WARSAW UNIVERSITY OF TECHNOLOGY
Faculty of Electronics and Information Technology

Institute of Microelectronics and Optoelectronics

annual report 2021

WARSAW UNIVERSITY OF TECHNOLOGY
Faculty of Electronics and Information Technology

Institute of Microelectronics and Optoelectronics

annual report 2021

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From the Director

This Annual Report summarizes the activities of the Institute of Microelectronics and Optoelectronics (IMiO) in the year 2021, with particular attention given to its research and educational potential. The Institute is a part of the Faculty of Electronics and Information Technology, the biggest Faculty of the Warsaw University of Technology. Among six institutes constituting the Faculty, the Institute of Microelectronics and Optoelectronics is the one most focused on advanced technologies of modern electronics and photonics.

It should be noted that the Institute has its roots deep in history. Although formally founded in 1970, it evolved from the Chair of Radio Engineering established in 1929 by Professor Janusz Groszkowski, who is often called "the father of Polish electronics." The Institute is linked with the beginnings of the Faculty of Electronics and Information Technology not only by the person of Prof. Groszkowski, who worked in IMiO until the end of his career, but also by its location – part of the Institute is situated in the Building of Radio Engineering at the Warsaw University of Technology – the main campus where the Faculty started its operation in 1951 (as the Faculty of Communications). Currently, the Institute's Technology Centre is located there. It includes laboratories specializing in silicon processing (clean-room), hybrid technologies and assembly techniques, fiber optics and integrated optoelectronics, laser optoelectronics, and characterization of new electronic and photonic materials. All 11 high-tech laboratories in the field of electronic and photonic technologies, established as a result of investments conducted in recent years within the Innovative Economy Operational Program framework, have reached their full operational capacity and are extensively used to conduct advanced research and provide research services.

The current research activities of the Institute are focused on the fields of microelectronics, nanoelectronics, and photonics. These include, in particular: VLSI circuits, design of ASICS's and electronic circuits, microsystems, microelectronic and nanoelectronic semiconductor devices (among others based on Si and wide-band semiconductors), ultra-thin films, hybrid circuits (e.g., microwave, optoelectronic), photonic systems (including design of ASPIC's circuits), sensors, lasers, active photonic materials, fiber optics and integrated photonics, nanophotonics, metamaterials, plasmonics, topological photonics, photovoltaics, and image processing. It is worth noting that the research activities of the Institute include modelling, CAD, manufacturing, and versatile characterization.

In teaching, the Institute meets the challenges imposed by the development of modern technology and information society. The educational offer (at all levels – B.Sc., M.Sc., and Ph.D.) corresponds to the main fields of advanced electronics and photonics and, simultaneously, the primary research expertise of the Institute. The Institute's involvement in distance learning studies of Electronics and Telecommunications is also worth mentioning, mostly postgraduate studies in the domain of tools and techniques of virtual education that began in 2004. Several student laboratories in electronics, microelectronics, and photonics, located in the recently expanded wings of the Faculty building, have reached their full operational capacity in 2017, improving considerably the quality of the education offered by IMiO.

In the year 2021, our staff authored and co-authored 84 publications, including 63 papers in scientific journals from the JCR list, and 6 patent applications. Moreover, the Institute's expertise and infrastructure made it possible to involve in numerous international and domestic projects.

I want to thank all the colleagues working at the Institute of Microelectronics and Optoelectronic for their constant commitment and effort to make the Institute a unique place to be. Without our collective achievements, the Institute could not be what it is today.

Professor Jan Szmidt

CONTENTS

1. GENERAL INFORMATION

1.1. Board of Directors

Director of the Institute

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1.2. Organisation of the Institute and Areas of its Activities

The Institute of Microelectronics and Optoelectronics is a part of the Faculty of Electronics and Information Technology – the largest among all units of Warsaw University of Technology. At present, the Institute consists of four divisions with primary competence covering the significant areas of modern electronics and photonics. These are:

- Microelectronics and Nanoelectronics Devices Division;
- VLSI Engineering and Design Automation Division;
- Microsystem and Electronic Material Technology Division;
- Optoelectronics Division.

During almost fifty years of research, the Institute has built and developed its competence in:

- modelling of physical effects in modern semiconductor devices;
- advanced technologies of silicon-based microelectronics and photonics,
- non-standard dielectric layer deposition techniques;
- characterization of electronic materials and devices;
- designing and development of application specific VLSI circuits;
- design and technology of thick-film hybrid circuits, fabrication of thick-film microsystems;
- modelling and design of sensors and optical-waveguide microsystems;
- laser physics and laser technique;
- optical spectroscopy of solids;
- fiber-optic photonics, including fiber-optic communication, sensing as well as design and development of fiber lasers and amplifiers;
- design and development of photonic integrated circuits (PICs);
- 2-D and 3-D image processing systems, including monitoring systems;
- photovoltaics;
- plasmonics;
- microwaves, microwave photonics, and microwave measurement techniques;
- new materials for high-temperature, high-power, and high-frequency electronics;
- new materials and structures for modern photonics.

