The **AMSP'25 conference** will cover and discuss new trends in **materials science, characterization techniques, and their applications** in various fields, including optics, photonics, and optoelectronics. The informal atmosphere, combined with the spirit of the beautiful mountains, will stimulate discussions on recent advances in these fields and foster future collaborations.

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AMSP'25
Advances in Materials Science & Photonics
International Conference

Book of abstracts

International Conference
Advances in Materials Science & Photonics

15-18 July 2025, Grand Hotel Bansko

Conference Chairs:

prof. Vera Marinova, IOMT-BAS, Bulgaria
prof. Tsvetanka Babeva, IOMT-BAS, Bulgaria
prof. Shiuan Huei Lin, NYCU, Taiwan

Sponsor:

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Preface

Dear Colleagues and Guests,

The organizing Committee warmly welcomes you to join the International Conference on Advances in Materials Science & Photonics (AMSP'25) during 15-18 July 2025 in Bansko, Bulgaria.

The aim of the AMSP'25 conference is to bring together scientists from different fields in materials development, optoelectronics and photonics. We believe the event will provide many opportunities for the participants to discuss and exchange new ideas and to find partners for future collaborations. We also welcome young scientists to join the event and to share their research progress.

The conference is organized by the Institute of Optical Materials and Technologies "Acad. Jordan Malinowski", Bulgarian Academy of Sciences (IOMT-BAS) and is dedicated to the 15th anniversary of IOMT-BAS and 25th anniversary of our collaboration with National Yang Ming Chiao Tung University (NYCU).

We thank the Bulgarian National Science Fund for the financial support under Project КП-06-МНФ/7, to Bulgarian Academy of Sciences for Bilateral agreement for International projects with National Science and Technology council (NSTC), Taiwan and to our national and international partners and collaborators.

With warmest regards,

Vera Marinova
Tsvetanka Babeva
Shiuan Huei Lin

Conference Chairs
AMSP'25

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Organizing Committee / Conference Chairpersons

Prof. Vera Marinova, IOMT-BAS, Bulgaria
Prof. Tsvetanka Babeva, IOMT-BAS, Bulgaria
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Prof. Chih-Wei Luo, NYCU, Taiwan
Prof. Dimitrios Zografopoulos, CNR, Italy
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PROGRAM
International Conference of "Advances in Materials Science & Photonics"
15-18 July 2025 Bansko, Bulgaria

1ST DAY TUESDAY – 15 July

12:00-15.00 Arrival, lunch at the hotel, accommodation and conference registration

15:00-15.30 **Opening:**
Welcome greetings: **Vera Marinova, Shiuan Huei Lin**

Conference Remarks: Vera Marinova

SESSION I

Presider: Nikolay Nedyalkov

15:30 "Selective Color Appearance of Liquid-Crystal-Aided Laser-Induced Periodic Surface Structures (LIPSS)" . . . . . **Jieh-Wen Tsung (NYCU)**

16:00 **Coffee break (group photo)**

16:30 "Augmented Reality Glasses with Volume Holographic Optical Elements" . . . . . **Shiuan Huei Lin (NYCU)**

17:00 "Liquid Crystals Nanocomposites for Electro-optics" . . . . . **Yordan G. Marinov (ISSP-BAS)**

17:30 "Automated Bird Tracking and Non-Invasive Laser Repulsion Method" . . . . . **Yu-Pin Lan (NYCU)**

18:00-20.00 **Dinner**

20:00-21.30 **Round Table Discussions**

2ND DAY WEDNESDAY – 16 July

SESSION II

Presider: Shiuan Huei Lin

09:00 "The Unique World of Laser Micro- and Nanostructuring: Technologies With no Efficient Alternative" . . . . . **Nikolay Nedyalkov (IE-BAS)**

09:30 "Terahertz Spectroscopy for the Electromagnetic Characterization of Resistive and Reactive thin Films" . . . . . **Dimitrios Zografopoulos (AUTH, CNR-IMM)**

10:00 **Coffee break**

10:30 "Macromolecular design and evaluation of amphiphilic copolymers for advanced biotechnological applications" . . . . . **Darinka Christova (IP-BAS)**

11:00 "Developing Biosensor Technology in IOMT: Present and Prospects" . . . . . **Georgi Dyankov (IOMT-BAS)**

11:30 "Overview of the Taiwan Instrumentation and Detector Consortium and Its Key Initiatives" . . . . . **Chia-Ming Kuo (NCU)**

12:00-14.00 **Lunch break**

SESSION III

Presider: Jenh-Yih Juang

14:30 "Molecular Beam Epitaxy and Characteristics of III-VI Compound Semiconductors" . . . . . **Wu-Ching Chou (NYCU)**

15:00 "Harnessing Theory for Unique 2D Ferroelectricity and Wafer-Scale Quantum Devices" . . . . . **Hung-Chung Hsueh (NTU)**

15:30 "Multilayer Van der Waals Materials for Nanophotonic Applications" . . . . . **P. G. Zotev (University of Sheffield)**

16:00 **Coffee break**

16:30 "Al-doped ZnO Thin Films as Transparent Conductors in Liquid Crystal Devices" . . . . . **Dimitre Dimitrov (ISSP-BAS)**

17:00 "Hollow Fiber Fabrication via Electrospinning and Atomic Layer Deposition for Gas Sensing " . . . . . **B. Blagoev (ISSP-BAS)**

17:30 "Surface modification of titanium and Ti-based alloys" . . . . . **Stefan Valkov (IE-BAS)**

18:00 Companies presentations

18:30-20.00 Dinner

20:00-21.30 Round Table Discussions

3RD DAY THURSDAY – 17 July

SESSION IV

Presider: Jieh-Wen Tsung

9:00 "A Comparative Study on the Magnetocaloric Effect of $ReVO_4$ (Re = Tb, Ho, Lu) and Eu-doped $HoMn_2O_5$ Crystals" . . . . . **Jenh-Yih Juang (NYCU)**

9:30 "Electronic Structure of $La_3Ni_2O_7$ thin Films and Implications for Superconductivity " . . . . . **Jiunn-Yuan Lin (NYCU)**

10:00 Coffee break

10:30 "Development of High-Quality Layered $PdSe_2$ Crystal" . . . . . **Dimitre Dimitrov (ISSP-BAS)**

11:00 "Applying Surface Techniques to Improve Next-Generation Semiconductors". . . . . **Chun-Liang Lin (NYCU)**

11:30 "Growth of Single Crystalline Compounds at TCECM" . . . . . **Chin Shan Lue (NCKU)**

12:00-14.00 Lunch break

SESSION V

Presider: Stefan Valkov

14:30 "Light-Driven Surface Functionalization: Advanced Laser Processing for Antibacterial Applications" . . . . . **Albena Daskalova (IE-BAS)**

15:00 "Laser speckle photometry for monitoring of dynamic events" . . . . . **Elena Stoykova (IOMT-BAS)**

15:30 "Phase-shifting methods in ESPI for dynamic deformation studies" . . . . . **Violeta Madjarova (IOMT-BAS)**

16:00 Coffee break

SESSION VI

16:00-18.30 Poster Session (farewell drink)

18:30-20:00 Dinner time

20.00-21:30 Round Table Discussions

4TH DAY FRIDAY – 18 JULY

SESSION VII

YOUNG SCIENTIST PRESENTATIONS

Presider: Elena Stoykova

09:00 "SPR as an effective technique for pesticides detection" . . . . . **Evdokiya Hikova (IOMT-BAS)**

09:30 "Change of the optical properties of polarization sensitive polymer (PAZO) after heating – an overview". . . . . **Georgi Mateev (IOMT-BAS)**

10:00 "Pt-based metal dichalcogenides: synthesis, properties and applications" . . . . . **Nikolay Minev (IOMT-BAS)**

10:30 Coffee break

11:00 "Synthesis and Characterization of $MoSe_2$ and MoS_2 and their heterostructures" . . . . . **Blagovest Napoleonov (IOMT-BAS)**

11:30 "Search for non-resonant Higgs boson pair production in the bbγγ final state for CMS Run-2" . . . . . **Yu-Hsuan Chou (NCU)**

12:00 Closing remarks, best young scientist presentation and best poster awards

12:30 Departure to Sofia

ABSTRACTS
ORAL PRESENTATIONS

Selective Color Appearance of Liquid-Crystal-Aided Laser-Induced Periodic Surface Structures

Jia-Pei Hsieh[1], Jing-Gue Chang[1], Chih-Yuan Tu[1], Kue-Yo Chen[1], Yu-Yuan Chen[1], Chun-Hsiang Tseng[2], Vera Marinova[3], Shiuan-Huei Lin[1], Hui-Hsin Hsiao[2], Chih-Wei Luo[1], and Jieh-Wen Tsung[1*]

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[2]Department of Engineering Science and Ocean Engineering, National Taiwan University, Taiwan
[3]Institute of Optical Materials and Technologies, Bulgarian Academy of Science, Sofia, Bulgaria

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Laser-Induced Periodic Surface Structure (LIPSS) combined with a layer of liquid crystal (LC) shows electronically selective color in this research. LC spontaneously aligns in parallel to the LIPSS nano grooves. An in-plane switching (IPS) LC cell with LIPSS-processed indium tin oxide (ITO) electrodes is fabricated, and compared to a traditional IPS LC cell with rubbed aligning polymer. At the fist place, an LC cell providing tunable gray scale is expected. Surprisingly, the LC cell shows brilliant glowing colors, which changes dramatically from golden yellow to midnight blue when the voltage is applied. The polarized optical microscope pictures show that light is diffracted and propagating in the cell. With the transmission spectra, diffraction, multiple reflection, and grating-assisted total internal reflection (TIR) are identified. The LC switches the polarization of light, turning the diffraction and TIR on-and-off. LIPSS provides not only alignment but also structural color, modulated by the LC. The grating-assisted TIR opens up new possibility for waveguides and transparent displays. Fabrication of LIPSS LC cell is fast and clean. Only laser and cleaning is required, omitting large amount of toxic materials and hazardous waste. Efforts are made to offer an environmental friendly method to produce nano optoelectronics.

Acknowledgments: The authors thank Dr. Dimitre Dimitrov and Dr. Stefan Petrov for offering the transparent conducting material and the substrates with alignment layer. The authors thank Dr. Ching-Hang Chien for discussion about surface plasmon excitation. Their generous offer supported at the early stage of this research. This work was supported by the Center for Emergent Functional Matter Science of National Yang Ming Chiao Tung University from the Featured Areas Research Center Program within the framework of the Higher Education Sprout Project by the Ministry of Education (MOE) in Taiwan. This research was supported by the National Science and Technology Council, Taiwan, under Grant no. NSTC 111-2112-M-A49 -042 -MY3 and Grant no. NSTC 112-2119-M-A49-012-MBK.

Augmented Reality Glasses with Volume Holographic Optical Elements

Shiuan Huei Lin[1*], Zih Fan Chen[1], Chi Sun[1], Yuan-Yan Liang[1], and Vera Marinova [2]

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It has been demonstrated that the eyewear displays with see-through capability are crucial for Augmented Reality (AR) applications, enabling the seamless integration of virtual digital content with the real world. However, maintaining a compact and lightweight design while ensuring high-quality image viewing remains a challenge. Research indicates that waveguides incorporating two in- and out-coupling diffractive optical elements (DOEs) offer a simple and compact configuration, addressing these requirements and providing high see-through transmittance due to diffractive selectivity. These optical elements come in various types, broadly classified into two major groups: thin grating (such as surface relief grating (SRG)) and volume holographic optical element (VHOE) [1-3]. This paper builds on our prior study to carry out a systematic analysis on the color gamut coverage, offering valuable insights for the development of a practical and efficient diffractive light guide system tailored for full-color near-eye AR glasses.

