faculty of Chemistry, University of Plovdiv, 4000 Plovdiv, Bulgaria*

[5] *Institute of Biophysics and Biomedical Engineering, Bulgarian Academy of Sciences, "Acad. Georgi Bonchev" Str., Bl. 21, 1113 Sofia, Bulgaria*

*corresponding author contacts: maria.todorova@issp.bas.bg ; julia.genova@issp.bas.bg

Abstract: Lipid membranes are central to the functionality of nanocarriers, and their response to nanoparticle incorporation is crucial for therapeutic performance. This study examines the effects of fructose-capped silver nanoparticles (AgNPs) on the thermodynamic, mechanical, and photothermal properties of SOPC-based liposomal bilayers. A multitechnique approach combining infrared (IR) spectroscopy, differential scanning calorimetry (DSC), thermally induced shape fluctuation analysis, and laser irradiation at 343, 515, and 1030 nm was employed.

DSC measurements reveal that AgNP incorporation reduces the main phase transition temperature from 3.41 °C (pure SOPC) to 2.80 °C and decreases the transition enthalpy from 0.280 to 0.234 J/g. Vesicle fluctuation analysis shows a corresponding decrease in bending modulus from 1.18×10^{-19} J to 0.93×10^{-19} J, indicating increased bilayer flexibility. FTIR spectra confirm interactions between fructose-capped AgNPs and the lipid carbonyl and phosphate groups.
Photothermal experiments demonstrate a strong wavelength dependence: irradiation at 515 nm induces a temperature increase of approximately 22 °C (0.2 W cm^{-2}), while 1030 nm excitation produces only 3-5 °C heating. These results show that fructose-capped AgNPs moderately fluidize lipid bilayers while enabling efficient and controllable photothermal response, supporting their potential use in multifunctional liposomal nanomedical systems.

Keywords: nanoparticle membrane interactions; photothermal therapy; infrared (IR) spectroscopy; phase transition; elastic properties; laser irradiation.

Acknowledgments:
The authors are thankful for the received funding in 2023 via the Bulgarian National Science Fund (KP-06-N78/8 from 14 December 2023). D.Y. is grateful for the financial support from the European Union NextGenerationEU, through the National Recovery and Resilience Plan of the Republic of Bulgaria, Project No. BG-RRP-2.004-0002, "BiOrgaMCT". Equipment from INFRAMAT (Research Infrastructure from National roadmap of Bulgaria), supported by the Bulgarian Ministry of Education and Science, was used in a part of the present investigation.

SUGAR-MEDIATED MODULATION OF THE DIELECTRIC PERMITTIVITY OF PHOSPHATIDYLCHOLINE MEMBRANES

Ognyan Petkov[1,*], *Angelina Stoyanova-Ivanova*[1], *Vesela Yordanova*[2], *Krassimira Antonova*[1], *Georgi Popkirov*[3], *Galya Staneva*[2], *and Victoria Vitkova*[1]

[1] *Georgi Nadjakov Institute of Solid State Physics, Bulgarian Academy of Sciences, 72 Tsarigradsko Chaussee, Blvd., 1784 Sofia, Bulgaria;*

[2] *Institute of Biophysics and Biomedical Engineering, Bulgarian Academy of Sciences, Acad. G. Bonchev Str., Bl. 21, 1113 Sofia, Bulgaria;*

[3] *Central Laboratory of Solar Energy and New Energy Sources, Bulgarian Academy of Sciences, 72 Tsarigradsko Chaussee, Blvd., 1784 Sofia, Bulgaria;*

*corresponding author contacts: ogikrpetkov@gmail.com

Abstract: To further elucidate the underlying mechanism by which sucrose influences bilayer structure and dielectric behavior, a theoretical model was developed that accounts for the polarizabilities of carbon–carbon and carbon–hydrogen bonds, as well as the average separation between aliphatic chains within the membrane. The model was evaluated using experimental data obtained for 1-palmitoyl-2-oleoyl-sn-glycero-3-phosphocholine lipid membranes by fast Fourier transform impedance spectroscopy on black lipid membranes, fluorescence spectroscopy on large unilamellar vesicles, and electrodeformation of giant unilamellar vesicles. These complementary approaches have been employed to probe changes in the membrane impedance, lipid rotational order, degree of hydration, and dipole potential. The results suggest that sucrose is associated with modulation of the electrical properties and molecular reorganization of the lipid bilayer. The observed membrane capacitance and enhanced lipid packing observed in the presence of sucrose may be related to membrane thinning and an increase in the dielectric permittivity of the lipid bilayer.

Acknowledgments:
The project “Development of photonic sensing effects at the solid surface/bionanocomposite interface for detection and control of biogenic impacts (PhotonSensorEffect)”, BG-RRP-2.017-0041-C01 is implemented within the framework of investment C2.I2 of the Recovery and Resilience Plan of Bulgaria, with the aim of increasing the innovation capacity of the Bulgarian Academy of Sciences in the field of green and digital technologies.

ELECTROANALYSIS OF NICKEL-CONTAINING DENTAL ARCHWIRES UNDER IN VITRO AND IN VIVO ENVIRONMENTS

Angelina Stoyanova-Ivanova[1], Velizar Georgiev[1], Mirela Georgieva[2], Petar Lilov[1], Todor Vlakhov[1], Laura Andreeva[2], and Valeri Petrov[2]*

[1]G. Nadjakov Institute of Solid-State Physics, Bulgarian Academy of Sciences, 72 Tzarigradsko Chaussee, 1784 Sofia, Bulgaria
[2]Department of Orthodontics, Faculty of Dental Medicine, Medical University of Sofia, St. G. Sofiiski Blvd.,1431 Sofia, Bulgaria

*corresponding author contacts: velizar@issp.bas.bg

Abstract: Orthodontic archwires play a significant role in the treatment of conditions related to misaligned teeth. In order to properly align the teeth, an archwire must have a specific set of biomechanical and biocompatible properties in order to not endanger the patient's health further. These properties include releasing biologically tolerable forces, being made of materials that are biocompatible with human physiology and being resistant to corrosion. The most commonly used types of dental archwires today are made from stainless steel and nickel-titanium, which both contain nickel in their composition [1]. While generally accepted as safe, biocompatible and resistant to corrosion, these alloys still contain and release nickel, which can lead to sensibilization and a development of nickel allergy [2]. Thus, comprehensive evaluation of it is of significant importance. Using impedance spectroscopy, the corrosion of the studied archwires was analysed. It is also important to study alternatives to these wires that avoid the problem of nickel release by having their alloy free of it. One such alternative are archwires made from TiNb alloys [3], which are of interest for future studies, including analysis of their corrosion. The results obtained from this work give us information on their resistance to corrosion and determine a safe timeframe for their clinical use.

References:

[1] Stoyanova-Ivanova, A.; Georgiev, V.; Martins, J.N.R. Nickel Ion Release in Nickel-Containing Orthodontics Archwires: A Narrative Review of In Vitro and In Vivo Studies. Dent. J. 2025, 13, 206. https:// doi.org/10.3390/dj13050206
[2] Gölz L, Papageorgiou SN, Jäger A. Nickel hypersensitivity and orthodontic treatment: a systematic review and meta-analysis. *Contact Dermatitis*. 2015;73(1):1-14.
[3] Nordstrom B, Shoji T, Anderson WC, et al. Comparison of changes in irregularity and transverse width with nickel-titanium and niobium-titanium-tantalum-zirconium archwires during initial orthodontic alignment in adolescents: A double-blind randomized clinical trial. *Angle Orthod*. 2018;88(3):348-354.