The research activity is supported by a number of projects financed by the National Science Centre and National Centre for Research and Development, projects funded within EU Framework Programmes, as well as industry-funded.
The results are systematically published in a number of papers submitted to prestigious international scientific journals and presented at national and international conferences.

In parallel to scientific activity also the didactic offer of the Institute has been recently expanded with completely new specializations: "Electronics and Photonics" (for first-degree education) and "Integrated Electronics and Photonics Systems" (for second-degree education), which have been developed within the framework of the project "NERW PW Science-Education-Development-Cooperation" financed from Axis III Higher Education for the Economy and Development of the Operational Programme Science Education Development 2014–2020.

1.3. Microelectronics and Nanoelectronics Devices Division

The research carried out in the Microelectronics and Nanoelectronics Devices Division falls into three main areas: technology, diagnostics, modelling of semiconductor structures, and applications of microcontrollers.

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Lidia Łukasiak, Ph.D., D.Sc.	Professor
Jakub Jasiński, Ph.D.	Assistant Professor
Jarosław Judek, Ph.D., D.Sc.	Research Assistant Professor
Konrad Kiełbasiński, Ph.D.	Assistant Professor
Andrzej Mazurak, Ph.D.	Assistant Professor
Sławomir Szostak, Ph.D.	Assistant Professor
Jakub Walczak, Ph.D.	Senior Lecturer
Agnieszka Zaręba, Ph.D.	Senior Lecturer

Junior academic staff

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Mirosław Puźniak, M.Sc.	Ph.D. Student
Yevgen Syryanyy, M.Sc.	Ph.D. Student

Technical and administrative staff

Witold Ciemiewski
Kazimierz Dalbiak
Krzysztof Krogulski

To name a few examples of its research topics:

- Fabrication of novel semiconductor, dielectric and conductive materials, including amorphous and transparent semiconductors and oxides, as well as high-k dielectric layers employing magnetron sputtering, ALD, or plasma techniques;
- Electrical (bulk properties, interface properties, contact properties, DC and high-frequency range, pulse measurements, charge-pumping) and structural characterization (surface properties, cross-section, chemical composition, and topography) of fabricated materials and periodic structures;
- Optimization of electrical and optical properties of fabricated materials using Design-of-Experiments (DoE) method to obtain tailored properties (transparency, reflection, etc.) of obtained layers that can be used in novel nanophotonic structures which possess tailorable and dynamically controllable spectral and angular optical properties;
- Integration and studies of two-dimensional (2D) and nanocrystalline materials in novel nanoelectronic and photonic devices;
- Design, modeling, and fabrication of nanophotonic periodic and metamaterial structures in thin- and ultra-thin regime (primarily planar hyperbolic metamaterials) based on novel semiconductor, dielectric, and conductive materials;
- Design and assembly of dedicated measurement tools, power supplies, and embedded systems with the integrated optoelectronic and photonic devices; SMD assembly and reliability tests;

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- Design autonomous nodes of wireless sensor networks such as smart mesh, smart dust, and IoT, using energy-harvesting technology;
- Hardware solutions of the problems with wireless short-range and long-range communication based on technologies and standards (NFC, HDX, FDX, EPC, Bluetooth, SubGHz, WiFi, GSM, ZigBee, and others in the 802.15.4 standard);
- Design, assembly, and programming customized, precise laboratory measurement devices;
- Wear-out and degradation processes in MOS/MIS structures and devices (breakdown of dielectrics layers, hot carriers effects, radiation damage effects);
- Advanced design and modeling of semiconductor and photonic structures using in-house software development capabilities based on well-established models of electromagnetic field interaction with matter;
- Transport mechanisms and quantum effects in MOS/MIS structures (transistors, memories, resonance, and tunnel diodes) with ultra-thin dielectric materials.

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1.4. VLSI Engineering and Design Automation Division

The research carried out in the division falls into several main areas: development of IC design methodologies and tools, design of digital and analog integrated circuits for nonstandard demanding applications, investigations of new devices and circuits for future generations of microelectronic systems.

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Zbigniew Jaworski, Ph.D.	Assistant Professor
Dominik Kasprowicz, Ph.D.	Assistant Professor
Arkadiusz Łuczyk, Ph.D.	Assistant Professor
Krzysztof Siwiec, Ph.D.	Assistant Professor
Andrzej Wielgus, Ph.D.	Assistant Professor
Marek Niewiński, Ph.D.	Senior Lecturer
Adam Wojtasik, Ph.D.	Senior Lecturer

Junior academic staff

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Adam Borkowski, M.Sc.	Ph.D. Student
Bartosz Dec, M.Sc.	Assistant
Marika Grochowska, M.Sc.	Ph.D. Student
Paweł Pieńczuk, M.Sc.	Ph.D. Student
Daniel Pietroń, M.Sc.	Ph.D. Student
Łukasz Wiechowski, M.Sc.	Ph.D. Student

Technical and administrative staff

Stanisław Jeszka, M.Sc.
Marcin Ludwiniak, M.Sc.
Elżbieta Piwowarska, Ph.D.
Kamil Stępniewski, M.Sc.