References:

[1] Jing-Ai Piao, Gang Li, Mei-Lan Piao, and Nam Kim, "Full Color Holographic Optical Element Fabrication for Waveguide-type Head Mounted Display Using Photopolymer," J. Opt. Soc. Korea 17, 242-248 (2013)

[2] Tian Shu, Guangyin Hu, Rengmao Wu, Haifeng Li, Zhuopeng Zhang, and Xu Liu, "Compact full-color augmented reality near-eye display using freeform optics and a holographic optical combiner," Opt. Express 30, 31714-31727 (2022)

[3] Ching-Cherng Sun, Wen-Kai Lin, Tsung-Hsun Yang, Zih-Fan Chen, Chi Sun, Wei-Chia Su, Shao-Kui Zhou, Yeh-Wei Yu, Tsung-Xian Lee, Chih-Yuan Cheng, and Shiuan Huei Lin, "Color Gamut Characteristics of Diffractive-Light Guides of Near-eye Augmented Reality Glasses," iScience, Vol. 27(6), 21 June, 2024, 110023 (2024)

Acknowledgments: The author would like to thank all team members' efforts in Taiwan MR&3D Team. The research has been sponsored by the National Council of Science and Technology in Taiwan with grant no. MOST 111-2221-E-A49 -055 -MY3 and NTSC 114-2927-I-A49-503.

Liquid Crystals Nanocomposites for Electro-optics

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Liquid crystals (LCs) (also known as mesophases) are eminent representatives of soft condensed matter, combining properties of liquids (fluidity, viscosity, lack of overall 3D order) with properties of solids (long-range orientational order, specific orientational elasticity, thermal, optical, electric, conductance, magnetic, etc. anisotropy, partial translational order and corresponding elasticities). The inclusion of solid nanosized particles in LCs provides nanostructured materials of current research interest and object of intensive studies. These nanocomposite structures became known as nanostructured LCs, because suspended nanoparticles modify in a specific way the LC ordering on the nanoscale, thus providing new soft-matter structures of interest for science and diverse applications, e.g., for electro-optics. Conceptually, many of those novel structures could be successfully investigated by applying usual spectroscopy methods such as optical, complex electrical impedance, dielectric, and flexoelectric spectroscopy, in order to understand the structuring of such LCs-based nanocomposites both on nano and micro level.

In this speech we shall present the results of our studies on nematic LCs nanostructured with metallic and inorganic nanoparticles, such as gold or silver nanospheres, as well as silica nanoparticles (aerosil nanospheres), and molecules of photoactive liquid-crystalline azo dyes. Through our investigations of thin films (25–50 μm-thick) of such nanocomposites, the electro-optical response and other key properties and characteristics of such LC+NANO systems could be understood in terms of interaction between LCs and suspended nanoparticles. Results would be useful in further designing of new hybrid LC-based systems with desired properties and performance.

Acknowledgments: This work was supported by the Ministry of Education and Science of Bulgaria, through the National Research Fund of Bulgaria (research projects "Liquid crystal nanocomposites for applications in photonics, sensors and biomedicine", No. KP-06-N58/6/2021.

Automated Bird Tracking and Non-Invasive Laser Repulsion Method

Yu-Pin Lan*, Jung-Cheng Chen, Zheng-Yi Lai, Cheng-Feng Yu, Chao-Feng Wu, Yung-Chieh Chang, Kai-Chen Chien, Ya-Ying Yang, Hsuan-Yu Lin, Yan-Jun Zeng, Justin Chen

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Birds play a crucial role in ecological balance, but their presence in agricultural fields, fisheries, and near airports can lead to significant challenges, including crop damage, disrupted fishery resources, and bird strikes. Conventional bird control methods, such as poisoning and trapping, have ethical and environmental concerns, prompting the need for sustainable, humane alternatives. This topic presents an automated optical bird-repellent system that integrates artificial intelligence (AI), machine learning, and laser technology to deter birds without harm, offering a potential solution to bird-related issues in critical environments. The system comprises a high-resolution detection camera, AI-based image segmentation, bird identification, localization algorithms, and a laser module that repels birds through visual deterrence. The detection camera captures real-time images of the area to be protected, which are processed by the system to detect and classify birds using machine learning models. The birds are then localized and grouped into flocks using the K-means clustering algorithm [1], with the largest flock prioritized for laser deterrence. A laser with a wavelength sensitive to bird vision is used to disorient and drive birds away. The laser's pattern is dynamically adjusted by a motor-controlled mirror, preventing habituation and ensuring the continued effectiveness of the system. The entire setup is powered by solar energy, making it sufficient and sustainable, particularly suitable for deployment in remote areas. Integrating AI and real-time image processing allows for rapid identification and response, ensuring that the most significant threats are addressed first. The solar-powered design further enhances its suitability for long-term, environmentally friendly deployment.

References:

[1] S. M. Aqil Burney, et al. "K-Means Cluster Analysis for Image Segmentation." International Journal of Computer Applications, Vol. 96, Issue. 4 (2014)

Acknowledgments: The author would like to thank all team members for their efforts. The research has been sponsored by the National Council of Science and Technology in Taiwan with grant no. MOST NSTC 113-2221-E-A49-074-MY3.

The Unique World of Laser Micro- and Nanostructuring: Technologies With no Efficient Alternative

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Laser technologies offer unique processing of practically all known materials with high spatial resolution. The specific mechanisms of laser-mater interaction and material dynamics during relaxation stage, lead to formation of specific micro- and nanostructures that attract fundamental and practical interest in different areas. In this presentation some specific laser-based method for processing and fabrication of functional materials will be presented. These are related to formation of 2- and 3D micro- and nanostructures of different materials including metals, semiconductors, and dielectrics, as well as complex composites. Methods for formation of nanostructures inside dielectric materials and formation of electrically conductive lines on the surface of insulating ceramics will be demonstrated. Some of the unique capabilities of pulsed laser deposition for formation of complex structures will also be presented. Applications of the formed materials in the field of photonics and sensors will be demonstrated and discussed.

Acknowledgments: The author acknowledges the financial support of project KP-06-N87/8 "Development of sensor elements based on composite metal-oxide thin films and nanostructures" under the "Competition for financial support of basic research projects – 2024" Program of the Bulgarian National Science Fund.

Terahertz Spectroscopy for the Electromagnetic Characterization of Resistive and Reactive thin Films

D. C. Zografopoulos[1,2*], I. Dionisiev[3], N. Minev[3], G. Petrone[2,4], F. Maita[2], L. Maiolo[2], D. Dimitrov[3,5], V. Marinova[3], A. Liscio$_2$, V. Mussi[2], R. Beccherelli[2], and W. Fuscaldo[2]

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We present a protocol for the characterization of 2D/thin-film materials and metasurfaces in the homogenization regime by means of terahertz time-domain spectroscopy (THz-TDS). By employing a Gires–Tournois étalon configuration in reflection mode, it is shown that amplitude measurements suffice to accurately characterize the sheet resistance of thin conducting films [1] and the sheet reactance of metallic metasurfaces at THz frequencies [2]. A large series of samples are characterized: aluminum-doped zinc oxide, nanometric Ti and reduced graphene oxide films, tungsten and palladium diselenide and reactive metasurfaces. The results confirm that THz-TDS in reflection mode provides a powerful tool for the fast and nondestructive characterization of metasurfaces and emerging 2D materials for THz applications.

References:

[1] D. C. Zografopoulos, I. Dionisiev, N. Minev, G. Petrone, F. Maita, L. Maiolo, D. Dimitrov, V. Marinova, A. Liscio, V. Mussi, R. Beccherelli, and W. Fuscaldo "Terahertz time-domain characterization of thin conducting films in reflection mode". *IEEE Trans. Antennas Propag.*, 72:9301-9316, 2024.
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Acknowledgments: This work was supported by the Bilateral Project "Two-Dimensional Nanomaterials Toward Terahertz Optoelectronic Applications" between the Consiglio Nazionale delle Ricerche and the Bulgarian Academy of Sciences, by the Project "Ecosistemi dell'Innovazione" ECS00000024 – Rome Technopole – of the Italian Ministry of University and Research, public call n. 3277, Piano Nazionale Ripresa e Resilienza (PNRR) - Mission 4, Component 2, Investment 1.5, financed by Next Generation EU under Grant CUP B83C22002890005 and by the Bulgarian Science Fund under Project K5-06-H-68/1.

Macromolecular Design and Evaluation of Amphiphilic Copolymers for Advanced Biotechnological applications

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Amphiphilic polymers comprising hydrophilic and lipophilic components are at the forefront of modern polymer materials research due to their exciting properties and versatile functionality in biomedical and technological field. With the advancement in polymerization methods combined with diverse modification and coupling techniques, a large range of functional amphiphilic polymer architectures such as block, graft, star-shaped, hyperbranched and cross-linked copolymers become available. High performance materials for application in drug delivery, tissue engineering, surface modification, and many other are designed on this basis in response to the increasingly sophisticated demands of industry. Recently, considerable research in the field is dedicated to the design of macromolecular structures with smart responsive behavior. In this aspect the macromolecular architecture can be used as an advanced tool in the attempts to tailor the copolymer properties for specific applications. In this paper, different synthetic strategies in developing functional amphiphilic copolymers with complex macromolecular architecture will be presented. The attention will be focused on preparation of poly(vinyl alcohol) derivatives of versatile material properties applying environmentally friendly reaction conditions. Some emerging applications of the developed polymer materials in different technological fields will be highlighted as well.

Acknowledgments: Research equipment of Distributed Research Infrastructure INFRAMAT, part of Bulgarian National Roadmap for Research Infrastructures, supported by Bulgarian Ministry of Education and Science was used in these investigations.

Developing Biosensor Technology in IOMT: Present and Prospects

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Surface plasmons (SP), being waves propagating at the metal/dielectric interface, are extremely sensitive to the change in the refractive index of the dielectric, sensing that takes place within the attenuation and penetration lengths of the wave in the dielectric. Since the excitation of the SP is a strictly resonant process, all these changes are relatively easily detectable by the observation of the resonance conditions. Due to these circumstances, sensors based on surface plasmon resonance (SPR) have attracted enormous attention and to their advantages such as high sensitivity, label-free real-time detection, and quantitative evaluation. As a kind of alternative to traditional immunological assays, SPR sensors are ideal for studying surface bioaffinity, adsorption of biological and chemical analytes.

It has been widely believed that SPR sensors have low sensitivity and they cannot detect analytes < 400 Da, low sub-picomole (pM) concentrations, and therefore are not capable of detecting tumor markers, hormones, antibiotics and etc.; they are not applicable for diagnosing the disease in the initial stage. Therefore, modifications of SPR sensors are needed to significantly improve their feasibility. This, combined with the inherent low cost of SPR sensors, the easy way of performing the analysis (which does not require specialized personnel) can open the way for these devices for their wide application for medical diagnostics outside specialized laboratories.