Acknowledgments: The project "Development of photonic sensing effects at the solid surface/bionanocomposite interface for detection and control of biogenic impacts (PhotonSensorEffect)", BG-RRP-2.017-0041-C01 is implemented within the framework of investment C2.I2 of the Recovery and Resilience Plan of Bulgaria, with the aim of increasing the innovation capacity of the Bulgarian Academy of Sciences in the field of green and digital technologies. This publication has been created with the financial support of the European Union - NextGenerationEU.

POSTER PRESENTATIONS

SESSION 1:

BIOENGINEERING AND FUNDAMENTAL APPLICATIONS

NEW MATERIALS AND TECHNIQUES FOR BIOMEDICAL APPLICATIONS

2D MATERIALS IN TISSUE ENGINEERING

Mila Krumova[*,1], *Nikolay Minev*[1], *Blagovest Napoleonov*[1], *Galya Staneva*[2], *Anelia Kostadinova*[2], *Vladimira Videva* [1,3], *Dimitre Dimitrov*[1,4] *and Vera Marinova* [1,5]

[1]*Institute of Optical Materials and Technologies, Bulgarian Academy of Sciences, Sofia 1113, Bulgaria*

[2]*Institute of Biophysics and Biomedical Engineering, Bulgarian Academy of Sciences, Sofia 1113, Bulgaria*

[3] *Faculty of Chemistry and Pharmacy, Sofia University "St. Kl. Ohridski", Sofia, Bulgaria*

[4] *Institute of Solid-State Physics, Bulgarian Academy of Sciences, Sofia, Bulgaria*

[5] *National Centre of Excellence Mechatronics and Clean Technologies, 8 Kliment Ohridski Blvd., Blk. 8, 1756 Sofia, Bulgaria*

*corresponding author contacts: mkrumova@iomt.bas.bg

Abstract: Two-dimensional (2D) nanomaterials are a rapidly advancing category of materials with immense potential in biomedical and regenerative applications. Due to their ultrathin atomic layers, high surface area, mechanical adaptability, and adjustable physicochemical characteristics, they interact effectively with biological environments. When integrated into composite systems, 2D materials enhance cellular adhesion, proliferation, and differentiation, thereby promoting tissue repair and regeneration. In wound healing, their intrinsic photothermal, antibacterial, and antioxidant activities assist in preventing infection, and accelerating recovery. In this study, we present different ways of evaluating material's suitability of biomedical applications, such as using atomic force microscopy (AFM), measuring their surface energy etc. Further exploration of 2D materials will drive the development of next-generation biomaterials for precise and effective tissue engineering and wound management.

Keywords: 2D materials, wound healing, antibacterial, cell adhesion

Acknowledgments:
We acknowledge the Bulgarian Science Fund support under the project number FNI КП-06-Н-68/1. Financial support from the Research equipment of distributed research infrastructure INFRAMAT (part of Bulgarian National roadmap for research infrastructures) supported by Bulgarian Ministry of Education and Science is also acknowledged. Research equipment of the project № BG16RFPR002-1.014-0006 "National Centre of Excellence Mechatronics and Clean Technologies" was used for experimental work financially supported by European Regional Development Fund under "Research Innovation and Digitization for Smart Transformation" program 2021-2027.

COMPARATIVE EVALUATION OF THE SURFACE ROUGHNESS OF DENTAL COMPOSITES TREATED BY TWO POLISHING SYSTEMS

Radostina Anastasova, Silvia Stankova, Dzhendo Dzhendov, Miroslav Stoykov, and Tsanka Dikova*

Medical University of Varna, Faculty of Dental Medicine,
Address:84 "Tsar Osvoboditel" blvd., 9000 Varna, Bulgaria

*corresponding author contacts: radostina.anastasova@mu-varna.bg

Abstract: Finishing and polishing are essential final stages of tooth restorations, significantly contributing to the longevity of the fillings. There are many different polishing systems and protocols, but they all aim to produce a smooth, shiny surface on the restorations.
The purpose of our study is to evaluate the surface roughness of three dental composites treated by two polishing systems. Nanocomposite, hybrid packable and hybrid flowable composites were used in this study. Sixty samples (20 samples from each type of composite resin) were prepared using a silicone mold. All samples have round shape with dimensions 2 mm in depth and 0.8 mm in diameter. Each specimen was light-cured for 20 seconds. Prior to the finishing and polishing procedures, surface roughness was measured using a Mitutoyo profilometer. The surfaces were then finished with a fine diamond bur and polished using two different systems: EVE TwistDia and Kerr OptiDisk. Half of the samples in each composite group were polished with the EVE system, while the remaining half were polished with the Kerr system. Surface roughness measurements were taken after each stage, and the parameters Ra, Rq, and Rz were recorded. The collected data were analyzed statistically.

Keywords: dental composites, finishing/polishing protocols, surface roughness

INTELLIGENT 2D NANOMATERIALS FOR LASER ANTIBACTERIAL THERAPY

Maria Martinova[*,1], *Nikolay Minev*[1], *Vladimira Videva*[1,2], *Blagovest Napoleonov*[1], *Dimitre Dimitrov*[1,3], *and Vera Marinova*[1]

[1]*Institute of Optical Materials and Technologies, Bulgarian Academy of Sciences, Sofia 1113, Bulgaria*

[2] *Faculty of Chemistry and Pharmacy, Sofia University "St. Kl. Ohridski", Sofia, Bulgaria*

[3] *Institute of Solid-State Physics, Bulgarian Academy of Sciences, Sofia, Bulgaria*

* corresponding author contacts: mdmartinova@iomt.bas.bg

Abstract: Bacterial infections and the growing threat of antibiotic resistance have become major challenges for modern healthcare. In response, increasing attention has been directed toward intelligent nanomaterials capable of providing precise, controllable antibacterial activity through external stimulation. Among these, intelligent two-dimensional (2D) nanomaterials activated by laser or near-infrared (NIR) irradiation [1] represent a promising non-antibiotic strategy. These materials combine features such as high photothermal and photodynamic efficiency, the ability to generate reactive oxygen species, and controlled release of active agents under light exposure. Through intelligent structural design and functional modification, they can achieve selective action against bacteria while minimizing damage to surrounding tissues. Comprehensive characterization techniques such as AFM, SEM, and surface energy analysis further enable the evaluation of their nanoscale morphology, surface properties, and interactions with bacterial cells**.** Laser-activated intelligent 2D nanomaterials thus offer a multifunctional and adaptive platform for effective bacterial eradication, biofilm disruption, and accelerated wound healing. Continued research in this field may lead to innovative, safe, and efficient light-responsive antibacterial therapies for future biomedical applications.

Reference:
[1] Netra Hiremath et al., ACS Appl. Nano Mater. 2022, 5, 2, 1719–1733.

Keywords: Intelligent 2D materials, laser-activated antibacterial therapy, near-infrared irradiation, photothermal effect

Acknowledgments:
We acknowledge the Bulgarian Science Fund support under the project number FNI КП-06-H-68/1. Financial support from the Research equipment of distributed research infrastructure INFRAMAT (part of Bulgarian National roadmap for research infrastructures) supported by Bulgarian Ministry of Education and Science is also acknowledged. Research equipment of the project № BG16RFPR002-1.014-0006 "National Centre of Excellence Mechatronics and Clean Technologies" was used for experimental work financially supported by European Regional Development Fund under "Research Innovation and Digitization for Smart Transformation" program 2021-2027.