Current research projects in the Division include:

- methodologies of integrated circuit design for manufacturability: application of statistical process and device simulation in IC design, investigations of spatial on-chip correlation of random process disturbances, analysis of layout sensitivity to spot defects;
- development of CAD tools for integrated circuit design and verification, with special emphasis on analog full custom ASICs design;
- design of digital, analog and mixed signal VLSI circuits for special applications such as microprocessors, Global Navigation Satellite Systems, innovative AD converters, data processing in physical experiments and medical equipment, RF front ends for wireless data transmission etc.;
- modelling and control of leakage currents in nanometer digital circuits;
- investigations and development of new VESTIC microelectronic technology.

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1.5. Electronic Materials and Microsystem Technology Division

The research activity of the Division concentrates on optoelectronics (e.g., measuring systems using fiber optic sensors), and hybrid technologies and the development of wide bandgap semiconductor technology in the design, modelling and manufacturing of microelectronic devices operating at high temperatures, including power semiconductor devices. Fundamental and applied research are carried out. Research groups are organised for defined tasks.

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Michał Borecki, Ph.D., D.Sc.	Professor
Ryszard Kisiel, Ph.D., D.Sc.	Professor
Mateusz Śmietana, Ph.D., D.Sc.	Professor
Marcin Koba, Ph.D, D.Sc.	Assistant Professor
Piotr Firek, Ph.D.	Assistant Professor
Monika Janik, Ph.D.	Assistant Professor
Jerzy Kalenik, Ph.D.	Assistant Professor
Konrad Kiełbasiński, Ph.D.	Assistant Professor
Krystian Król, Ph.D.	Assistant Professor
Aleksander Werbowy, Ph.D.	Assistant Professor

Junior academic staff

Dariusz Burnat, M.Sc.	Ph.D. Student
Piotr Ciszewski, M.Sc.	Ph.D. Student
Tomasz Gabler, M.Sc.	Ph.D. Student
Maciej Kamiński, M.Sc.	Ph.D. Student, Assistant
Kinga Kondracka, M.Sc.	Ph.D. Student
Norbert Kwietniewski, M.Sc.	Research Assistant
Katarzyna Lechowicz, M.Sc.	Ph.D. Student, Constructor
Agnieszka Martychowiec, M.Sc.	Ph.D. Student, Constructor
Emil Pituła, M.Sc.	Ph.D. Student, Constructor
Oskar Sadowski, M.Sc.	Ph.D. Student
Krzysztof Wilczyński, M.Sc	Ph.D. Student

Science, technical and administrative staff

Ryszard Biaduń
Aleksander Nawrat, Ph.D., D.Sc.
Bartłomiej Stonio, M.Sc.
Jakub Warszewski, M.Sc.

The main research areas are as follows:

- the use of graphene in the design of photodetectors for the far-infrared range with the electrical and optical characterization of graphene produced on different substrates, or a transferred onto the substrate;
- design, modelling, fabrication and characterization visible-blind UV photodetectors and radiation detectors based on wide bandgap semiconductors and heterostructures;
- the design, modelling, fabrication and characterization of power devices based on silicon carbide (SiC) technology including high voltage PiN diodes;
- the development of electrical characterization methods for the determination of energy distribution of traps in MOS and junction devices;
- designing, modelling and fabrication of microelectronic and optoelectronic devices using transparent dielectric and conductive oxides;
- fabrication and characterization of high-k dielectric layers;
- fabrication and investigation of the following optoelectronic devices: integrated passive and active light wave guiding structures (modulators, bistable switches etc.) and fibre optic sensors;

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- computer engineering for fibre optics;
- new Surface Mount Technologies (SMT) on rigid, semi-rigid and fully flexible printed circuit boards (PCBs);
- application of thin and thick film technology in hybrid devices and thick film sensors fabrication;
- investigation of the electronic structure, stability and optical properties of amorphous silicon and its devices (thin film transistors, solar cells, etc.);
- design, fabrication and characterization of multi-junction photovoltaic cells with high energy efficiency;
- design and monitoring of photovoltaic systems, strategy for development of photovoltaics;
- electronic packaging technology including power devices;
- plasma deposition of nanocrystalline diamond (NCD), diamond-like carbon (DLC) thin films and their application in fibre optic and waveguide sensing structures;
- development of state-of-the-art power supplies and advanced power electronics for renewable energy conversion and storage, e-mobility, electric drives and vehicles, smart buildings, smart grids, smart city and military applications based on silicon carbide and gallium nitride power devices.

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1.6. Optoelectronics Division

The main activity of the Optoelectronics Division is concentrated on research and education in all major areas of optoelectronics. This covers, in particular, the fields of laser physics and laser technique, laser spectroscopy, fiber-optic communication and sensing, microwave photonics, 2-D and 3-D image processing, photovoltaics, as well as integrated photonics (including photonic integrated circuits). In all of these fields the Optoelectronic Division offers top-level research expertise of the staff complemented with state-of-the-art research laboratories.