Considering the above mentioned advantages, unsolved problems and development perspectives, it was considered appropriate to start research in the field of SPR-based biosensors at IOMT 7 years ago. During this period, the topic has been supported by the Research Fund and the Ministry of Education and Science for a total of about 500,000 Euros.

This report reviews what has been done in the field, in particular:
- Detection methods; - Immobilization methods;
- Immunological assays developed;
- Cell-based assays developed;
- Detection accuracy and sensitivity achieved;
- Technological level of point-of-care device development.

The current status of biosensor technology development is analyzed and new promising developments in the field are commented.

Acknowledgments: Bulgarian National Science Fund, grant number КП-06-Н789/14.12.2023, entitled “Surface plasmon resonance in the near infrared region (1 – 2.5 μm) and its application for detecting biomolecular interactions” and Bulgarian Ministry of Education and Science (MES), Project № DO1-352 from 13 December 20

Overview of the Taiwan Instrumentation and Detector Consortium and Its Key Initiatives

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The Taiwan Instrumentation and Detector Consortium (TIDC) was established to coordinate national efforts in advanced detector research and development, with a primary focus on high-energy and nuclear physics applications. This presentation provides an overview of the consortium's organizational framework, strategic objectives, and ongoing collaborative programs.

TIDC plays a central role in promoting cross-sector partnerships among universities, research institutes, and industry. By leveraging Taiwan's technical expertise and research infrastructure, the consortium supports a broad portfolio of detector initiatives. Highlights include contributions to major international experiments such as the CMS and ATLAS upgrades at the LHC, sPHENIX and STAR at RHIC, and the ePIC experiment at the Electron-Ion Collider.

With a coordinated approach to resource integration, workforce development, and technological innovation, TIDC aims to strengthen Taiwan's long-term engagement in frontier experiments and to position itself as a regional hub for detector R&D. The talk will also outline upcoming opportunities for international collaboration and joint development efforts across multiple scientific domains.

Molecular Beam Epitaxy and Characteristics of III-VI Compound Semiconductors

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III-VI compound semiconductors made of group III and VI elements have a very wide spectral range covering IR to UV. They also have very rich two-dimensional (2D) and three-dimensional (3D) crystal structures. In this report, the molecular beam epitaxy of 2D and 3D III-VI semiconductors, GaSe, GaTe, InSe, In_2Se_3, and β-Ga_2O_3 were discussed [1-3]. The samples' surface morphology was characterized by atomic force microscopy (AFM) and scanning electron microscopy (SEM). The control of crystal structures of 2D and 3D III-VI semiconductors were revealed by transmission electron microscopy (TEM), X-ray scattering and Raman scattering. High quality interfaces of β-In_2Se_3/β-Ga_2O_3 and GaSe/β-Ga_2O_3 hetero-structures demonstrate potential device applications.

References:

[1] Ssu-Kuan Wu, Hong-Jyun Wang, Sheng-Wei Hsiao*, Jui-Sheng Huang, Wu-Ching Chou*, Chu-Shou Yang*, Shu-Jui Chang, Chia-Hsing Wu and Yu-Che Huang, "Control of Lateral Epitaxial Nanothin β-In2Se3 Grown by Molecular Beam Epitaxy: Implications in Fabricating of Next-Generation Transistors", ACS Applied Nano Materials 7, 20445 (2024).

[2] Nhu Quynh Diep, Yu Xun Chen, Duc Loc Nguyen, My Ngoc Duong, Ssu Kuan Wu, Cheng Wei Liu, Hua Chiang Wen, Wu Ching Chou*, Jenh Yih Juang, Yao Jane Hsu, Van Qui Le, Ying Hao Chu, and Sa Hoang Huynh, "Monotonously Alloying-Driven Band Edge Emission in Two-Dimensional Hexagonal $GaSe_{1-x}Te_x$ Semiconductors for Visible to Near-Infrared Photo-detection", J. Materials Chemistry C 11, 1772 (2023).

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Harnessing Theory for Unique 2D Ferroelectricity and Wafer-Scale Quantum Devices

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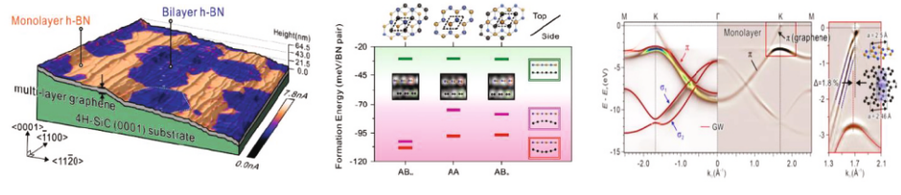
Ferroelectricity in van der Waals (*vdW*) materials with non-centrosymmetric stacking offers exciting possibilities for future 2D devices with nonvolatile and reconfigurable functionalities. However, achieving the energetically unfavorable stacking configurations necessary for electric polarization during epitaxial growth remains a significant challenge, particularly in heteroepitaxy on *vdW* substrates for scalable, atomic-scale ferroelectric building blocks. This work addresses this challenge by demonstrating the successful epitaxial growth of hexagonal boron nitride (h-BN) multilayer films on single-crystal graphene synthesized on miscut SiC (0001) [1]. A pivotal aspect of this work is the discovery and understanding of the unique 2D ferroelectricity inherent in this h-BN/graphene heterostructure. Crucially, theoretical calculations play a vital role, revealing that the moiré-patterned h-BN/graphene heterointerface intrinsically exhibits polarization. This insight guided the experimental design and validated the observed polarized AB stacking in multilayer h-BN films, which minimizes total formation energy. Experimental validation through layer-dependent band dispersions confirms these theoretical predictions. The resulting multilayer h-BN layers exhibit robust, homogeneous ferroelectricity with switchable out-of-plane polarization via interlayer sliding. This study highlights the indispensable role of theoretical simulations (first-principles and many-body perturbation theory) in both predicting and explaining the origin of this novel 2D ferroelectricity, as well as in controlling the stacking-controlled heteroepitaxy of *vdW* materials. This approach enables the large-scale integration of ferroelectric *vdW* materials with versatile functionalities, offering a promising platform for next-generation 2D ferroelectric devices and paving the way for potential wafer-scale applications.



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Acknowledgments: NSTC Taiwan, NCHC, TKU

Multilayer Van der Waals Materials for Nanophotonic Applications

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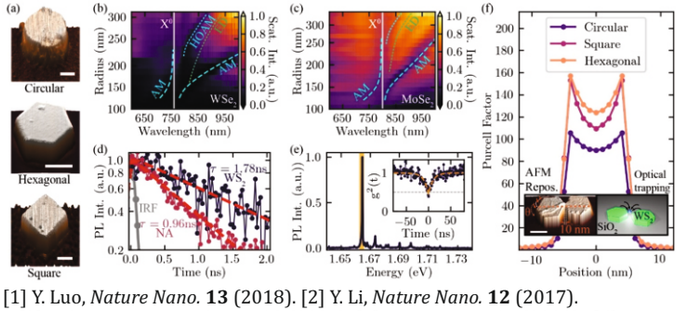
Many of today's industries, such as optical communication and photonic information processing, have emerged due to photonics research into optical waveguiding, lasing, Purcell enhancement of emission and second harmonic generation. These discoveries have been enabled by the nano-scale patterning of noble metals [1] or high refractive index dielectrics such as silicon [2] and III-V [3] materials. While these materials offer a large range of opportunities for both research and industry, recently discovered multilayer van der Waals materials may expand the possibilities of photonics in the visible and infrared part of the spectrum due to high, super-Mossian refractive indices (n>4) [4], a large range of transparency windows, and numerous advantages due to their weak van der Waals adhesive forces. In order to inspire and facilitate the adoption of layered materials in photonics research and industry, we extract the dielectric constants of a diverse set including transition metal dichalcogenides (TMDs), III-VI semiconductors, and magnetic materials. Employing well established, CMOS-compatible techniques, we fabricate nano-scale resonators with a range of geometries (Fig. 1(a)) from these materials and observe the formation of Mie resonances. We demonstrate strong coupling between the excitonic features of TMDs and anapole modes, with Rabi splittings up to 140 meV (Fig. 1(b),(c)), paving the way to sub-picosecond switching applications [5]. After the transfer of a monolayer of WSe_2 onto WS_2 nanoantennas, we observe room temperature Purcell enhancement of emission (see Fig. 1(d)) [6] and low temperature formation of single photon emitters (see Fig. 1(e)) with enhanced quantum efficiencies [7] within a system fabricated entirely from layered materials. Due to the weak van der Waals interactions of the nanoresonators with the substrate, we were able to employ an atomic force microscopy (AFM) cantilever in the repositioning of double-pillar nanoantennas to achieve ultra-small gaps (≈10 nm, Fig. 1(f)) [5]. This post-fabrication technique enables stable, low-power optical trapping of quantum emitters with Purcell enhancement above 150 (Fig. 1(f)).



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Al-doped ZnO Thin Films as Transparent Conductors in Liquid Crystal Devices

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Transparent conducting oxides (TCOs) are crucial functional layers in a wide range of devices, including flat panel displays, photovoltaics (organic, inorganic, and dye-sensitized solar cells), thin film electrodes in sensors, liquid crystal displays (LCDs), light-emitting diodes (LEDs), and transparent field-effect transistors (FETs) [1,2]. This study compares the functionality of aluminum-doped zinc oxide (AZO), fluorine-doped tin oxide (FTO), and indium-doped tin oxide (ITO) transparent conductive layers in anti-parallel (AP) liquid crystal (LC) cell structures. We discuss the influence of their optical, electro-optical, and wettability properties on the modulation behavior of the fabricated liquid crystal devices. AZO offers several advantages over ITO, including lower cost, greater abundance, high thermal stability, flexibility, and non-toxicity. Unlike ITO, which contains the expensive element indium, AZO is composed of readily available and inexpensive aluminum and zinc. We investigated the structural, optical, and electrical properties of AZO layers deposited using the ALD technique and compared these properties with those of commercially available FTO and ITO. Liquid crystal devices incorporating the studied TCO transparent conductive electrodes were successfully fabricated. The measured driving voltage and response time values demonstrate the significant potential of AZO for integration in next-generation ITO-free optoelectronic devices. These findings suggest that AZO is a promising alternative to ITO and hold significant potential for advanced applications in high-end optoelectronics.

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Acknowledgments: We acknowledge the Bulgarian Science Fund support under the project number FNI КП-06-H 58/12 and bilateral agreement between the Bulgarian Academy of Sciences (BAS) and Taiwan National Council of Science and Technology (NSTC) grant no NTSC 114-2927-I-A49-503. 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.

Hollow Fiber Fabrication via Electrospinning and Atomic Layer Deposition for Gas Sensing

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High-aspect-ratio (HAR) nanostructures, particularly submicron hollow fibers, have attracted considerable attention owing to their exceptionally high specific surface area and their broad applicability across a range of advanced technologies. These include energy storage systems (e.g., batteries), catalysis, advanced sensing platforms, nanoelectronics, optoelectronics, nano-biotechnology, water purification, and smart textiles. Among the available fabrication techniques, combining electrospinning with atomic layer deposition (ALD) has proven to be particularly effective.