MOLYBDENUM BASED NANOMATERIALS FOR BIOMEDICAL APPLICATIONS

Blagovest Napoleonov[1*], *Vladimira Videva*[1,2], *Dimitrina Petrova*[1,3], *Anelia Kostadinova*[4], *Galya Staneva*[4], *Dimitre Dimitrov*[1,5], *and Vera Marinova*[1,6]

[1] *Institute of Optical Materials and Technologies, Bulgarian Academy of Sciences, Sofia, Bulgaria*
[2] *Faculty of Chemistry and Pharmacy, Sofia University, Sofia, Bulgaria*
[3] *South-West University" Neofit Rilski", Blagoevgrad, Bulgaria*
[4] *Institute of Biophysics and Biomedical Engineering, Bulgarian Academy of Sciences, Sofia, Bulgaria*
[5] *Institute of Solid State Physics, Bulgarian Academy of Sciences, Sofia, Bulgaria*
[6] *National Centre of Excellence Mechatronics and Clean Technologies, Sofia, Bulgaria*

*corresponding author contacts: bnapoleonov@iomt.bas.bg

Abstract: Escalating device-associated infections and antimicrobial resistance are driving demand for materials-based, non-leaching antibacterial coatings. Among emerging two-dimensional (2D) platforms, molybdenum disulfide (MoS_2) offers tunable surface chemistry and reported antibacterial activity. Here, we synthesize CVD MoS_2 thin films on Si/SiO_2 substrates and evaluate them as antibacterial coatings, relating film thickness and surface chemistry to the biological response. MoS_2 films are synthesized by chemical vapor deposition (CVD) on Si/SiO_2 substrates. UV-ozone pretreatments are used to tune surface energy and cleanliness prior to growth. Structural and surface characterization (Raman spectroscopy, AFM and XPS) establishes links between crystallinity, thickness and antibacterial activity.

The cytotoxicity of MoS_2 layers toward normal human skin cells has been assessed, and microbiological studies have been conducted to determine their inhibitory activity against pathogens. The aim is to establish selective action against pathogenic species while, at the same time, demonstrating good biocompatibility with normal human cells. These complementary evaluations seek to confirm that MoS_2 thin films can suppress pathogenic growth without adversely affecting healthy skin cells, supporting their use as scalable antibacterial coatings for biomedical devices.

Keywords: MoS_2; Antibacterial coatings; UV-Ozone pretreatment; Biocompatibility

Acknowledgments:
We acknowledge the Bulgarian Science Fund support under the project number FNI КП-06-H-68/1. Financial support from the Research equipment of distributed research infrastructure INFRAMAT (part of Bulgarian National roadmap for research infrastructures) supported by Bulgarian Ministry of Education and Science is also acknowledged. Research equipment of the project № BG16RFPR002-1.014-0006 "National Centre of Excellence Mechatronics and Clean Technologies" was used for experimental work financially supported by European Regional Development Fund under "Research Innovation and Digitization for Smart Transformation" program 2021-2027.

EFFECT OF SURFACE LASER TREATMENT ON THE STRUCTURAL, ELECTROCHEMICAL, AND ANTIBACTERIAL PROPERTIES OF TiO_2–CU COATINGS

Elena Zheleva[1], *Maria P. Nikolova*[1,*], *Iliyan Tzvetkov*[1], *Veselina Dukova*[1], *Imants Adians*[1,2], *Nikolay Nedyalkov*[3], *Stefan Valkov*[3,4], *Yordan Handzhiyski*[5], *and Margarita D. Apostolova*[5]

[1] *Department of Material Science and Technology, University of Ruse "Angel Kanchev", 8 Studentska Str., 7017 Ruse, Bulgaria*
[2] *Rezekne Academy, Riga Technical University, LV-1658 Riga, Latvia*
[3] *Institute of Electronics, Bulgarian Academy of Sciences, 72 Tzarigradsko Chaussee Blvd., 1784 Sofia, Bulgaria*
[4] *Department of Mathematics, Informatics and Natural Sciences, Technical University of Gabrovo, 4 H. Dimitar Str., 5300 Gabrovo, Bulgaria*
[5] *Roumen Tsanev Institute of Molecular Biology, Bulgarian Academy of Sciences, Acad. Georgi Bonchev Str., Bl. 21, 1113 Sofia, Bulgaria*

*corresponding author contacts: mpnikolova@uni-ruse.bg

Abstract: Metallic materials are widely used in orthopaedic and dental implants due to their excellent mechanical properties, but their long-term performance is often limited by poor osseointegration, corrosion, wear, and implant-related infections. Surface functionalization with advanced coatings is an effective strategy to overcome these limitations. Thus, this study investigates TiO_2–Cu coatings produced by magnetron co-sputtering and subsequently modified by surface laser treatment (LST).

The oxide coatings were deposited onto polished Ti6Al4V alloy substrates using reactive DC magnetron sputtering in a pure oxygen atmosphere. Post-deposition laser treatment was carefully optimised to avoid structural degradation of the coatings. Chemical composition, structural features, and phase evolution induced by the laser treatment were analysed using SEM–EDS, XRD, and FTIR techniques. Changes in surface topography were quantified through image-based analysis of backscattered electron (BSE) SEM micrographs. The electrochemical stability and copper ion release of laser-treated and untreated coatings were evaluated by electrochemical impedance spectroscopy (EIS) after 7 days of immersion in simulated body fluid (SBF). Surface wettability with SBF was examined using the sessile drop method, while coating adhesion was assessed by scratch testing. Furthermore, the antibacterial performance of both treated and untreated coatings was evaluated through antimicrobial assays against *Staphylococcus aureus*.

Keywords: TiO_2-Cu coatings; Ti6Al4V alloy; laser treatment.

Acknowledgments:
This research was funded by the Bulgarian National Science Fund, grant number KII-06-H67-5 (2022).

LASER-ENGINEERED ANTI-SOILING GLASS SURFACES FOR SOLAR ENERGY APPLICATIONS

Liliya Angelova[1,*], *Aleksandra Zhelyazkova*[1], *and Albena Daskalova*[1]

[1]*Institute of Electronics, Bulgarian Academy of Sciences, 72 Tsarigradsko chaussee blvd., 1784, Sofia, Bulgaria*

*corresponding author contacts: liliyaangelova9@gmail.com, lily1986@abv.bg

Abstract: The accumulation of dust and environmental contaminants on photovoltaic (PV) surfaces remains a major limitation for long-term energy yield, often requiring mechanical or chemical cleaning that increases maintenance costs and risks surface damage. The present work demonstrates a sustainable approach to overcoming this challenge through femtosecond (fs) laser surface structuring of soda-lime glass. Controlled femtosecond laser processing with pre-defined laser parameters was used to generate hierarchical micro- and nanostructures with defined morphologies, including parallel and intersecting microchannels decorated with laser-induced periodic surface structures (LIPSS). Femtosecond laser structured glass substrates were exposed to a series of durability tests simulating real-life conditions — thermal cycling, UV exposure, abrasion, and chemical resistance. Comprehensive characterization of the influence of environmental factors before and after the tests revealed that the laser-induced patterns demonstrated remarkable structural and functional stability confirming their robustness undergoing the performed tests. The surfaces bearing intersecting microchannels exhibited strong hydrophilic behavior with water contact angles below 5°. Interestingly, after dust exposure, the same textured surfaces displayed reversible hydrophobicity (contact angles ≈120°), attributed to adsorption of organic and inorganic residues, providing an additional self-cleaning benefit. Optical transmittance of structured surfaces was maintained within the same range after durability testing.