Head of the Division

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Marcin Kaczkan, Ph.D. D.Sc.	Assistant Professor
Muhammad Ali Butt, Ph.D.	Research Assistant Professor
Bartosz Fetliński, Ph.D.	Research Assistant Professor
Piotr Garbat, Ph.D.	Assistant Professor
Anna Jusza, Ph.D.	Assistant Professor
Andrzej Kaźmierczak, Ph.D,	Research Assistant Professor
Agnieszka Mossakowska- -Wyszyńska, Ph.D.	Assistant Professor
Jerzy Piotrowski, Ph.D.	Assistant Professor
Stanisław Stopiński, Ph.D.	Assistant Professor
Anna Tyszka-Zawadzka, Ph.D.	Assistant Professor
Piotr Warda, Ph.D.	Assistant Professor
Piotr Witoński, Ph.D.	Assistant Professor
Krzysztof Madziar, Ph.D.	Senior Lecturer
Marek Sutkowski, Ph.D.	Senior Lecturer
Agnieszka Szymańska, Ph.D.	Senior Lecturer

Junior academic staff

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Dawid Budnicki, M.Sc.	Ph.D. Student
Aleksandra Dzieniszewska, M.Sc.	Ph.D. Student
Bartosz Janaszek, M.Sc.	Ph.D. Student, Research Assistant
Marcin Kieliszczyk, M.Sc.	Ph.D. Student, Research Assistant
Marcin Kowalczyk, M.Sc.	Ph.D. Student
Małgorzata Kuklińska, M.Sc.	Ph.D. Student
Filip Łabaj, M.Sc.	Ph.D. StudentAndrzej
Połatyński, M.Sc.	Ph.D. Student
Mateusz Słowikowski, M.Sc.	Ph.D. Student

Technical and administrative staff

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Maciej Juźwik, M.Sc.
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Maciej Szymkowski, M.Sc.
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The academic staff of the Division provides lectures in photonics fundamentals, laser physics and laser technique, laser spectroscopy, integrated optoelectronics, digital image processing, fiber-optic and microwave photonics and photovoltaics not only to the students of the Faculty of Electronics and Information Technology, but also supporting Faculty of Physics and Faculty of Mechatronics. The lectures are provided in Polish and/or English and are accompanied by top-level laboratory classes.

The main research topics of the Optoelectronic Division covers:

- photonic integrated circuits for applications in telecom, datacom and sensing;

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- design and development of solid state lasers and amplifiers (especially fiber lasers and amplifiers);
- new materials for optoelectronics, which includes spectroscopic investigations of novel rare-earth doped crystals and glasses emitting in UV-VIS-NIR-MIR spectral range, nanocomposites, plasmonic structures, metamaterials etc.;
- theoretical investigations of laser action in planar, fiber and hollow waveguide lasers, analysis of light generation in DFB (distributed feedback) structures, metamaterials, plasmonic and photonic crystals structures, investigation of the statistical properties of the light generated in various laser structures;
- 2-D and 3-D multispectral image analysis and processing;
- terahertz imaging;
- microwave technique and microwave photonics – measurement techniques, modelling and computer aided design of microwave devices and circuits, optical-microwave frequency conversion processes, optoelectronic and microwave devices for data transmission networks;
- photovoltaic systems and applications.

1.7. Statistical Data

SPECIFICATION	2020	2021	DIFFERENCE
Academic staff	**82**	**87**	**5**
Tenured professors	8	8	0
Professors	7	9	2
Docent	1	0	-1
Assistant professors	28	29	1
Senior lecturers	8	7	-1
Assistants	3	4	1
Ph.D. Students	27	30	3
Science, Technical and Administrative staff	**18**	**26**	**8**
Teaching activities	**82**	**75**	**-7**
Basic courses	40	43	3
Advanced courses	22	21	-1
Special courses	20	11	-9
Degrees awarded	**25**	**34**	**9**
D.Sc. degrees	1	0	-1
Ph.D. degrees	0	1	1
M.Sc. degrees	10	9	-1
B.Sc. degrees	14	24	10
Research projects	**27**	**31**	**4**
Granted by the University	9	18	9
Granted by State Institutions	15	11	-4
Granted by International Institutions	3	2	-1
Publications	**65**	**84**	**19**
Sci.-tech. books	1	3	2
Sci.-tech. papers in journals	53	65	12
Sci.-tech. papers in conference proceedings	11	16	-5
Patents	**2**	**6**	**4**
Reports	**50**	**55**	**5**
Conferences	**11**	**9**	**-2**
Awards	**5**	**8**	**3**

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Microelectronics and Nanoelectronics Devices Division

2. STAFF

2.1. Senior Academic Staff

Romuald B. Beck, M.Sc. ('76), Ph.D. ('82), D.Sc. ('96), Microelectronics, Electronics, Tenured Professor, full time, Head of Microelectronics and Nanoelectronics Devices Division ('04–'21), Leader of the Technology, Diagnostics and Modelling Group ('85–), Vice President of the Microelectronics Section of the Electronics and Telecommunication Committee of the Polish Academy of Sciences ('93–'08), Member od Programme Committee of: Diagnostics & Yield Conference ('88–), Member of the Faculty Council ('96–), Co-chairman ('03–), Chairman ('06); Member of Programme Committee of ELTE ('84, '04, '07, '13), Member ('05–'13) and Vice-Chair of Technical Programme Committee ESSDERC'2019, Senior Member of IEEE ('97-'06), Head of CEZAMAT Project Office ('08–'12), Vice-President for Scientific Affairs of CEZAMAT PW Ltd ('12–), Vice-Director for Scientific Affairs of CEZAMAT ('16-), WUT Rector's Collective Award for Scientific Achievements ('06, '08,'12, '19).