In this study, we report an optimized methodology integrating electrospinning and ALD for the production of diverse submicron tubular structures. Electrospinning provides a versatile technique for controlling the properties of polymer fiber matrices. By systematically varying parameters, such as polymer type and concentration, electrode spacing, and applied voltage, precise tuning of fiber diameter and morphology can be achieved. Subsequently, the ALD process facilitates the controlled deposition of various oxide and nitride coatings. This control is attained through adjusting precisely the selection of precursors and the deposition parameters, including temperature, pulse and purge durations, and number of ALD cycles. This synergistic approach enables the fabrication of dense or hollow, single- or multilayer fibers composed of a diverse range of materials, such as ZnO, CoO, NiO, Fe2O3, as well as doped or composite structures including ZnO:Al, ZnO:Co, ZnO/Al2O3, and ZnO:Co/Al2O3.

These precisely engineered submicron fiber structures demonstrate substantial potential for gas sensing applications, which is attributable to two primary factors. First, metal oxides, particularly transition metal oxides (TMOs), exhibit strong adsorption properties owing to their partially filled d orbitals, resulting in detectable changes in the electrical resistance upon gas adsorption. Second, the exceptionally high specific surface area inherent to these HAR structures significantly enhances the sensor's sensitivity, thereby improving the detection limits and response times.

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Surface Modification of Titanium and Ti-based Alloys

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Currently, titanium and Ti-based alloys are used in many industries, such as aerospace, automotive, biomedicine, implant manufacturing, and so on. They are characterized by excellent static and fatigue strength, good corrosion resistance, good biological response, and others. However, some drawbacks can be mentioned, related to the toxicity of their corrosion and wear products, low hardness, and wear resistance. In general, these limitations depend on the surface properties and performance of the materials and can be overcome by the application of an appropriate surface engineering method.

One technique for treating the surface of materials is the use of a high-intensity electron beam. During this technological process, accelerated electrons interact with the surface of the treated area, which results in the transformation of their kinetic energy into heat. The rate of the heating and cooling processes can achieve high values, which leads to some structural transformations, an increase in the hardness, and an improvement in the wear properties. Another method for changing the surface properties of materials is the deposition of coatings on their surfaces. Nanoscale transition metal nitride and oxide coatings have been widely reported to exhibit better corrosion than the base material.

This talk aims to summarize the results of the surface modification of titanium and Ti-based alloys by an electron beam surface modification technology, by the deposition of advanced coatings and thin films, as well as the combination of both technologies. The phase composition and microstructure of the modified surfaces were systematically studied, and the results obtained for the mechanical properties, corrosion resistance, and biological properties concerning the corresponding phase composition and microstructure are discussed.

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Development of High-Quality Layered $PdSe_2$ Crystal

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Palladium diselenide ($PdSe_2$) is an important transition metal dichalcogenide with a layers-dependent bandgap and many potential applications. Moreover, pentagonal $PdSe_2$, possess unique in-plane anisotropy. However, the availability of high-quality large-area crystals with phase control is still challenging. Herein, we report the successful growth of large-area $PdSe_2$ single crystals using the self-flux method [1]. The crystal structure, quality, optical properties and elemental composition were characterized by X-ray Diffraction, Spectroscopic Ellipsometry, Energy-Dispersive X-ray Spectroscopy, and High-Resolution Transmission Electron Microscopy (HR TEM). The Raman-active vibrational modes of $PdSe_2$ were identified using polarized Raman spectroscopy and Raman mapping. $PdSe_2$ featuring anisotropic structural, vibrational, and thermal properties offer new and exciting opportunities to enable efficient energy conversion and thermal management [2]. van der Waals heterostructures provide a versatile platform for tailoring electrical, magnetic, optical and spin transport properties via proximity effects. The controlled synthesis of $PdSe_2$ enables the potential for a broad range of heterostructures for integrated optical, electro-optical and spintronic applications [3].

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A comparative study on the magnetocaloric effect of $ReVO_4$ (Re = Tb, Ho, Lu) and Eu-doped $HoMn_2O_5$ crystals

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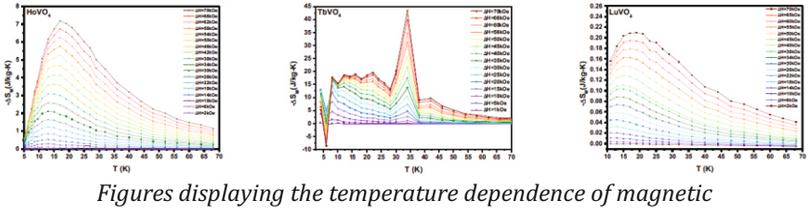
The magnetocaloric effect (MCE) has emerged as a subject of tremendous research interest owing to its implication in the trending eco-friendly cooling technology with potentially high thermodynamic efficiency. In this study, we performed comparative investigations on the correlations between the magnetic phase transition and MCE on a series of rare-earth vanadates ($ReVO_3$, with Re = Tb, Ho, and Lu) and multiferroic Eu-doped $HoMn_2O_5$ single crystals. All the crystals examined were prepared by the high-temperature solution growth method using a Pt crucible. The crystal structure and magnetic properties of all samples were characterized by X-ray diffraction and Quantum Design SQUID magnetometer, respectively. For $HoVO_4$, we observed a paramagnetic-to-antiferromagnetic phase transition near 250 K, and the material exhibits a maximum magnetic entropy change ΔS_M^{max} = 9,02 J/kg·K around 18 K with a relative cooling power at 7 Tesla, RCP(7 T) ≡ $\Delta S_M^{max} \times T_{FWHM} \approx$ 251.4 J/kg. Whereas, ΔS_M^{max} and RCP(7 T) for $TbVO_4$ and $LuVO_4$ are 54.7 J/kg·K, 343.1 J/kg and 0.26 J/kg·K, 12.2 J/kg, respectively. It is noted that $TbVO_4$ does not exhibit apparent magnetic phase transition down to 2 K and $LuVO_4$ displays a paramagnetic-to-ferromagnetic phase transition below 150 K, indicating that the detailed MCE is very much dependent on the magnetic ordering state of the material. Furthermore, the Eu-doped $HoMn_2O_5$ single crystal exhibit very strong magnetic anisotropy along the respective crystallographic axis, which may have significant implication in realizing substantial rotational magneto-



Figures displaying the temperature dependence of magnetic entropy change at various measuring fields.

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Electronic Structure of $La_3Ni_2O_7$ Thin Films and Implications for Superconductivity

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$La_3Ni_2O_7$ (LNO) single and polycrystals show superconductivity up to 80 K under extreme pressure. Very recently, superconductivity in LNO or Pr-doped LNO thin films at ambient pressure has been realized. However, the electronic structure in these thin films remains a mystery. To elucidate the essential ingredients of superconductivity in LNO thin films, knowledge of the electronic structure is indispensable. In this paper, polarized x-ray absorption spectroscopy (XAS) is utilized to reveal the nature of the electronic states and dimensionality in LNO thin films of various thickness and on various substrates. We find a different electronic structure from that of the bulk LNO, and the emergence of band in the LNO thin films. The similarity to and the difference from the band structure of bulk LNO under pressure are discussed.

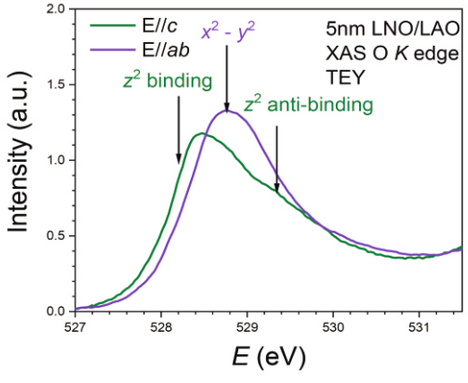

***Figure 1**: polarized O K edge XAS of a $La_3Ni_2O_7$ thin film on LAO substrate. The associated energy bands are indicated.*

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Applying Surface Techniques to Improve Next-Generation Semiconductors

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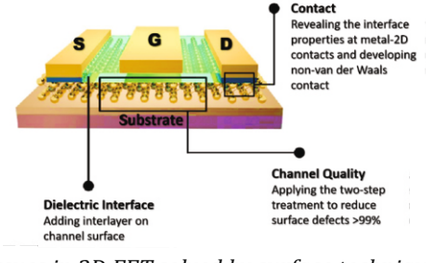
Next-generation semiconductor devices are facing a limit of scaling. Thus, it is urgent to find a new type of material to replace Si. Two-dimensional (2D) materials provide a solution to this problem since the thickness of monolayer 2D materials can be reduced to only few atoms. However, to fabricate a field effect transistor (FET) based on 2D materials exhibit a lot of problems such as low carrier mobilities, low on currents, and high contact resistance. Surface techniques can provide several crucial methods to investigate or even tune the electronic properties of 2D FET. For example, scanning tunneling microscopy (STM) is a powerful method, it allows us to reveal both the geometry and electronic structure of 2D materials down to atomic scale. In this presentation, I will introduce several examples of 2D materials and devices studied by STM. First, for the issue in the channel of 2D FET, the defect induced mobility modulation in FET devices fabricated by MoS_2 is visualized by STM. It is clear that the mobility of FET made by MoS_2 is correlated to the density of defects on the surface [1]. Therefore, a feasible method to sufficiently reduce defects on surface is necessary. Ar^+ bombardment and post-annealing are methods widely used in surface science research for sample preparation. Surprisingly, a two-step approach, including Ar^+ bombardment and post-annealing, can reduce surface defects on $PtTe_2$ and $PdTe_2$ surface by more than 99%. The defect density < 1.0×10^{10} cm^{-2} is achieved, which cannot be done solely with annealing [2]. Second, for the issue in the contact electrodes of 2D FET, by introducing atomic H to create surface defects on WS_2, the growth behavior of Ni thin film changes from Volmer–Weber mode (island growth) to a near Frank-van der Merwe mode (layer-by-layer growth) [3].



Issues in 2D FET solved by surface techniques

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Light-Driven Surface Functionalization: Advanced Laser Processing for Antibacterial Applications

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Ultra-short femtosecond lasers are becoming recently a widely used tool for creation of micro and nanopatterms due to their advantages, expressed in high precision processing without thermal damage (Fig.1). In order to minimize the bacterial contamination of the surface, one of the possible nondestructive attempts are to produce a hierarchical micro-nanostructure by employing a femtosecond laser processing to alter the frequently touched material surfaces of metals and plastics and induce a groove like textures. This effect will provide a difference in surface roughness characteristics and influence bacteria adhesion on the substrate. Due to the deviation in surface roughness between different laser processing conditions, the creation of antimicrobial characteristics could be established with respect to polished surfaces since the bactericidal efficiency depends strongly on the height and distance between the morphological structures. Laser texturing should be employed to control bacterial attachment only by geometrical means in a non-destructive manner. The presented initial results of changes in surface roughness and topography, without surface damage, of diverse materials (used in everyday life like stainless steel, glass and polypropylene), processed by fs laser radiation, demonstrated that the obtained structures are in the dimensions of already proven structural characteristics of surfaces, which could have a strong bactericidal effect.