These results highlight fs-laser texturing as an eco-friendly, coating-free strategy for developing durable, self-cleaning, surfaces with sufficient optical transparency suitable for PV applications. The demonstrated stability and tunable wettability of the laser-fabricated structures underline their potential for integration into large-scale PV manufacturing, paving the way for high-efficiency solar energy systems.

Keywords: femtosecond laser processing; photovoltaic systems; superhydrophilicity

Acknowledgments:

The authors acknowledge the Next Generation EU program under project BG-RRP-2.017-0001-C01-Laser methods for developments of sensors and self-cleaning surfaces-(SENSA). The research was carried out with the help of infrastructure purchased under the National Roadmap for Scientific Infrastructure (ELI-ERIC-BG), project D01-351.

CHANGES IN ENAMEL MORPHOLOGY AND ROUGHNESS OF TEETH SUBJECTED TO BLEACHING

Silviya Stankova, Dzhendo Dzhendov, and Tsanka Dikova*

Medical University "Prof. Dr. Paraskev Stoyanov", Faculty of Dental Medicine,
84 Tsar Osvoboditel Blvd, 9000 Varna, Bulgaria

*Corresponding author contacts: silviastankova@abv.bg

Abstract: Tooth bleaching with peroxide-based chemical products is the simplest non-invasive method of lightening the tooth color. Extracted teeth were subjected to in vitro bleaching by products with different concentrations (35% and 20%) of hydrogen peroxide with or without chemical activation by metal salt (ferric sulfate) and enzymes (horseradish peroxidase and catalase from bovin liver). Changes in the enamel morphology and roughness of the treated teeth have been studied using surface roughness tester and optical microscopy. It was found that the average teeth roughness (Ra) increased after bleaching with all these products: 20% hydrogen peroxide, 20% hydrogen peroxide + ferric sulfate, 20% hydrogen peroxide + horseradish peroxidase and 20% hydrogen peroxide + catalase, except for the teeth bleached by a factory product (35% hydrogen peroxide) without any activation. The percentage differences in Ra were most significant in the group of teeth with catalase activation (22%), followed by the group with ferric sulfate activation (16%), and the smallest was in the group with horseradish peroxidase activation (5%). For the teeth treated with 35% HP, however, the percentage differences were negative (-2%).

Keywords: tooth bleaching, enamel, peroxide, surface roughness

APPLICATIONS OF NOBLE METAL NANOPARTICLES IN BIOPHOTONICS

*Nikolay Nedyalkov *, Nadya Stankova, Anna Dikovska, Rumen Nikov, and Rosen Nikov*

Institute of Electronics, Bulgarian Academy of Sciences, 72 Tsarigradsko Chaussee, 1784 Sofia, Bulgaria

*Corresponding author contacts: nnn_1900@yahoo.com

Abstract: In this work some basic effects of interaction of noble metal nanoparticles with light are presented and is demonstrated how these can be used in bioapplications. Theoretical and experimental results on the heating process and near field localization arising when gold nanoparticles are irradiated by ultrashort and short laser pulses are presented. The theoretical analysis is based on one- or two-temperature heat model for estimation of the nanoparticle temperature and Finite Difference Time Domain (FDTD) method for description of the near field distribution in the vicinity of the particles. It is found that at even moderate laser fluences, particle temperature can reach a value sufficient for bubble formation in biological tissues. The analysis of the near field distribution shows that when particle is deposited on substrate surface, the dielectric properties of the substrate define the localization and enhancement of the near field intensity. The efficiency of this process determines the contribution of particle heating or near field intensity enhancement in the surface modification process. Theoretical and experimental results on the heating process of gold nanoparticles irradiated by nanosecond laser pulses are also presented. The efficiency of particle heating is demonstrated by in-vitro photothermal therapy of human tumor cells. The results indicate clear cytotoxic effect of application of nanoparticles, as more efficient is the case of using particles with diameter of 100 nm. As a further application, Surface Enhanced Raman Spectroscopy of pesticides, based on noble metal nanoparticles is also presented. The presented results can be a basis for development of different theranostics techniques in medicine based on noble metal nanoparticles.

Acknowledgments:
This work is financed by EU - Next Generation EU program under project BG-RRP-2.017-0001-C01“Laser methods for developments of sensors and self-cleaning surfaces“ (SENSA).

INVESTIGATION OF HEXAFERRITES WITH POTENTIAL APPLICATIONS IN BIOLOGY AND MEDICINE

Tatyana Koutzarova[1,2]*, *Svetoslav Kolev*[1,3], *Kiril Krezhov*[1], *Petya Peneva*[1], *Borislava Georgieva*[1], *Chavdar Ghelev*[1], *Lan-Maria Tran*[4], *Michal Babij*[4], *and Benedicte Vertruyen*[5]

[1]*Institute of Electronics, Bulgarian Academy of Sciences, 72 Tsarigradsko Chaussee, 1784 Sofia, Bulgaria*
[2]*Center of Competence "Smart Mechatronics, Eco-and Energy-Saving Systems and Technologies", 5 Doctor Iliev Detskia Str., 5300 Gabrovo, Bulgaria*
[3]*Neofit Rilski South-Western University, 66 Ivan Mihailov Str., 2700 Blagoevgrad, Bulgaria*
[4]*Institute of Low Temperature and Structure Research, Polish Academy of Sciences, ul. Okólna 2, 50-422 Wroclaw, Poland*
[5]*GREENMAT, Chemistry Institute B6a, University of Liège (ULiege), 4000 Liège, Belgium*

*corresponding author contacts: tanya@ie.bas.bg, tatyana_koutzarova@yahoo.com

Abstract: The development of nanotechnology has made it possible to expand the field of application of hexaferrites and their entry into biomedical applications. Over the past decade, research has been focused on applying them in medical hyperthermia, MRI contrast agents, antimicrobial agents and drug delivery. Hexaferrites are part of composite materials and structures for electromagnetic (EM) absorption or shielding. With the development of communication technologies, EM pollution is also increasing, and the potential health risks are still unclear. The observation of the magnetoelectric effect in some hexaferrites makes them suitable for the development of modern magnetic field sensors for biomedical applications, such as magnetocardiography, magnetotomography, magnetomyography, magnetoneurography, etc. The use of ME materials in biology and medicine is still in its infancy. All this poses the need to deepen research on hexaferrites in connection with their application in biology and medicine. Here we will present our findings on the structural and magnetic properties of nanosized M-type hexaferrites. A comparative analysis of their properties in terms of the influence of the preparation method and the type of substitution of the magnetic Fe^{3+} cations will be presented.

Keywords: hexaferrites, magnetoelectrics, magnetic properties, EM shielding

Acknowledgments:
The research was supported by the Bulgarian National Science Fund under contract KP-06-N48/5. This research was also funded by the European Regional Development Fund within the OP "Research, Innovation and Digitalization Programme for Intelligent Transformation 2021-2027", Project No. BG16RFPR002-1.014-0005 Center of Competence "Smart Mechatronics, Eco- and Energy Saving Systems and Technologies".