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Monika Janik, B.Eng. ('14), M.Sc. ('15) in Biotechnology from the Wroclaw University of Science and Technology, Poland. Ph.D. ('19) with distinctions in Science and Information Technology (specialization: photonics) from Photonics Research Center, University du Quebec en Outaouais, Canada as a part of the Industrial Research Chair project. Optoelectronics: optical fiber sensors and biosensors, optical resonance devices, micro-interferometers, fs laser micromachining. Biomedical sensing technologies designing, sensors' surface modifications. Assistant Professor, full time, Electronic Materials and Microsystem Technology Division. Award with a research project funded by National Science Center, Poland, under the "MINIATURA" program ('19), Laureate of the START 2021 Program of the FNP Foundation for Polish Science, WUT Rector's Collective Award for Scientific Achievements (1st stage) ('21).

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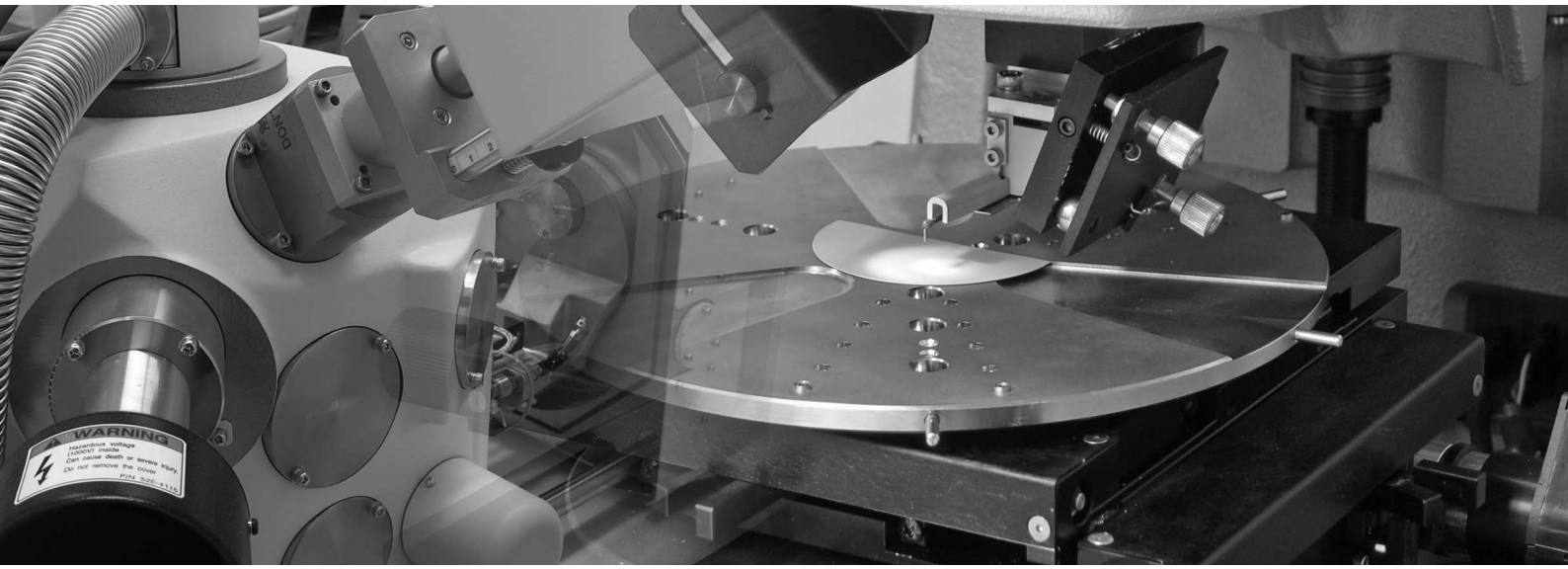

Electronic Materials and Microsystem Technology Division

2.2. Junior Research Staff

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2.3. Science, Technical and Administrative Staff

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VLSI Engineering
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3. TEACHING ACTIVITIES

3.1. Basic Courses

[Edu1] **Algorithms and Data Structures** (Algorytmy i struktury danych), **AISDE**, Adam Wojtasik

[Edu2] **Application of Matlab in Calculation Methods** (Matlab w zastosowanych metodach obliczeniowych) **MZMO**, Krystian Król

[Edu3] **Computer-Aided Design of Printed-Board Circuits** (Projektowanie obwodów drukowanych), **PADS**, Jerzy Kalenik