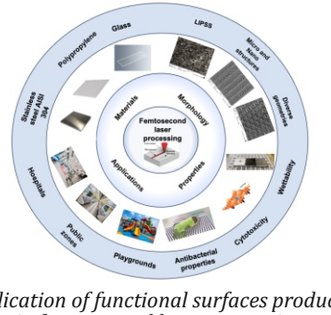

Fig. 1 *Application of functional surfaces produced via femtosecond laser processing.*

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Growth of Single Crystalline Compounds at TCECM

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In this talk, I will introduce to the priority project about the crystal growth and investigation supported by the National Science and Technology Council (NSTC). It is called Taiwan Consortium Emergent Crystalline Materials (TCECM). I will focus on the introduction of two crystal growth laboratories at National Cheng Kung University (NCKU). The first one is conducted by Prof. Mitch Chou who currently concentrates on the growth of wide bandgap semiconductors such as SiC and Ga2O3. Another is our crystal growth laboratory where we already successfully grew over one hundred kinds of single crystalline compounds. These crystals cover a wide range of materials including novel superconductors, charge-density-wave compounds, emergent topological materials, layered magnetic systems, and multifunctional 2D materials. Through growing high-quality single crystals and collaborating with over 80 research groups from both domestically and abroad, we have published over one hundred journal papers in the past five years. The journals include Nature Electronics, Nature Communications, Science Advances, Physical Review Letters, Physical Review B, Physical Review Research, Advanced Materials, Advanced Functional Materials, Small, ACS Nano, ACS Catalysis, ACS Materials Letters, ACS Applied Materials & Interfaces, Journal of Materials Chemistry A, 2D Materials, npj 2D Materials and Applications, npj Quantum Materials, Applied Physics Letters, APL Materials, …etc.

Laser speckle photometry for monitoring of dynamic events

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Laser speckle photometry (LSP) is an effective tool for non-destructive defects detection and monitoring the speed of processes in industrial or biological objects. This technique is implemented as a single-beam intensity-based method that takes advantage of the high sensitivity of coherent optical metrology and simplicity of the optical system required to capture sequences of images of dynamic speckle patterns formed on the rough 3D object surface. The acquired raw data exhibit low spatial correlation of the speckle intensity within each image and high temporal correlation between images. The speckle nature of the raw data contaminated with a signal-dependent noise entails statistical processing for retrieval of the relevant information. The measurement output is a 2D distribution of an estimate of activity on the object surface that visualizes areas with different speed of ongoing processes. High contrast of the activity map is crucial for conducting robust measurements. The obtained maps, however, have also highly fluctuating signal-dependent entries and may need filtering for sensitivity enhancement. Continuous monitoring also requires a large amount of data to be stored and processed in order to track a process.

This lecture addresses the key issues related to successful implementation of the LSP, also known as dynamic speckle analysis. Such issues are the accuracy of the estimates of some statistical parameter chosen to describe activity, optimization of the laser light intensity distribution on the object surface and normalization of the estimates, as well as compression of speckle images. The ground for applying compression to the speckle intensity data stems from the fact that the captured intensity values are of minor importance for activity evaluation since only the temporal rate of their fluctuations encodes occurrence of activity. We consider compression by binarization, coarse quantization, and transformation to compressed images using JPEG standards, singular value decomposition or principal component analysis. The effect of environmental noise such as vibrations or ambient light, impacting the shot noise at acquisition and the enhancement of spatial/temporal resolution of the output are also discussed. Both synthetic and experimental speckle patterns have been analyzed to evaluate the efficiency of the different approaches. High-speed camera impact test, OCT measurement and hidden defects detection are included for illustration.

Acknowledgments: This work was supported by COST Action CA21155 "Advanced Composites under **HIgh** STRAin raTEs loading: a route to certification-by-analysis" and Institute of Information & Communications Technology Planning & Evaluation (IITP) grant funded by the Korea government (MSIT) (No. 2019-0-00001, Development of Holo-TV Core Technologies for Hologram Media Services)

Phase-shifting methods in ESPI for dynamic deformation studies

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Optical coherent methods such as Electronic Speckle Pattern Interferometry (ESPI) have been broadly used for studying dynamic deformations in various materials. In all the interferometry-based techniques, the quantitative evaluation of the optical signal phase, thus the deformation, without sign ambiguity, is possible only if appropriate phase-shifting methods are implemented. In Dynamic or transient events investigations, finding the appropriate phase-shifting method is not a trivial task. This work presents three different approaches for the optical set-up for ESPI with phase shifting in the cases of dynamic event studies. The presented systems are out-of-plane sensitive systems. The first ESPI system is a Fizeau type interferometer with a temporal carrier introduced by injection current change of the laser diode. The second ESPI system is a Michelson type interferometer with Wollaston prism. These two systems are used to demonstrate the potential of the Hilbert transform (HT) method to obtain the optical phase in Dynamic ESPI. Its numerical implementation as a digital HT filter on the ESPI interference signal is in the first optical set-up, while its optical implementation is demonstrated in the second set-up via spatial phase shifting by the Wollaston prism of linearly and circularly polarized light. The third setup is a Polarization Fizeau type interferometer with pixelated polarization camera. Studying of various materials and deformation scenarios are showed: (i) thermal deformation sample composed of stainless steel – cupper – ceramic materials jointed together to simulate areas of sharp difference in the thermal expansion coefficients; (ii) thermal expansion of plexiglass plate that has defects introduced; and (iii) cycling deformations introduced by PZT on a plexiglass plate. We determined the accuracy in cycling deformation studies to be 20 – 30 nm, compared to the introduced by the PZT deformation.

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ABSTRACTS
YOUNG SCIENTISTS

SPR as an effective technique for pesticides detection

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The misuse of pesticides is a problem discussed at global level. Pesticides are among the main pollutants of nature, and a consequence of human misuse. The subject of this work is the detection of Carbendazim (CBZ). This pesticide can be toxic to a number of living organisms, including humans, when found in nature in high concentrations. Currently, CBZ is banned in the EU, but it has been systematically detected during quality control in many fruits and vegetables, because of its high effectiveness as a fungicide.

The detection methods developed so far require analyses to be performed by highly qualified personnel, transportation of large quantities of samples to a specialized laboratory, and are also time-consuming and expensive. This determines the need for reliable technology for rapid and qualitative detection of these pesticides. This work shows the capabilities of the developed biosensor technology, based on surface plasmon resonance (SPR) for rapid detection of CBZ in situ.

It has been reported* that the detection of substances with a small molecular weight, such as CBZ (191 Da) by the SPR method can be difficult. To solve the problem, the following are required: i) appropriate selection of the bioreceptor and ii) increased sensitivity of the biosensor. Based on the long-term experience of the scientific team in the development of SPR biosensors, a specific method for immobilization of the bioreceptor is proposed, as well as a method for increasing the sensitivity of the chip so that the sensitivity and accuracy of detection reach the values of conventional methods - ELISA and chromatographic methods.

In this work, the results from our first model experiments in detection of CBZ are summarized. The results are promising and clearly demonstrate the applicability of the biosensor technology in food quality control, as well as for in vitro cellular assays to determine toxicity at minimally detectable concentrations.

** Li Q., Dou X., Zhao X., Zhang L., Luo J., Xing X. and Yang M. A gold/Fe3O4 nanocomposite for use in a surface plasmon resonance immunosensor for carbendazim Microchimica Acta **2019**, 186/313. DOI:10.1007/s00604-019-3402-0.*

Change of the optical properties of polarization sensitive polymer (PAZO) after heating – an overview

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In this work we present the effect of thermal treatment of azopolymer PAZO thin films on their absorbance spectra as proof of the structural changes of the film and the formation of aggregation which allow for improvement of its optical properties and enhancement of the photoinduced birefringence in wide range around 532 nm. We investigate samples without thermal treatment and samples that were heated to different temperatures (in the range of 200-300°) with different rates and then we measure the change in the optical properties with various methods such as UV-VIS and IR spectroscopy, fluorescence spectroscopy e.t.c. With optical setup for measuring the photoinduced birefringence we prove that under certain conditions we can improve its parameters for pumping lasers at 532 nm which has great possible applications in the fields of polarization holography, optical storage of information e.t.c.

Acknowledgments: The authors are grateful for the funding from the European Union–NextGenerationEU, through the National Recovery and Resilience Plan of the Republic of Bulgaria, project BG-RRP-2.004-0002, "BiOrgaMCT". The financial support by the Bulgarian National Science Fund (BNSF) under contracts КП-06-Н88/2 and КП-06-МНФ/7 is gratefully acknowledged by E.S. Research equipment of Distributed Research Infrastructure INFRAMAT, part of Bulgarian National Roadmap for Research Infrastructures, supported by Bulgarian Ministry of Education and Science, was used in this investigation.

Pt-based metal dichalcogenides: synthesis, properties and applications

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Noble-metal dichalcogenides (NMDs) have attracted significant attention as new members of the 2D material family due to their layer-controllable metal-to-semiconductor transition. Additionally, NMDs have demonstrated outstanding performance in opto-electronics and photonics as photo detectors, transistors, sensors, super-capacitors, in biomedicine, etc. Their unique chemistry-characterized by highly anisotropic structural features, low-energy differences between polymorphs, controllable phase changes, and catalytic properties sets them apart from other transition-metal dichalcogenides.

Thermally Assisted Conversion (TAC), has been employed for the synthesis of 2D $PtSe_2$ and $PtTe_2$ nanolayers. This method is notable for its relatively low growth temperature and the production of polycrystalline films with nanometer-sized grains on regular glass substrates. Integration of $PtSe_2$ as transparent, conductive layers in Polymer Dispersed Liquid Crystal (PDLC) structures, functioning as near-infrared light shutters, has been demonstrated.

In addition, hetero structures based on $PtSe_2$ and other 2D materials were also created and analyzed using atomic force microscopy (AFM), Raman, photoluminescence (PL) and UV-VIS spectroscopy. These preliminary measurements show potential of the fabricated van der Waals heterostructures to be used in a wide field of applications.

Acknowledgement: This work was supported by the Bulgarian Science Fund under the grant number КП- 06-Н-68/1 and КП-06-МНФ/7. Authors acknowledge the bilateral projects between Consiglio Nazionale delle Ricerche and Bulgarian Academy of Sciences "Two-dimensional nanomaterials toward terahertz optoelectronic applications" (B83C23000610005) and bilateral agreement between the Bulgarian Academy of Sciences (BAS) and Taiwan National Council of Science and Technology (NSTC) grant no NTSC 114-2927-I-A49-503. 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.

Synthesis and Characterization of $MoSe_2$ and MoS_2 and their heterostructures

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In this study, we present the synthesis and characterization of $MoSe_2$ and MoS_2 thin films using distinct growth techniques, aimed at advancing their potential applications in sensing and optoelectronics. $MoSe_2$ films were synthesized through the Thermal Assisted Conversion (TAC) method using a Mo liquid precursor solution composed of MoO_3 dissolved in a 1:1 mixture of H_2O and H_2O_2, with NaCl as an additive. The precursor formulation enables controlled Mo delivery, while NaCl influences the crystallization and growth kinetics.

For MoS_2 synthesis, an innovative pre-treatment strategy of c-cut sapphire substrates using sodium sulfide (Na_2S) was employed to enhance the growth process. By dipping the substrate in a 2×10^{-2} M deionized water solution of Na_2S, in situ generation of hydrogen sulfide (H_2S) occurs through a reaction with atmospheric moisture. This approach provides an efficient catalyst for MoS_2 monolayer formation, offering a viable alternative to conventional Ar/H_2 gas mixtures commonly used in synthesis protocols. The method significantly improves film quality, uniformity, and growth rate, as confirmed by XPS, AFM, and Raman analyses. Furthermore, the Na_2S pre-treatment simplifies the synthesis process and enhances scalability, making it a cost-effective and practical approach for future technological applications.