GREEN SYNTHESIS OF SILVER OXIDE NANOPARTICLES IMMOBILIZED ON CARBON MATRIX

Stela Atanasova - Vladimirova[1], *Pavlina Dolashka*[2], *Nartzislav Petrov*[2], *Bogdan Ranguelov*[1], *and Iskra Piroeva*[1]

[1]*Institute of Physical Chemistry, Bulgarian Academy of Sciences, 1113 Sofia, Bulgaria*
[2]*Institute of Organic Chemistry with Center for Phytochemistry, Bulgarian Academy of Sciences, 1113 Sofia, Bulgaria*

*corresponding author contacts: statanasova@ipc.bas.bg

Abstract: Nanoparticles (NPs) have unique properties because of small size and higher surface to volume area. These particles are being increasingly used in many fields. The active carbon from peach pit were used as a matrix to incorporate Ag Nps. Because of tremendous application possibilities, the chemical literature is replete with different approaches to the synthesis of Ag NPs. Silver Oxide Nanoparticles are preparing by siver nitrate. Samples were investigated by field emission scanning electron microscope, JSM IT 800 (Jeol, Japan), equipped with JED 2300 EDS analyzer to obtain topological, morphological and compositional information. The entire sample was coated with gold before SEM analysis.

EDS revealed a high signal for Silver and Oxygen, which confirms the presence of Silver in the oxide form. The composition of each element contained in the analyte is obtained from the EDS, which gives strong peaks of 2.98 eV for Silver and 0.52 eV for Oxygen. These values are specific for Siver and Oxygen, which confirms the elemental composition of the compound synthesized.

Keywords: Ag Nps, Scanning Electron Microscope, EDS

Acknowledgments: This research is funding by Project BG-RRP-2.017-0006-C01 from the Recovery Plan for Europe (NextGenerationEU), SAV and BR acknowledges the support from the CoE “National center for/of mechatronics and clean technologies” (Project BG05M2OP001–1.001–0008) supported by the ERDF within the Bulgarian OP “SESG 2014–2020.“ and the project INFRAMAT (National Roadmap for Research Infrastructure) financed by Bulgarian Ministry of Education and Science was used in this investigation.

MORPHOLOGICAL CHARACTERIZATION AND STRUCTURAL ANALYSIS OF COPPER NANOPARTICLES IMMOBILIZED ON CARBON MATRIX

Iskra Piroeva[1,*], *Pavlina Dolashka*[2], *Nartzislav Petrov*[2], *Bogdan Ranguelov*[1], *and Stela Atanasova – Vladimirova*[1]

[1]*Institute of Physical Chemistry, Bulgarian Academy of Sciences, 1113 Sofia, Bulgaria*
[2]*Institute of Organic Chemistry with Center for Phytochemistry, Bulgarian Academy of Sciences, 1113 Sofia, Bulgaria*

*corresponding author contacts: ipiroeva@ipc.bas.bg

Abstract: Chemical synthesis of nanoparticles often uses toxic and expensive chemicals that have an adverse effect on human health and the environment. Green synthesis, which is non-toxic and environmentally friendly, has been developed as the most appropriate approach to solving these problems. The active carbon from peach pit were used as a matrix to incorporate Cu Nps.

Various SEM and EDX investigations were carried out to evaluate the surface morphology and core mapping of the produced Cu NPs. Based on the established morphology of Cu NPs and the information from scanning electron microscopy with energy-dispersive spectroscopic analyses, the characteristics of the synthesized Cu NPs were elucidated.

EDS revealed a high signal for Copper and Oxygen, which confirms the presence of Copper in the oxide form. The composition of each element contained in the analyte is obtained from the EDS, which gives strong peaks of Lα 0.93 eV for Copper and Kα 0.52 eV for Oxygen. These values are specific for Copper and Oxygen, which confirms the elemental composition of the compound synthesized.

Keywords: Cu Nps, Scanning Electron Microscope, EDS

Acknowledgments:
This research is funding by Project BG-RRP-2.017-0006-C01 from the Recovery Plan for Europe (NextGenerationEU), SAV and BR acknowledges the support from the CoE “National center for/of mechatronics and clean technologies” (Project BG05M2OP001–1.001–0008) supported by the ERDF within the Bulgarian OP “SESG 2014–2020“ and the project INFRAMAT (National Roadmap for Research Infrastructure) financed by Bulgarian Ministry of Education and Science was used in this investigation.

PREPARATION OF BIODEGRADABLE PECTIN-BASED POLYMER FILMS WITH COMFREY EXTRACT (*S. Officinale*) WITH POTENTIAL ANTI-INFLAMMATORY AND ANTIMICROBIAL ACTIVITY

Dobromira Yaneva[1,2,*], *Kristiyan Stefanov*[1], *Nadezhda Petkova*[1], *Dragomir Vassilev*[2]

[1] *University of Food Technology – Plovdiv, Bulgaria*
[2] *Technical University of Gabrovo, Bulgaria*

*corresponding author contacts: d.yaneva@tugab.bg

Abstract: Black comfrey (*Symphytum officinale*), also known as knitbone, is one of the most powerful herbs in traditional and modern medicine for topical use. The anti-inflammatory and regenerative capacity of black comfrey root extracts is due to the synergy between pyrrolizidine derivatives, phenolic acids, and polysaccharide complexes. Black comfrey is often compared in effectiveness to topical nonsteroidal anti-inflammatory drugs. Clinical trials show that topical application of a comfrey ointment significantly reduces pain and swelling in ankle sprains and knee osteoarthritis. The effect is comparable to that of diclofenac gel. Although the antimicrobial effect is not the primary characteristic of black comfrey (compared with herbs like rue or tea tree), it is scientifically documented. In vitro studies show moderate activity against gram-positive bacteria (such as Staphylococcus aureus), which often cause skin infections. The antimicrobial effect is often considered secondary – by suppressing microbial growth on the wound surface, allowing allantoin to work more effectively without interference from an infectious process.

The present study aims to develop an innovative transdermal therapeutic system in the form of a biodegradable polymer film (patch). The system is designed to provide controlled release of the active substances from black comfrey for local treatment of inflammatory processes and soft tissue injuries. Pectin isolated from celery was used as the matrix carrier, with glycerol added as a plasticizer to improve elasticity. The active phase is an aqueous extract of black comfrey roots obtained by ultrasonic extraction. The technological process includes polymer hydration, component homogenization, deaeration, and controlled drying using the solvent casting method.

Mechanical tests were performed on samples of the produced polymer film, determining tensile strength (the maximum stress the film withstands before breaking), elongation at break (the ability of the patch to stretch before rupturing), surface pH, and bioadhesion (measured as the force required to detach the patch from a model surface). The release kinetics of the active substances were analyzed using the Higuchi mathematical model. The release rate is highest at the beginning and gradually decreases over time, which is ideal for rapid control of inflammation immediately after applying the patch.

The study demonstrates successful incorporation of *S. Officinale* extract into a pectin matrix. The developed bioactive film possesses suitable mechanical properties and a controlled release profile, positioning it as a promising agent in modern phytotherapy for topical use in osteoarthritis and sports injuries.