[Edu4] **Digital Circuits** (Układy cyfrowe), **UCYF**, Elżbieta Piwowarska

[Edu5] **Digital and Computer Systems** (Systemy Cyfrowe i Komputerowe) **SCK**, Arkadiusz Łuczyk, Elżbieta Piwowarska

[Edu6] **Electronic Elements and Circuits – Laboratory** (Elementy i układy elektroniczne – laboratorium), **ELIUL**, Andrzej Pfitzner, Agnieszka Zaręba

[Edu7] **Electronic Elements and Circuits** (Elementy i układy elektroniczne), **ELIU**, Andrzej Pfitzner, Agnieszka Zaręba

[Edu8] **Electronics 2** (Elektronika 2), **ELE2**, Jakub Jasiński

[Edu9] **Fields and waves**, (Pola i fale), **POFA**, Jerzy Piotrowski

[Edu10] **Fundamentals of Electronic Devices and Circuits** (Podstawy elementów i układów elektronicznych) **PELEL**, Sławomir Szostak, Lidia Łukasiak

[Edu11] **Fundamentals of Digital Circuits** (Podstawy Techniki Cyfrowej), **POCY**, Andrzej Wielgus, Elżbieta Piwowarska

[Edu12] **Fundamentals of Lasers** (Lasery – kurs podstawowy), **LKP**, Paweł Szczepański

[Edu13] **Fundamentals of materials and constructions** (Podstawy Materiałów I Konstrukcji), **POMAK**, Piotr Firek, Jerzy Kalenik

[Edu14] **Fundamentals of Microprocessor Techniques** (Podstawy techniki mikroprocesorowej), **TMIK**, Lidia Łukasiak

[Edu15] **Fundamentals of Microwave Engineering** (Podstawy techniki w.cz.), **TWCZ**, Jerzy Piotrowski

[Edu16] **Fundamentals of Photonics** (Podstawy fotoniki), **FOT**, Michał Malinowski

[Edu17] **Fundamentals of Solid State Electronics** (Elektronika ciała stałego), **ELCS**, Jan Szmidt, Agnieszka Zaręba

[Edu18] **Introduction to Computer Science** (Wstęp do Informatyki), **WINF**, Michał Borecki, Dominik Kasprowicz, Marek Niewiński, Andrzej Wielgus, Adam Wojtasik

[Edu19] **Introduction to Microelectronics** (Podstawy mikroelektroniki), **PMK**, Andrzej Pfitzner

[Edu20] **Introduction to Microsystems** (Wstęp do mikrosystemów), **WMS**, Andrzej Mazurak, Robert Mroczyński

[Edu21] **Introduction to Numerical Methods** (Wstęp do metod numerycznych), **WNUM**, Krystian Król

[Edu22] **Introduction to Photonics** (Wstęp Do Fotoniki) **WDOF**, Michał Malinowski, Ryszard Piramidowicz, Anna Jusza, Stanisław Stopiński, Krzysztof Anders

[Edu23] **Introduction to Programming** (Podstawy programowania), **PRM**, Marek Niewiński

[Edu24] **Introduction to the UNIX System** (Użytkowanie systemu UNIX), **USUX**, Andrzej Wielgus

[Edu25] **Introduction to Semiconductor Devices** (Podstawy Przyrządów Półprzewodnikowych) **PPP**, Lidia Łukasiak, Agnieszka Zaręba, Sławomir Szostak

[Edu26] **Introduction to Semiconductor Devices – Laboratory** (Laboratorium Podstaw Przyrządów Półprzewodnikowych) **LPPP**, Jakub Jasiński, Konrad Kiełbasiński, Agnieszka Zaręba

[Edu27] **Ligthwave Telecommunication** (Telekomunikacja optofalowa), **TEOP**, Agnieszka Szymańska

[Edu28] **Meeting 4 – Advanced Course Laboratory** (Zjazd 4 – Zaawansowane laboratorium kierunkowe), **ZJ4Z**, Agnieszka Szymańska

[Edu29] **Methods of Image Acquisition and Processing for Photography** (Techniki rejestracji i obróbki obrazów w fotografii), **TROOF**, Marek Sutkowski

[Edu30] **Object Programming** (Programowanie obiektowe), **PROE**, Marek Niewiński

[Edu31] **Operating Systems** (Systemy operacyjne), **SOE**, Andrzej Wielgus

[Edu32] **Optical Waveguide Lasers and Amplifiers** (Wzmacniacze i lasery światłowodowe) **WLS**, Ryszard Piramidowicz, Krzysztof Anders

[Edu33] **Optoelectronic Devices and Systems** (Elementy i systemy optoelektroniczne), **ESO**, Marcin Kaczkan

[Edu34] **Preliminary project** (Projekt Wstępny), **WPROJ**, Andrzej Mazurak

[Edu35] **Photonics elements** (Elementy Fotoniczne) **ELFO**, Jakub Jasiński, Konrad Kiełbasiński, Agnieszka Zaręba

[Edu36] **Photonic semiconductor devices** (Fotoniczne Przyrządy Półprzewodnikowe), **FPP**, Marcin Kaczkan, Agnieszka Mossakowska-Wyszyńska