The improved synthesis strategies enhance the control over film quality and growth parameters, offering practical advantages for industrial scalability and integration into optoelectronic and sensing applications. Additionally, this work lays the foundation for further exploration of substrate pre-treatment techniques and alternative precursor formulations, contributing to the broader advancement of 2D materials research and their practical deployment in next-generation technologies.

Acknowledgments: This work was supported by the Bulgarian Science Fund under the grant number КП- 06-COST/15 under the COST CA 20116 Action “European Network for Innovative and Advanced Epitaxy” (OPERA) and КП-06-МНФ/7. 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.

Search for non-resonant Higgs boson pair production in the bbγγ final state for CMS Run-2

Yu-Hsuan Chou[1*], Chia-Ming Kuo[1] on behalf of the CMS collaboration

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A search for non-resonant Higgs boson pair production in final states with two bottom quarks and two photons is presented, which is one of the most sensitive decay channels at the Large Hadron Collider. The gluon-gluon fusion and vector boson fusion processes are considered in this analysis. The H→bb decay provides a high statistical yield, while the H→γγ decay offers a significant signal-to-background discrimination. We can directly access trilinear self-coupling and the coupling between Higgs bosons and vector bosons. This analysis using Compact Muon Solenoid Run-2 data is improved by a factor of four compared to previous 2016 results, benefiting from the larger statistics and the analytical techniques. Limits on the cross-section are derived as a function of various coupling modifiers.

References:

[1] CMS collaboration, "Search for nonresonant Higgs boson pair production in final states with two bottom quarks and two photons in proton-proton collisions at

ABSTRACTS

POSTER PRESENTATIONS

Financial support by the Bulgarian National Science Fund
Project КП-06-МНФ/7

Poster Session: 17 July 2025
16.00 – 18.30 h

P1. Characterization of a hydrosensitive copolymer nanosized coatings for applications as active media in optical humidity sensing
Katerina Lazarova, Ketrin Pavlova, Martina Docheva, Silvia Bozhilova, Darinka Christova and Tsvetanka Babeva

P2. Design of a Novel Optical System Integrating a Holographic Quarter-Wave Plate for Laser Tracking Interferometer
Yu-Ta Chen, Fan-Hsi Hsu, Ting-Han Chen, Hung-Yu Chen

P3. High speed impact testing of composites with dynamic speckle analysis
Mikhail Levchenko, Elena Stoykova, Andrei Anisimov

P4. Biospeckle Analysis of pea seed germination using SS-OCT images following Hydro- and Carbon Nanotube Priming
Maryam Viqar, Violeta Madjarova, Elena Stoykova, Keehoon Hong

P5. Optimization of brilliant yellow thin films deposition for optical recording using poly(vinyl alcohol) and polyethylene glycol matrices
B. Blagoeva, L. Nedelchev, D. Nazarova, D. Dimov, E. Stoykova

P6. Speckle excitation by tensile loading for laser photometric defect detection
Branimir Ivanov, Elena Stoykova, Violeta Madjarova, Ginka Ivanova, Keehoon Hong

P7. Influence of Perchloroethylene treatment on the electrochemical behavior of household chimney soot for application as supercapacitator material
M. Petrov, T. Stankulov, L. Slavov, B. Karamanova, A Stoyanova

P8. Direct Detection of Faraday Phase Shift in Magneto-Optical Materials
Petar Kolev, Tinko Eftimov , Evdokiya Hikova, Petar Veselinov, Hristo Kisov and Georgi Dyankov

P9. Recording of polarization gratings through digital polarization holography on azopolymer thin films
Nataliya Berberova-Buhova, Georgi Mateev, Branimir Ivanov, Lian Nedelchev, Elena Stoykova, Kristina Borisova, Aleksandra Antonova, Dimana Nazarova

P10. Synthesis and Comprehensive Characterization of Submicron Tubular Inorganic Fibers for Gas Sensing Applications
B. Georgieva, B. S. Blagoev, K. Starbova, N. Starbov, K. Buchkov, V. Mehandzhiev, A. Paskaleva, D. Spasov, L. Slavov, I. Avramova, P. Tzvetkov

P11. Nanocomposite polymer electrolytes for dielectric applications: The effect of Graphene Oxide nanofiller
Todor E. Vlakhov, Georgi B. Hadjichristov, Angel D. Dimitrov, Yordan G. Marinov

P12. Nano-thin phospholipid Langmuir-Blodgett monolayer as a component in an impedimetric microdetector for Cadmium ions
Todor E. Vlakhov, Georgi B. Hadjichristov, George R. Ivanov, Yordan G. Marinov

P13. Epoxy composites with organoclay – structure and mechanical properties
Verislav Angelov

P14. Al-doped ZnO nanolayers for electro-optical applications
Stefani Bogoeva, Dimitrina Petrova, Vladimira Videva, Vera Marinova and Dimitre Dimitrov

P15. Antibacterial activity of ZnO and Al doped ZnO nanocoatings
Maria Stefanova, Dimitrina Petrova, Vladimira Videva, Dimitre Dimitrov, Nadia Todorova and Vera Marinova

P16. 2D van der Waals heterostructures: synthesis and characterization
Mila Krumova, Maria Martinova, Nikolay Minev, Blagovest Napoleonov, Vladimira Videva, Dimitre Dimitrov and Vera Marinova

P17. Synthesis of 2D WSe_2 Nanolayers via Ultraviolet/Ozone Pre-deposition Treatment
Vladimira Videva, Veronika Todorova, Irnik Dionisiev, DimitreDimitrov, Peter Rafailov, Velichka Strijkova, Ivalina Avramova and Vera Marinova

P18. Effect of UV-Ozone treatment on the optical and electrical properties of AZO thin films
D. Petrova, M. Stefanova, S. Bogoeva, B. Napoleonov, B. Blagoev, V. Videva, V. Marinova and D. Dimitrov

P19. Investigation of mechanical and optical behavior of graphene/$PtSe_2$ nanocomposites
Nikolay Minev, Blagovest Napoleonov, Vera Marinova, Tatyana Petrova, Apostol Apostolov

Characterization of a hydrosensitive copolymer nanosized coatings for applications as active media in optical humidity sensing

Katerina Lazarova[1*], Ketrin Pavlova[1*], Martina Docheva[1], Silvia Bozhilova[2], Darinka Christova[2] and Tsvetanka Babeva[1]

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In the present sudy a branched copolymers of poly(vinyl alcohol) comprising graft poly(N,N-dimethylacrylamide) side chains were synthesized and investigated for optical sensing applications. The mail goal was to compare two copolymers with different side chains regarding the response of thin-film coatings of the copolymers to environmental changes of the relative humidity (RH). For the deposition of the nanosized coating, ranging 150-200nm, a spin-coating method was applied. Full optical characterization was conducted as from measured reflectance spectra R of the samples an optical constants (refractive index n and absorption coefficients k) were calculated. The response of the coatings/films toward the change of humidity level was studied via spectrophotometric measurements of the samples when exposed to increasing or decreasing relative humidity from 5% to 95% RH and vice versa. The influence of the change in the humidity of the environment on the physical characteristics of the nanosized copolymer coatings was investigated - a change of the thickness and of the refractive index for each copolymer was found. In order to study the possibility for application in sensing devices, the percentage of hysteresis (H) of the hydrosensitive copolymer nanosized coatings was determined. The change of the color in CIE color space of the samples when exposed to different humidity level was determined. The possibility of using the developed PVA-*graft*-poly(N,N-dimethylacrylamide) copolymers for humidity detection is demonstrated and discused.

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Design of a Novel Optical System Integrating a Holographic Quarter-Wave Plate for Laser Tracking Interferometer

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With the continuous advancement of precision manufacturing and automation industries, the demand for accurate workpiece measurement has been steadily increasing. Laser tracking interferometers, which are capable of achieving nanometer-level precision, have become indispensable tools in aerospace, automotive manufacturing, and precision mechanical engineering. However, their measurement accuracy is often compromised by assembly errors associated with dual-axis rotation mechanisms and laser beam misalignment. Moreover, optical components employed in laser tracking interferometers—such as quarter-wave plates (QWPs)—are expensive to produce, require intricate fabrication processes, and contribute to bulky system configurations. To address these challenges, this study proposes a novel design for laser tracking interferometers aimed at mitigating the effects of assembly errors on overall measurement accuracy, as illustrated in *Fig. 1*. In addition, a newly developed holographic quarter-wave plate (HQWP), shown in *Fig. 2*, is introduced to overcome the cost and performance limitations of conventional QWPs. This HQWP employs a photopolymer-based recording material that offers advantages such as simple fabrication, low cost, and high diffraction efficiency.

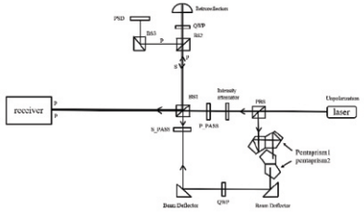

Fig.1. *Proposed novel laser tracking interferometers.*

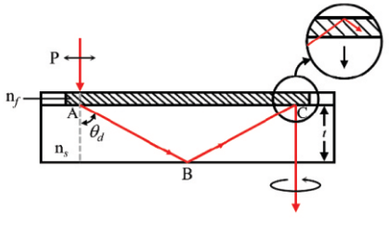

Fig. 2. *Structure design of holographic element.*

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High speed impact testing of composites with dynamic speckle analysis

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Digital Image Correlation (DIC) is a widely used approach in impact testing of composites, relying on retrieving the maximum correlation within pixel intensity subsets across two or more images to generate full-field displacement and strain maps. The accuracy of this method depends on the application of printed speckle patterns on the sample surface. However, in certain conditions - such as high temperatures - the printed speckle pattern may fail to adhere properly. In such cases, laser created speckle offers a viable alternative. However, for DIC, the mean speckle size must be sufficiently large to ensure accurate correlation, which is not always feasible. Dynamic laser speckle, as a pointwise highly sensitive to micro-changes of topology technique, does not face this limitation and effectively highlights areas with varying surface dynamics.

In this study, we explore the potential of dynamic speckle analysis for extracting valuable information from raw data captured by a high-speed camera operating at 100,000 fps during an impact testing experiment on composite plates. The experiment utilizes a gas gun for impact generation and laser illumination for speckle excitation. Due to the rapid surface changes of the sample, statistical processing with spatial averaging is employed to enhance data interpretation. The resulting output is a map illustrating the degree of change in recorded intensity over a specified time interval. Additionally, a cumulative parameter is introduced to track the overall evolution of the sample's surface dynamics over time.

Acknowledgments: This work was supported by COST Action CA21155 "Advanced Composites under HIgh STRAin raTEs loading: a route to certification-by-analysis" and by by the European Regional Development Fund under Research Innovation and Digitization for Smart Transformation program 2021-2027 under the Project BG16RFPR002-1.014-0006 National Centre of Excellence Mechatronics and Clean Technologies.