Keywords: *Symphytum officinale*, pectin, bioadhesion, anti-inflammatory effect

POSTER PRESENTATIONS

SESSION 2:

APPLICATION OF MODERN ENGINEERING TECHNOLOGIES IN THE MEDICENE

SURFACE MODIFICATION OF NOVEL BIOMATERIALS

ADVANCED THIN FILMS AND COATINGS FOR BIOMEDICAL APPLICATION

POTENTIAL OF CELL SURFACE ENGINEERING FOR BIOMEDICAL APPLICATIONS

Tanya V. Dimitrova[1,*], *Yordan Handzhiyski*[1], *Stefan Valkov*[2,3], *Maria Ormanova*[2,3], *Maria P. Nikolova*[4], *and Margarita D. Apostolova*[1]

[1] *Roumen Tsanev Institute of Molecular Biology, Bulgarian Academy of Sciences, Acad. Georgi Bonchev Str., Bl. 21, 1113 Sofia, Bulgaria*
[2] *Institute of Electronics, Bulgarian Academy of Sciences, 72 Tzarigradsko Chaussee Blvd., 1784 Sofia, Bulgaria*
[3] *Technical University of Gabrovo, 4 H. Dimitar Str., 5300 Gabrovo, Bulgaria*
[4] *University of Ruse "Angel Kanchev", 8 Studentska Str., 7017 Ruse, Bulgaria*

*corresponding author contacts: tdimitrova13@bio21.bas.bg

Abstract: Cell-surface engineering of implant materials is an effective strategy to regulate bone-forming cell interactions while simultaneously reducing the risk of infection. Titanium alloys are widely used for biomedical implants, however, their performance may be compromised by bacterial colonization, corrosion, and insufficient bone integration. In this study, nanoscale surface modification of the Ti6Al4V alloy was achieved via magnetron sputtering of Ti–Cu oxide multilayer coatings. Two coating architectures, consisting of 6 × 2 and 12 × 2 TiO_2/CuO layers, were designed to evaluate their biological performance. The multilayer configuration enabled controlled copper ion release over time, resulting in pronounced antibacterial activity, particularly against Gram-positive bacteria, with more than 96% reduction in bacterial growth. MG-63 osteoblast-like cells exhibited high viability, preserved morphology, and effective mineralization, indicating that the engineered surfaces support bone-related cellular functions while limiting bacterial attachment. By integrating controlled surface chemistry, nanoscale architecture, and ion release, this cell-surface engineering approach demonstrates strong potential to improve the performance of next-generation biomedical implants.

Keywords: Ti6Al4V alloy, TiO_2/CuO layers, MG-63 cells, Gram-positive and Negative bacteria

Acknowledgment: This research was funded by the Bulgarian National Science Fund, grant number КП-06-Н67-5 (2022)

ULTRAFAST LASER MICRO- AND NANOPATTERNING FOR THE FABRICATION OF ANTIMICROBIAL AND BACTERICIDAL SURFACES

Liliya Angelova [1,*], *Laura Mears*[2], *Daniela Miano*[2], *Richard van Nieuwendhowen*[2], *Markus Valtiner*[2], *and Albena Daskalova*[1]

[1]*Institute of Electronics, Bulgarian Academy of Sciences, Sofia, Bulgaria*
[2] *Technische Universität Wien, Vienna, Austria*

*corresponding author contacts: liliyaangelova9@gmail.com, lily1986@abv.bg

Abstract: Antimicrobial resistance has emerged as a critical global challenge, driving the demand for innovative material solutions that can limit pathogen survival and transmission. Conventional cleaning and disinfection methods offer only transient protection, as surfaces are rapidly re-contaminated. To address this limitation, the present research explores the design of laser-engineered micro- and nanostructured stainless steel (SS) surfaces designed to ensure intrinsic, long-term antimicrobial performance. The approach is based on creating bactericidal surface topographies that mechanically compromise bacterial cell membranes, eliminating the need for chemical additives or coatings. Using ultrafast laser processing, diverse micro- and nanoscale textures are generated with precise control over geometry, spacing, and energy input. This technique enables direct, non-contact modification of a wide range of engineering materials, including metals and polymers, while preserving their bulk properties. This study presents preliminary findings demonstrating precise control over the surface wettability and roughness of stainless steel (SS) structured using femtosecond (fs) laser processing. The research is the first step in investigating how surface roughness, morphology, design, and wettability govern bacterial adhesion and cell disruption. Various micro- and nano-texturing patterns were developed on SS surfaces, followed by comprehensive surface and chemical characterization, including topographical and wettability analyses. The outcomes are expected to advance the design of next-generation antimicrobial materials that inherently suppress microbial growth without the use of chemicals. Such an approach supports global initiatives against antimicrobial resistance, providing a long-lasting, environmentally responsible solution for reducing infection risks on high-contact surfaces.

Keywords: antimicrobial resistance, micro/nano laser surface texturing, bactericidal surfaces

Acknowledgments:
This research was funded by the BULGARIAN NATIONAL SCIENCE FUND (NSF) under grant agreement number KP-06-Austria/5 (2025–2027) “Advancing the understanding the adhesion of antimicrobial and bactericidal surfaces produced through ultrafast laser micro- and nanopatterning“. The research was carried out with the help of infrastructure purchased under the National Roadmap for Scientific Infrastructure (ELI-ERIC-BG), project D01-351.

SURFACE ENGINEERING OF PEEK USING ULTRASHORT LASER PULSES: A PATHWAY TO ENHANCED CELLULAR RESPONSE

Aleksandra Zhelyazkova [1,*], *Liliya Angelova* [1], *Flora Lemaire*[2], *Halima Kerdjoudj*[2], *and Albena Daskalova*[1]

[1]*Institute of Electronics, Bulgarian Academy of Sciences, Sofia, Bulgaria*
[2]*University of Reims Champagne Ardenne, Reims, France*

*corresponding author contacts: alexandra_jivkova@abv.bg

Abstract: The growing prevalence of orthopedic trauma and disorder complications, coupled with advances in material science, has led to significant improvements in the design and performance of orthopedic implants. Polyetheretherketone (PEEK) has become a leading candidate for bone trauma regeneration, craniofacial, orthopedic, and spinal applications due to its mechanical strength and fatigue resistance. However, its chemical inertness limits osseointegration and stable bonding with bone tissue. Femtosecond laser surface modification offers a promising strategy to overcome these challenges. By generating a combination of micro- and nanoscale textures, femtosecond laser processing enhances precise control of surface roughness and wettability, while providing a clean, reproducible, and chemical-free alternative to conventional modification methods. This study focuses on the development and analysis of femtosecond laser-textured PEEK surfaces to affect their osteointegration potential. Various micro- and nano-texturing patterns were developed on PEEK surfaces, followed by comprehensive morphological and chemical characterization using SEM, EDX, XRD, 3D profilometry, and water contact angle analyses. Based on the optimized femtosecond laser-engineered surface architectures, several topography designs were selected, and biological assessments of the modified PEEK substrates were conducted in simulated body fluid. Preliminary *in vitro* studies for monitoring osteoblastic cells' viability, adhesion, and morphology were also performed. The results demonstrate that laser-induced micro/nano structuring significantly enhances PEEK's bioactivity, suggesting strong potential for next-generation, personalized bone implants with improved osteointegration capacity.

Keywords: Polyetheretherketone (PEEK); Femtosecond (fs) laser hierarchical structuring; Surface biofunctionalization; Bioactivity; Osseointegration

Acknowledgments:
This research was funded by the BULGARIAN NATIONAL SCIENCE FUND (NSF) under grant number. **KP-06-Rila/6** (2024–2026) "Improving the efficiency of PEEK implants for bone tissue regeneration by femtosecond laser functionalization". The research was carried out with the help of infrastructure purchased under the National Roadmap for Scientific Infrastructure (ELI-ERIC-BG), project D01-351.