[Edu37] **Physical Fundamentals of Information Processing** (Fizyczne podstawy przetwarzania informacji), **FPPI**, Jan Szmidt, Agnieszka Zaręba

[Edu38] **Programming for mobile Apple iOS and MacOS X** (Programowanie dla systemów: mobilnego iOS oraz MacOS X), **APIOS**, Adam Wojtasik

[Edu39] **Programming microcontrollers in C language** (Programowanie mikrokontrolerów w języku C), **PMIK**, Sławomir Szostak

[Edu40] **Programming Paradigms** (Paradygmaty Programowania) **PAPRO**, Michał Borecki, Dominik Kasprowicz, Marek Niewiński, Andrzej Wielgus, Adam Wojtasik

[Edu41] **Semiconductor Devices** (Przyrządy półprzewodnikowe), **PP**, Lidia Łukasiak, Agnieszka Zaręba

[Edu42] **Semiconductor Physics in Electronics and Photonics** (Fizyka Półprzewodników w Elektronice i Fotonice), **FPEF**, Piotr Firek, Agnieszka Zaręba

[Edu43] **Structured Programming** (Programowanie Strukturalne) **PROS**, Michał Borecki, Dominik Kasprowicz, Marek Niewiński, Andrzej Wielgus, Adam Wojtasik

3.2. Advanced Courses

[Edu44] **3D Vision Systems** (Systemy wizji 3D) **SWIZ**, Piotr Garbat

[Edu45] **Analog Integrated Circuit Design for VLSI Systems** (Projektowanie bloków analogowych dla systemów VLSI) **PSSA**, Tomasz Borejko

[Edu46] **Characterization of Materials for Microelectronics** (Charakteryzacja materiałów dla mikroelektroniki) **CHA**, Aleksander Werbowy, Piotr Firek

[Edu47] **Computational Methods in Microelectronics and Photonics** (Metody obliczeniowe w mikroelektronice i fotonice), **MOBI**, Andrzej Pfitzner, Dominik Kasprowicz, Agnieszka Mossakowska-Wyszyńska

[Edu48] **Digital VLSI Systems** (Scalone Systemy Cyfrowe VLSI) **SSCV**, Zbigniew Jaworski, Elżbieta Piwowarska

[Edu49] **Fiber-Optic Communication** (Komunikacja światłowodowa), **KOS**, Ryszard Piramidowicz

[Edu50] **Fundamentals of Nanoelectronics and Nanophotonics** (Podstawy nanoelektroniki i nanofotoniki), **NANO**, Bogdan Majkusiak, Paweł Szczepański

[Edu51] **Fundamentals of Photovoltaics** (Podstawy fotowoltaiki) **PFOT**, Michał Malinowski

[Edu52] **Integrated Analog Circuit Design** (Projektowanie analogowych układów scalonych) **PAUS**, Krzysztof Siwiec, Tomasz Borejko

[Edu53] **Introduction to Digital VLSI System Design** (Projektowanie scalonych systemów cyfrowych), **PSSC**, Zbigniew Jaworski

[Edu54] **Laboratory of Fundamentals of Nanoelectronics and Nanophotonics** (Pracownia podstaw nanoelektroniki i nanofotoniki), **PNAN**, Bogdan Majkusiak, Paweł Szczepański

[Edu55] **Lasers** (Lasery) **LAS**, Paweł Szczepański

[Edu56] **Mathematical Methods in Electronics and Photonics** (Metody Matematyczne w Elektronice i Fotonice) **MEF**, Andrzej Pfitzner, Agnieszka Mossakowska, Dominik Kasprowicz

[Edu57] **Microsystems Engineering** (Inżynieria mikrosystemów) **MIK**, Piotr Firek

[Edu58] **Monte Carlo Methods** (Metody Monte Carlo) **MMC**, Dominik Kasprowicz, Marek Niewiński

[Edu59] **Nanotechnologies** (Nanotechnologie), **NAN**, Jan Szmidt, Aleksander Werbowy

[Edu60] **Photonic integrated circuits** (Fotoniczne układy scalone) **FUS**, Ryszard Piramidowicz, Anna Jusza, Krzsztof Anders, Stanisław Stopiński

[Edu61] **Photonic Integrated Circuits for Optical Logic** (Zintegrowane optoelektroniczne układy logiczne) **ZOUL**, Michał Malinowski, Agnieszka Mossakowska-Wyszyńska

[Edu62] **Sensors** (Czujniki) **SEN**, Mateusz Śmietana, Marcin Koba, Monika Janik

[Edu63] **Spectroscopic Methods** (Techniki spektroskopowe) **TSP**, Michał Malinowski

[Edu64] **VLSI System Design** (Projektowanie systemów scalonych w technice VLSI), **PSSV**, Zbigniew Jaworski

3.3. Courses in English

[Edu65] **Electronics 1, EELE1**, Bogdan Majkusiak, Jakub Walczak, Andrzej Mazurak