Biospeckle Analysis of pea seed germination using SS-OCT images following Hydro- and Carbon Nanotube Priming

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Fourier Domain Optical Coherence Tomography (FD-OCT) at near infrared region is an imaging modality that can provide not only three-dimensional tomographic images of biological object, but also give valuable data on influence of environmental factors on plants. These data are obtained via OCT speckle signal statistical processing obtained from OCT images of seeds that are subjected to various treatments. A pointwise intensity-based correlation approach was employed in this work to statistically assess varying activity levels within the seeds. The use of non-destructive seed evaluation techniques is fundamental in determining dormancy and germination, both of which significantly impact crop productivity. This intensity-based method enabled the visualization of activity not only across the axial scans but also along different depths by estimating correlation parameters. This is done through enface imaging owing to volumetric reconstruction capabilities performed by the OCT. The system used is a Swept-Source OCT (SS-OCT) with a Fourier Domain Mode Locking (FDML) laser source whose central wavelength is 1309 nm, bandwidth of 100 nm and sweeping frequency of 1.6 Mhz. Seeds were treated with water, carbon nanotubes, and left untreated as a control. The resulting activity maps effectively distinguished between the different treatment groups utilizing the intensity-based correlation method.

Acknowledgments: This work was supported by Institute of Information & Communications Technology Planning & Evaluation (IITP) grant funded by the Korea government (MSIT) (No. 2019-0-00001, Development of Holo-TV Core Technologies for Hologram Media Services) and by the European Regional Development Fund under Research Innovation and Digitization for Smart Transformation program 2021-2027 under the Project BG16RFPR002-1.014-0006 National Centre of Excellence Mechatronics and Clean Technologies.

Optimization of brilliant yellow thin films deposition for optical recording using poly(vinyl alcohol) and polyethylene glycol matrices

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The azo dye brilliant yellow (BY) is a promising medium for optical applications. To induce birefringence in BY, it is necessary that the layers deposited from it meet some requirements such as homogeneity, uniformity and appropriate thickness. In the present study, the deposition of thin layers of BY with a concentration of 10 wt% using two different polymer matrices is investigated. These are poly(vinyl alcohol), in short PVA and polyethylene glycol or PEG. A comparison of samples obtained by two deposition methods – drop-casting and spin coating – is also made. Finally, the maximal value of the photoinduced birefringence Δn_{max}, response time τ and time stability of the optical recording r upon irradiation of the azo dye with linearly polarized laser radiation are investigated. This experiment reveals the potential of brilliant yellow as a medium for polarization holographic recording.

Acknowledgments: The authors are grateful for the funding from the European Union–NextGenerationEU, through the National Recovery and Resilience Plan of the Republic of Bulgaria, project BG-RRP-2.004-0002, "BiOrgaMCT". The financial support by the Bulgarian National Science Fund (BNSF) under contracts КП-06-Н88/2 and КП-06-МНФ/7 is gratefully acknowledged by B.B. Research equipment of Distributed Research Infrastructure INFRAMAT, part of Bulgarian National Roadmap for Research Infrastructures, supported by Bulgarian Ministry of Education and Science was used in this investigation.

Speckle excitation by tensile loading for laser photometric defect detection

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Laser Speckle Photometry (LSP) is a full-field, non-destructive intensity-based technique that leverages the high sensitivity of speckle patterns to micro-scale changes in surface characteristics. The method requires a polarized laser light source, a beam expander, and a 2D optical sensor to form and record speckle patterns. The raw data consist of correlated in time images. Statistical processing is applied to analyze the evolution of speckle patterns across the tested sample. This evolution over time may result from processes occurring on the surface or within the bulk of the material, such as the case of paint drying or food quality assessment. In industrial inspection, dynamic speckle activity can be induced either by illuminating the sample with an additional laser source or by applying heat. The LSP measurements produces an activity map which is a contour representation of the chosen statistical parameter used to evaluate the speckle dynamics.

In this study, we investigated the application of LSP to rubber samples subjected to tension at varying tensile speeds. Specifically, we explored the detection of defects through dynamic speckle analysis at temporal and spatial averaging. Speckle excitation was achieved by stretching the sample over 30 s using a testing machine. The tensile speeds were varied from 1 mm/min to 20 mm/min, and efficiency of defect detection was estimated by comparing the built activity maps. We established that LSP had high sensitivity even at small tensile speeds as 1 mm/min when the extension of the upper border of the sample between two consecutive frames is less than a micrometer. We checked the LSP potential to detect a region which differs in its surface properties from the other parts of the sample.

Acknowledgments: This work was supported by Institute of Information & Communications Technology Planning & Evaluation (IITP) grant funded by the Korea government (MSIT) (No. 2019-0-00001, Development of Holo-TV Core Technologies for Hologram Media Services) and by the European Regional Development Fund under Research Innovation and Digitization for Smart Transformation program 2021-2027 under the Project BG16RFPR002-1.014-0006 National Centre of Excellence Mechatronics and Clean Technologies.

Influence of Perchloroethylene treatment on the electrochemical behavior of household chimney soot for application as supercapacitator material

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A study was conducted to determine to what extent the treatment with perchloroethylene would positively affect the properties of an otherwise waste product, such as chimney soot, related to its potential application as a supercapacitive material. Perchloroethylene is a widely used chemical in dry cleaning, it is a broad-spectrum solvent. Various electrochemical tests are presented allowing to evaluate the influence of the used modification/cleaning agent, comparing the results with those obtained after other types of treatments of the same type of material, as well as with those for established standard products. The characterization of the obtained material by Infrared and Raman spectroscopy allows to trace the structural changes that occurred, both in terms of the carbon component and in terms of the characteristic organic functional groups.

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Direct Detection of Faraday Phase Shift in Magneto-Optical Materials

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Magneto-optical materials are widely used for magnetic field measurement. Their applications is based on the linear magneto-optical effect (Faraday effect), where the rotation of the polarization angle of light propagating in the magneto-optical material is induced by an external magnetic field. The detection of Faraday rotation is typically based on its encoding in spectral or amplitude variations. However, this approach reduces the accuracy of magnetic field measurements because it does not allow a reference signal to be created that effectively accounts for changes caused by external conditions.

In this study we demonstrated a direct detection of a phase shift caused solely by the Faraday rotation. For this purpose, we applied the channeled polarimetry method. This is very different from the polarimetric detection methods known to date, since channeled polarimetry provides information about the phase shift, as do interferometric methods. Channeled polarimetry allows polarization information to be obtained from the analysis of the spectral domain.

Hire in we report experimental results for magnetic field /current detection using the channeled polarimetry method. The method directly detects the spectral dependence of the phase shift in the absence of a magnetic field, thereby serving as a reference signal against which the real-time measurement is made.

The achieved measurement accuracy of phase shift induced by the Faraday rotation was higher than 0.01 deg. The issue of temperature stability was addressed in the present study. Further investigation is required to ascertain whether the method accounts for the temperature dependence of the Verdet coefficient. Given that its influence is estimated to be approximately 1.5% over a hundred-degree temperature range, it is imperative to enhance the accuracy of temperature control.

The efficient solutions offered by spectrally channeled polarimetry applied to optical magnetic/current sensors would enable the widespread commercialization of these sensors.

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Recording of polarization gratings through digital polarization holography on azopolymer thin films

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Polarization-based diffraction gratings with various structural profiles were created for application with a reflective phase-type spatial light modulator (SLM). By employing a digital polarization holography setup—consisting of an SLM and two quarter-wave plates—spatially varying polarization gratings were recorded onto thin films made from the azopolymer PAZO (poly[1-[4-(3-carboxy-4-hydroxyphenylazo)benzene sulfonamido]-1,2-ethanediyl, sodium salt]). Both one-dimensional and two-dimensional polarization gratings with different shape parameters were inscribed, and the dynamic behavior of the diffraction orders was monitored in real time during the recording process. The resulting polarization gratings were examined using atomic force microscopy (AFM) and polarization optical microscopy.

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Synthesis and Comprehensive Characterization of Submicron Tubular Inorganic Fibers for Gas Sensing Applications

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This work presents a method for fabricating hollow metal-oxide fibers by combining electrospinning and atomic layer deposition (ALD). These techniques were selected for their ability to produce well-controlled, high-aspect-ratio nanostructures. While similar methods have been reported before, our approach introduces a modified processing sequence that improves the fibers' stoichiometry and crystallinity. The fabrication begins with electrospinning of polyvinyl alcohol (PVA) fibers, which serve as a sacrificial template. These fibers are then coated with aluminum oxide (Al_2O_3) using low-temperature ALD at 60 °C, a temperature below the PVA melting point. Trimethylaluminum (TMA) and deionized water (DI H_2O) are employed as precursors, with a pulse duration of 300 ms and a five-second nitrogen purge (99.999% purity) between each pulse. The polymer core was subsequently removed via two methods: (1) thermal annealing in air using a Carbolite horizontal tube furnace with a Eurotherm 3508 controller, following a heating regime of 5 °C/min up to 500 °C, a 24-hour dwell at 500 °C, and cooling at the same rate; or (2) dissolution in DI H_2O at 30 °C, 50 °C, or 80 °C, for 30, 60, or 120 minutes. This step yielded hollow Al_2O_3 fiber structures. Thermal atomic layer deposition (ALD) was employed to deposit functional metal-oxide layers, including pure ZnO and ZnO doped with Co, Fe, or Ni, onto the hollow fibers. The removal of the polymer core enabled the use of elevated deposition temperatures within the ALD growth window, thereby enhancing the film stoichiometry and crystallinity. Diethylzinc (DEZ) and deionized water (DI H_2O) served as precursors for ZnO, while cobaltocene, ferrocene, nickelocene, and ozone were utilized for the doped metal oxides. The deposition parameters – pulse duration, purge time, and substrate temperature, were systematically optimized to improve the film's uniformity and quality. The resulting hollow fiber structures were characterized using scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDX), X-ray diffraction (XRD), and X-ray photoelectron spectroscopy (XPS); their structural integrity and compositional precision was thus confirmed.

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Nanocomposite polymer electrolytes for dielectric applications: The effect of Graphene Oxide nanofiller

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Given their considerable potential as electrolytic materials for miniaturized energy storage systems and advanced dielectric applications, we investigated ion-conducting polymer nanocomposite electrolytes, specifically Sodium metaperiodate ($NaIO_4$)-complexed poly(ethylene oxide) (PEO)/polyvinylpyrrolidone (PVP) polymer blends doped with graphene oxide (GO) nanosheets. The GO monolayers used exhibited an average lateral size of approximately 5 μm and a thickness of 2 nm. The polymer matrix comprised a PEO:PVP weight ratio of 70:30, with 10 wt.% $NaIO_4$ serving as the ionic dopant. GO nanosheets were incorporated at varying concentrations of 0, 0.2, 0.4, and 0.6 wt.%.

Thin films of the resulting nanocomposites (approximately 150 μm in thickness) were produced by solution casting technique. Their ion transport and dielectric response were characterized using complex impedance and dielectric spectroscopy across a broad frequency spectrum (0.1 Hz to 1 MHz) under an alternating current (AC) electric field applied transversely to the films. Key electrical parameters, including ionic conductivity, complex dielectric permittivity, dielectric loss, and AC conductivity, were analyzed as functions of GO concentration. The influence of GO nanofillers on the dielectric and transport behavior was systematically studied.