INNOVATIVE BIOMATERIALS IN THE MANAGEMENT OF THE SYNDROME OF OBSTRUCTIVE SLEEP APNEA AND SNORING

*Miroslav Stoykov**, and Mario Milkov*

Medical University "Prof. Dr. Paraskev Stoyanov" – Varna, Bulgaria

*corresponding author contacts: miroslav.stoikov93@gmail.com

Abstract: The syndrome of Obstructive Sleep Apnea and snoring (SOSAS) is the most common sleep disorder of the century. It poses a significant risk for public health. Mandibular advancement devices (MADs) can be an effective alternative to the therapeutic gold standard continuous positive airway pressure (CPAP)-therapy in mild, moderate and lack of compliance cases. Modern biomaterials offer an optimal balance between mechanical strength, biological performance and comfort, improving both clinical outcomes and patient adherence to the treatment prescribed. The aim of the study was to examine recent progress in the field of innovative biomaterials, implemented in the clinical management of SOSAS.

A literature review focused on polymeric, composite, and bioactive materials used for MADs manufacturing for the time period 2015-2025, using Scopus, Web of Science and PubMed databases, was conducted. Mechanical properties, biocompatibility, deformation resistance, and influence on patient comfort were assessed.

Thermoplastic polymers (polyurethane, PETG, polylactic acid) showed excellent elasticity, structural durability and wear resistance under intraoral conditions. Nanoparticle-reinforced composites demonstrated improved strength while maintaining flexibility. Novel bioactive materials with antimicrobial coatings reduced inflammatory risk and allergic reactions. Additive manufacturing (3D-printing) enables precise, patient-specific appliance production.

The integration of innovative biomaterials in the therapy of SOSAS aims at developing comfortable, durable and better-tolerated intraoral appliances. The integration of advanced biomaterials significantly improves treatment efficacy and enhances patient compliance.

Keywords: obstructive sleep apnea, sleep medicine, biomaterials, intraoral appliances

Acknowledgments:
The study is financed by the European Union-NextGenerationEU, through the National Recovery and Resilience Plan of the Republic of Bulgaria, project № BG-RRP-2.004-0009 "Medical University – Varna: Enhancement of Translational Excellence Achievement in Medicine (MUVE-TEAM)"

FROM SIGNAL TO DIAGNOSIS – POLYSOMNOGRAPHY AS A MODERN ENGINEERING APPROACH IN THE DIAGNOSIS OF OBSTRUCTIVE SLEEP APNEA

Miroslav Stoykov, Mario Milkov, Zlatina Tsoneva, Silvena Baycheva, and Elena Todorova*

Medical University "Prof. Dr. Paraskev Stoyanov" – Varna, Bulgaria

*corresponding author contacts: miroslav.stoikov93@gmail.com

Abstract: The Syndrome of Obstructive Sleep Apnea and Snoring (SOSAS) is a frequent and often undiagnosed sleep disorder. It is characterized by repeated upper airway obstructions and breathing cessations during sleep. Elevated Body Mass Index (BMI) is a key risk factor. Polysomnography (PSG) is a gold standard examination to diagnose SOSAS. The present study examined overweight and obesity connection with SOSAS through the implementation of PSG.

A retrospective analysis of 42 adults undergoing polysomnography was performed. Data on BMI, Apnea–Hypopnea Index (AHI), age and sex were collected. OSA was defined as AHI ≥5 and categorized by severity. Logistic and ordinal regression analyses were used to determine associations between BMI and OSA presence and severity, adjusted for age and sex.

OSA (AHI ≥5) was present in 90% of participants with BMI ≥25 compared with 33% among those with BMI <25 ($p<0.05$). BMI per 5-unit increase was associated with a fourfold higher odd of OSA (OR=4.01; 95% CI:1.00–15.98; p=0.049). Ordinal regression confirmed a positive association between increasing BMI and OSA severity (OR=2.9 per 5 BMI units; 95% CI:1.1–7.5; p=0.03).

Overweight and obesity are independently associated with both the likelihood and severity of SOSAS. Routine screening should be prioritized among individuals with elevated BMI.

Keywords: obstructive sleep apnea and snoring, sleep medicine, apnea-hypopnea index, body mass index

Acknowledgments:
The study is financed by the European Union-NextGenerationEU, through the National Recovery and Resilience Plan of the Republic of Bulgaria, project № BG-RRP-2.004-0009 "Medical University – Varna: Enhancement of Translational Excellence Achievement in Medicine (MUVE-TEAM)"

SEM INVESTIGATION OF BONE SCAFFOLDS FABRICATED VIA LASER STEREOLITHOGRAPHY

Tsanka Dikova[1], Dzhendo Dzhendov[1], Ivaylo Parushev[1], Petar Valchanov[2], and Stanislav Mitkov[2]*

[1]Medical University of Varna, Faculty of Dental Medicine, 84 Tsar Osvoboditel Blvd, 9000 Varna, Bulgaria

[2]Medical University of Varna, Faculty of Medicine, 55 Marin Drinov Str, 9000 Varna, Bulgaria

*corresponding author contacts: jendo_jendov@abv.bg

Abstract: The aim of the present paper is to investigate 3D printed bone scaffolds using SEM. Virtual cubic samples, representing the morphological structure of the bone trabeculae, were generated using scanned woman distal tibia. They were obtained by laser stereolithography and can be used as templates in indirect production of porous scaffolds. Two groups of samples were designed: The first group (Group 1) representing bone tissue and the second group (Group 2) expressed with bone pores. Castable wax resin was used to make the samples. The virtual models were proportionally enlarged by 20% and 40%. The structure and porosity studies were carried out using a pore analyzer, optical microscopy and SEM. The studies show that the porosity of the bone skeletons is higher compared to the samples with bone pores (Group 1- 49%; Group 2- 10%). With a 20% increase of sizes, the porosity increased in the first group by 60% and by 15% in the second. With a 40% increase, there is a slight change in the values of 4% in the first group and 1.5% in the second. The variations in terms of the average pore width were very close (293-362 μm) in Group 2, and in Group 1 it was larger - between 527-792 μm.

Keywords: bone scaffolds; laser stereolitography; structure; porosity

SCANNING ELECTRON BEAM SURFACE MODIFICATION OF TiO_2/CUO MAGNETRON-SPUTTERED COATINGS ON TITANIUM ALLOY

Maria Ormanova[1,2,3,*], *Dimitar Dechev*[1], *Borislav Stoyanov*[2,3], *Nikolay Ivanov*[1], *Darina Kaisheva*[1,4], *Stefan Valkov*[1,2,3], *and Maria P. Nikolova*[5]

[1] *Acad. E. Djakov Institute of Electronics, Bulgarian Academy of Sciences, 72 Tzarigradsko Chaussee Blvd., 1784 Sofia, Bulgaria*
[2] *Technical University of Gabrovo, 4 H. Dimitar Str., 5300 Gabrovo, Bulgaria*
[3] *Center of competence "Smart mechatronic, eco-and energy-saving systems and technologies", 5300 Gabrovo, Bulgaria*
[4] *Neofit Rilski South-Western University, 66 Ivan Mihailov Str., 2700 Blagoevgrad, Bulgaria*
[5] *University of Ruse "Angel Kanchev", 8 Studentska Str., 7017 Ruse, Bulgaria*

*corresponding author contacts: maria.ormanova87@gmail.com

Abstract: Titanium-based alloys with functional oxide coatings are of significant interest for advanced structural and biomedical applications. In this work, multilayer TiO_2/CuO coatings (6 bilayers) were deposited on a Ti6Al4V alloy substrate by sequential magnetron sputtering, with TiO_2 as the first layer followed by CuO. Surface modification of the coated samples was performed using a scanning electron beam with beam currents of 1 and 2 mA, corresponding to beam powers of 60 and 120 W, in order to investigate the influence of electron beam power on the microstructure and properties of the coating–substrate system.