A notable enhancement in dielectric performance was observed, with the relative permittivity of the nanocomposite containing 0.6 wt.% GO increasing by up to a factor of 60 compared to the undoped PEO/PVP/$NaIO_4$ system. These findings underscore the potential of GO-doped PEO/PVP/$NaIO_4$ nanocomposites as advanced materials for solid-state ionic devices and next-generation energy storage technologies.

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Nano-thin phospholipid Langmuir-Blodgett monolayer as a component in an impedimetric microdetector for Cadmium ions

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We present a study on the application of molecular monolayers of the phospholipid dipalmitoyl-phosphatidylethanolamine (DPPE), fabricated via the Langmuir–Blodgett (LB) technique, for the sensitive physicochemical detection of cadmium ions (Cd^{2+}). DPPE LB films, with a nominal thickness of approximately 6 nm, were deposited onto planar interdigitated electrode structures. Complex electrical impedance spectroscopy (EIS), conducted over a frequency range of 0.1 Hz to 3 MHz, was employed to investigate the films' response to Cd^{2+} ions, utilizing a micropipette drop method for electrolyte application. Impedimetric detection is based on the changes in electrical impedance of the LB film that acts as the active sensing element of the prepared microsensor. Electrostatic interaction between Cd^{2+} ions and the phospholipid head groups in the DPPE LB monolayer induce alterations in the dielectric and conductive properties of the film. This change can be measured and correlated with the concentration of Cd^{2+} ions in solutions, e.g., aqueous media.

The experimental results show that the integration of phospholipid LB films with advanced measurement strategies – specifically, in-plane EIS, interdigitated electrodes, and localized liquid-phase sampling – yields a sensitive and robust platform for cadmium ion detection. Notably, the system exhibited detection capabilities down to concentrations as low as 1 μg/L.The use of DPPE LB monolayers offers a promising route for the development of compact, microscale sensors for Cd^{2+} ion monitoring. Through appropriate selection of phospholipid materials and structural optimization, the sensor's sensitivity and selectivity toward Cd^{2+} can be enhanced, minimizing interference from other metal ions. Such sensors hold potential for deployment in environmental monitoring (e.g., detection of cadmium in water sources), industrial process control (e.g., monitoring cadmium in effluents), and bioanalytical applications (e.g., studying Cd^{2+} interactions in biological systems).

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Epoxy composites with organoclay – structure and mechanical properties

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The present research aims to obtain epoxy composites with organoclay filler and to investigate some of their mechanical properties.
Epoxy composites were obtained by the method of "in situ" polymerization in the Laboratory "OLEM" at Institute of Mechanics-BAS and the mechanical characteristics (hardness and Young's modulus) were tested on a TIRA TEST machine. Epoxy composites with fillers - Cl-20A, Cl-30B, 1.44 P, 1.28 E, 1.31 PS have worse mechanical properties than neat epoxy resin. Composites with organoclay 1.34 TCN show slightly better mechanical properties, compared to pure epoxy resin.

The X-ray diffraction (XRD) measurements were performed on the organo-clay epoxy composites. The X-ray diffractograms were obtained using Bruker D8 Advance diffractometer with Cu Kα radiation (λ = 0.15418 nm) and LynxEye detector. Using the peak position (2θ) in the XRD patterns, the inter layer space was calculated through the Bragg's law: $n\lambda = 2d \sin\theta$, where λ is the wavelength of the incident wave (λ = 0.15418 nm), d is the spacing between the layers of organo-clay in the composites.

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Al-doped ZnO nanolayers for electro-optical applications

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Aluminum-doped zinc oxide (AZO) thin films are promising candidates for next-generation display technologies due to their excellent electrical and optical properties. This work presents a comprehensive investigation of AZO thin films fabricated via atomic layer deposition (ALD) for application in liquid crystal devices (LCDs) and Polymer Dispersed Liquid crystals (PDLC) structures. The research encompasses three key aspects: (1) optimizing the ALD process to achieve high-quality AZO films with desired properties; (2) exploring the impact of post-deposition treatments, such as UV-ozone exposure and thermal annealing, on film characteristics, including crystallinity and oxygen vacancy concentration; and (3) demonstrating the multifunctional capabilities of AZO by utilizing it as both an electrode and alignment layer in a vertically aligned LCD. The ALD technique enabled precise control over the deposition process and yielded AZO films with a preferred (100) crystallographic orientation. Post-deposition treatments were found to significantly affect film properties, offering a route to further optimization. The AZO layer, with its low surface free energy and after mechanical buffing, successfully induced vertical alignment of the liquid crystals. The resulting AZO-based LCD exhibited competitive electro-optical performance, highlighting the potential of AZO to replace indium tin oxide (ITO) in future display technologies. This research provides valuable insights into the fabrication, modification, and application of AZO thin films, paving the way for their integration into advanced and ITO-free devices.

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Antibacterial activity of ZnO and Al doped ZnO nanocoatings

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This study investigates the antibacterial functionality of thin coatings composed of zinc oxide (ZnO) and aluminum-doped zinc oxide (AZO). These metal oxide coatings were deposited using atomic layer deposition (ALD) technology. ZnO is an n-type semiconductor with a band gap of approximately 3.3 eV, enabling UV absorption and the generation of reactive oxygen species (ROS) with antibacterial properties. Additionally, ZnO exhibits several mechanisms that contribute to its antibacterial activity, including the release of Zn^{2+} ions, morphological damage to bacterial cell membranes, and influence on bacterial adhesion through surface charge and energy. However, ZnO's antibacterial activity is limited in the absence of light. This study characterized the structural, morphological, and optical properties of ZnO and AZO coatings using techniques such as atomic force microscopy (AFM), UV-Vis spectroscopy, fluorescence spectroscopy, and contact angle measurements. The antibacterial activity against *Escherichia coli* was evaluated under both dark and ultraviolet illumination conditions. AZO nanocoatings, with a band gap of 3.35 eV, demonstrated enhanced antibacterial activity compared to ZnO. This improvement is attributed to increased UV sensitivity and higher hydrophilicity. These findings suggest that ZnO and AZO nanocoatings hold promise as effective antimicrobial agents in various applications.

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2D van der Waals heterostructures: synthesis and characterization

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Two-dimensional (2D) materials, particularly transition metal dichalcogenides (TMDCs) such as tungsten diselenide (WSe_2) and platinum diselenide ($PtSe_2$), have emerged as promising candidates for next-generation photonic, electronic, and optoelectronic devices due to their unique thickness-dependent properties and strong light–matter interactions. WSe_2, with its direct bandgap in the monolayer form and pronounced excitonic effects, offers exceptional optical and electronic performance, while $PtSe_2$ exhibits a semimetal-to-semiconductor transition at reduced thickness, further expanding its applicability. In this work, we investigate the structural, optical, and interfacial properties of hybrid 2D systems, focusing on monolayer and few-layer WSe_2 and vertical heterostructures composed of $PtSe_2$ nanolayers with an intercalated graphane monolayer. Using a combination of Raman and photoluminescence spectroscopy, atomic force microscopy, and interface-sensitive analysis, we explore how layer number and interlayer coupling affect excitonic behavior, valley polarization, and the overall electronic response. Our findings reveal strong interfacial interactions in the $PtSe_2$/graphane/$PtSe_2$ heterostructure and highlight the potential of WSe_2-integrated systems for use in compact photonic technologies, including light emitters, modulators, and photodetectors operating in the visible to near-infrared spectral range.

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Synthesis of 2D WSe_2 Nanolayers via Ultraviolet/Ozone Pre-deposition Treatment

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Tungsten diselenide (WSe_2) is a semiconducting material in both bulk and monolayer form. Bulk WSe_2 has an indirect band gap of 1.2 eV which changes to a direct band gap of 1.65 eV in the monolayer material [1]. The material differs from other TMDs as it has relatively smaller effective electron and hole masses and is ambipolar [2]. Due to the ambipolar properties of WSe_2, the material can be used as both a n-type or a p-type charge carrier material, depending on the contact material [3]. Here we present the synthesis details of WSe_2 nanolayers using one-step thermally-assisted selenization of pre-deposited tungsten (W) film. An ultraviolet ozone treatment was applied to modify the precursor film from W to WO_3, which leads to larger lateral size and improved crystallinity of WSe_2 flakes, confirmed by atomic force microscopy (AFM) and Raman analysis. X-ray photoelectron spectroscopy (XPS) reveal formation of WO_3 after the UV-ozone treatment and improved stoichiometry od WSe_2. The samples were further analyzed and compared with UV–Visible (UV-vis) spectroscopy and photoluminescence (PL).

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Effect of UV-Ozone treatment on the optical and electrical properties of AZO thin films

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The integration of highly transparent and conductive thin films plays an important role for the advance of next generation technologies. Here we report about the deposition of Aluminium-Doped Zinc oxide (AZO) thin films on sapphire substrates (AZO/Sapphire) by using Atomic Layer Deposition (ALD) method and the influence of post-deposition UV–ozone treatment on the films' properties. The performed X-ray diffraction measurements (XRD) revealed a polycrystalline wurtzite structure with a preferable (100) orientation. The influence of UV–Ozone treatment on the transmission spectrum in the range of wavelengths from 200 nm to 2000 nm was moreover investigated. The photoluminescence spectra were obtained with excitation wavelengths from 300 nm to 530 nm. It was found that UV–Ozone treatment significantly increases the intensity of the emission, causing a shift of about 48 nm to the high-energy part of the photoluminescence spectrum when excited with a wavelength of 359 nm. The influence of UV–Ozone treatment on the electrical parameters of AZO/Sapphire was determined using the Hall effect by applying a magnetic field with an induction of 0.67 T. It is found that the UV–Ozone treatment improve the electrical and optical properties while did not cause significant changes to the polycrystalline structure and surface morphology of the AZO films which opens great potential for practical applicationя.

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Investigation of mechanical and optical behavior of graphene/$PtSe_2$ nanocomposites

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Graphene and transition metal dichalcogenides (TMDs) such as $PtSe_2$ have emerged as promising materials for next-generation electronic and optoelectronic applications due to their unique mechanical, electrical, and optical properties. Graphene offers exceptional mechanical strength and high electrical conductivity, while $PtSe_2$, a semiconducting TMD, provides strong light–matter interactions and tunable bandgap properties. This study explores the mechanical and optical behavior of Graphene/$PtSe_2$ heterostructures. A two-dimensional stress-function method is employed to analytically model stress transfer in a three-layered Graphene/$PtSe_2$/PET structure subjected to uniaxial mechanical loading. The resulting analytical expressions for axial, peel, and shear stresses are presented graphically in the structure's layers. The stress distribution is shown to be highly sensitive to geometric parameters (layer thickness and length), material properties, and the magnitude of the applied load. To complement the theoretical analysis, Graphene/$PtSe_2$ heterostructures were fabricated by transferring chemical vapor deposition (CVD)-grown graphene onto CVD-grown $PtSe_2$. The resulting structures were characterized using Raman spectroscopy, atomic force microscopy (AFM), UV-Vis spectroscopy, and X-ray photoelectron spectroscopy (XPS). XPS confirmed the formation of 2D $PtSe_2$, while Raman analysis verified the successful assembly of the Graphene/$PtSe_2$ heterostructure. These findings provide valuable insights into the design of mechanically robust and optically active 2D heterostructures for flexible electronic systems.

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