The phase composition was analyzed by X-ray diffraction, while the thickness of the modified zones and the elemental depth distribution were evaluated by glow discharge optical emission spectroscopy (GDOES). Microstructural characterization was carried out using scanning electron microscopy (SEM). Mechanical properties of the modified surface layers were assessed by nanoindentation to determine nanohardness and elastic modulus.

The results indicate that electron beam treatment significantly affects the phase composition and elemental redistribution within the multilayer coatings, leading to enhanced functional performance of the obtained samples. The novelty of this study lies in the combined application of alternating TiO_2/CuO magnetron-sputtered coatings and controlled scanning electron beam post-treatment as a strategy for tailoring surface architecture and mechanical response, opening new perspectives for the development of multifunctional titanium-based materials for next-generation biomedical implants.

Keywords: titanium-based alloys; TiO_2/CuO coatings; electron beam modification; biomedical implants.

Acknowledgments:
This research was supported by the Bulgarian National Science Fund under project No. KP-06-N 67/5.

GLOW-DISCHARGE OPTICAL EMISSION SPECTROSCOPY, METHOD PRINCIPLES AND APPLICATIONS

Ivan Zahariev[1,*], *Georgi Avdeev*[1], *and Dragomir Tatchev*[1]

[1]*Institute of Physical Chemistry, Bulgarian Academy of Sciences, Sofia 1113*

*corresponding author contacts: izahariev@ipc.bas.bg

Abstract: This report presents the main features and applications of the new Spectruma Analytik GDA 750 HR instrument, acquired/purchased under the INFRAMAT project. Glow Discharge Optical Emission Spectroscopy (GDOES) is a fundamental technique for the direct analysis of bulk solids, elemental surface analysis and depth profiling of thin films and industrial coatings. The observation of light with an optical emission spectrometer allows the identification of elements, thanks to their characteristic emission wavelengths, and their quantification by means of a calibration curve. GDOES is capable of providing qualitative and quantitative depth profiling of elements, measurement of elements from hydrogen to uranium and characterization of layers from the first nanometer to 200 μm in the sample, within minutes. Measurement results are presented on various types of materials, such as: anodized aluminum, protective zinc coatings, thin films for electronics, analysis of steels and cast irons, etc. One of the strengths of the method is the identification of the presence and distribution of elements deposited in very small quantities.

Keywords: GDOES

Acknowledgments:
This research is funding by Project BG-RRP-2.017-0006-C01 from the Recovery Plan for Europe (NextGenerationEU), SAV and BR acknowledges the support from the CoE “National center for/of mechatronics and clean technologies” (Project BG05M2OP001–1.001–0008) supported by the ERDF within the Bulgarian OP “SESG 2014–2020.“ and the project INFRAMAT (National Roadmap for Research Infrastructure) financed by Bulgarian Ministry of Education and Science was used in this investigation.

WIRE ARC ADDITIVE MANUFACTURING OF 316LSi BIOCOMPATIBLE COMPONENTS

Edmon Lazarov[1,*], *Georgi Kotlarski*[1,2], *Maria Ormanova*[1,2,3], *Stefan Valkov*[1,2,3], *Alexander Nikitin*[4], *Iuliia Morozova*[4], *Ralf Ossenbrink*[4], *Vesselin Michailov*[4], *Nikolay Doynov*[4,5]

[1]*Institute of Electronics of Bulgarian Academy of Sciences, Tsarigradsko Chaussee 72, 1784 Sofia, Bulgaria*
[2]*Center of competence "Smart mechatronic, eco-and energy-saving systems and technologies", 5 Doctor Iliev Detskia Str., 5300 Gabrovo, Bulgaria*
[3]*Technical University of Gabrovo, 4 H. Dimitar Str., 5300 Gabrovo, Bulgaria;*
[4]*Department of Joining and Welding Technology, Brandenburg University of Technology, Platz der Deutschen Einheit 1, 03046 Cottbus, Germany;*
[5]*Institute of Metal Science, Equipment, and Technologies with Center for Hydro- and Aerodynamics, Bulgarian Academy of Sciences, 67 Shipchenski prohod Blvd., 1574 Sofia, Bulgaria*

*corresponding author contacts: edmnlazarov@gmail.com

Abstract: In the present work, the possibility of manufacturing components using biocompatible materials such as 316LSi stainless steel was investigated. Two specimens were built using different welding speeds, namely 10 mm/s and 20 mm/s. The structure of the samples was observed using X-ray diffraction (XRD), optical microscopy, scanning electron microscopy (SEM), and energy dispersive X-ray spectroscopy (EDS) experiments. The microhardness of the samples was determined as well. The results indicated that building the components using differing welding speeds leads to changes in the macrostructure and microstructure of the samples, which intern alters the mechanical properties. The results were discussed regarding the biocompatibility of the samples, and future improvement of the technological process of manufacturing.

Keywords: wire arc additive manufacturing; WAAM; 316LSi; stainless steel; structure; hardness

INVESTIGATION OF THE STRUCTURE AND MECHANICAL PROPERTIES OF Ti-Nb COATINGS

Fatme Padikova[1,2,3,*], *Ivana Ilievska*[2,3], *Georgi Kotlarski*[2,3], *Maria Ormanova*[1,2,3], *Borislav Stoyanov*[1,3], *Vladimir Dunchev*[1,3], *and Stefan Valkov*[1,2,3]

[1] *Technical University of Gabrovo, 4 H. Dimitar Str., 5300 Gabrovo, Bulgaria;*
[2] *Acad. E. Djakov Institute of Electronics, Bulgarian Academy of Sciences, 72 Tzarigradsko Chaussee Blvd., 1784 Sofia, Bulgaria;*
[3] *Center of competence "Smart mechatronic, eco-and energy-saving systems and technologies", 5300 Gabrovo, Bulgaria.*

*corresponding author contacts: f.padikova@yahoo.com

Abstract: Ti–Nb alloys are widely recognized as highly promising materials for orthopedic applications due to their excellent functional properties, including superior biocompatibility and a relatively low Young's modulus that better matches that of human bone. The formation of TiNb intermetallic structures as thin films or surface coatings is particularly advantageous, as biomedical materials are primarily subjected to surface-related mechanical and biological interactions during service.

In the present study, TiNb coatings were fabricated on commercially pure titanium substrates using an electron beam surface treatment technique. Initially, a 1 μm thick Nb layer was deposited onto the Ti substrates by direct current (DC) magnetron sputtering. Subsequently, the samples were modified through scanning electron beam irradiation, with beam power varied between 1000 and 2000 W to promote intermetallic phase formation.

The phase composition of the resulting structures was analyzed by X-ray diffraction (XRD). Microstructural characteristics and chemical composition were examined using scanning electron microscopy (SEM) coupled with energy-dispersive X-ray spectroscopy (EDS). Mechanical properties were evaluated in terms of hardness, Young's modulus, and coefficient of friction (COF).

The obtained results demonstrate the feasibility of tailoring the surface properties of titanium substrates through controlled electron beam processing, leading to enhanced functional performance. These findings highlight the strong potential of Ti–Nb intermetallic coatings for advanced biomedical applications, particularly in the development of next-generation orthopedic implants.

Keywords: Ti–Nb alloys, Electron beam surface treatment, Biomedical coatings, Orthopedic implants

Acknowledgments:
This work was funded by the Bulgarian National Science Fund, grant # KP-06 67/5.

AUTHOR'S INDEX