3.4. Courses for other Faculties

[Edu66] **Energy Conditioning and Storage Laboratory, Faculty of Physics** (Laboratorium przetwarzania i magazynowania energii, Wydział Fizyki) **LPME**, Michał Malinowski

[Edu67] **Laboratory of Nanotechnology, Faculty of Physics** (Laboratorium nanotechnologii, Wydział Fizyki), **NAN**, Robert Mroczyński

[Edu68] **Laboratory of Photonics, Faculty of Physics** (Laboratorium fotoniki, Wydział Fizyki), **FOT**, Ryszard Piramidowicz

[Edu69] **Laser Technology, Faculty of Physics** (Technika Laserów, Wydział Fizyki), **TL**, Ryszard Piramidowicz

3.5. Courses in English for other Faculties

[Edu70] **Fiber Optic Communication Systems, Faculty of Physics, FOC,** Ryszard Piramidowicz

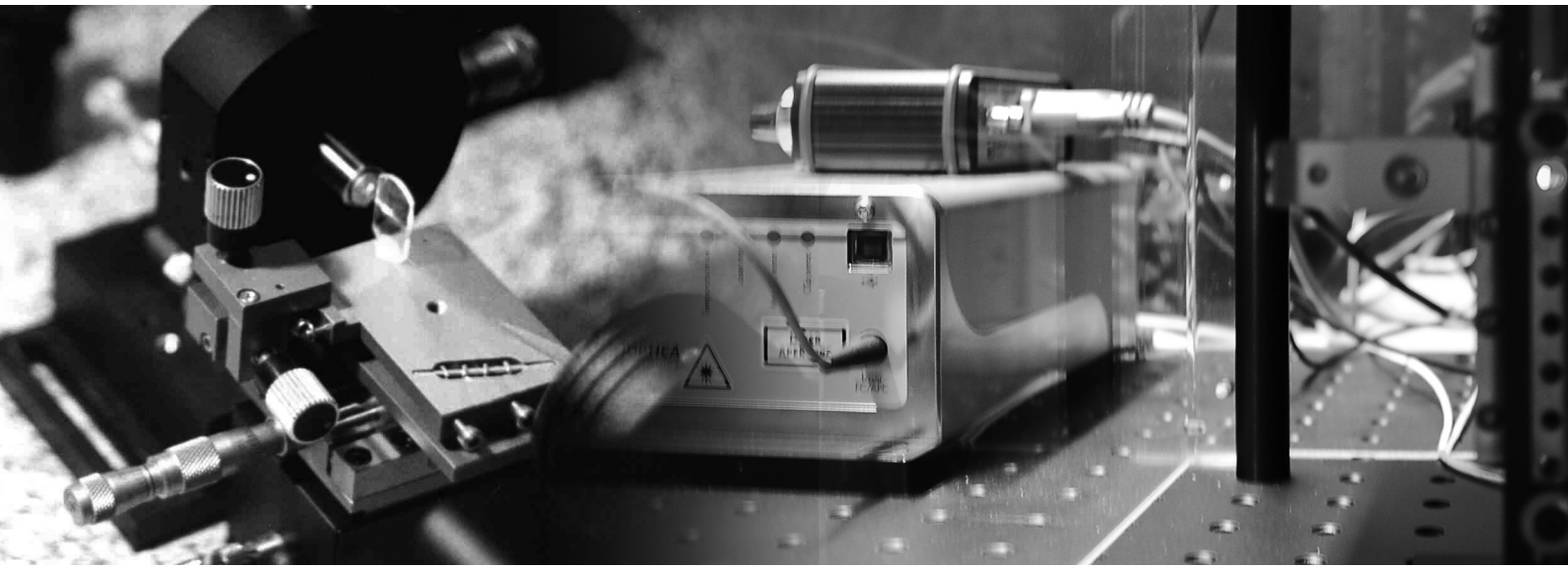
[Edu71] **Laser Technique, Faculty of Physics, LT,** Ryszard Piramidowicz

[Edu72] **Optical Fiber Technology, Faculty of Mechatronics, OFT,** Ryszard Piramidowicz

[Edu73] **Photographic Techniques in Image Acqusition, Faculty of Mechatronics, PTIA,** Marek Sutkowski

[Edu74] **Photonic Integrated Circuits, Faculty of Physics, PIC,** Ryszard Piramidowicz

[Edu75] **Semiconductor Optoelectronics, Faculty of Physics, SOP,** Paweł Szczepański



Optoelectronics Division

4. RESEARCH PROJECTS

Project definitions and descriptions – prepared by Project Leaders.

4.1. Projects Granted by the University

[Pro1] **Analysis of the posture of female soccer players, participating in the Polish Women's Extraleague** (Analiza postawy zawodniczek uprawiających piłkę nożną kobiet, uczestniczących w rozgrywkach Ekstraligi Kobiet PZPN, Inżynieria Biomedyczna), project leader: Marek Sutkowski, May 2021–November 2022

This work will be the results of measurements of the posture of young female soccer players and its analysis in two planes from the back in relation to the evaluation and diagnosis of compensation processes of the spine. Photogrammetric measurements allow to determine a 3D coordinates of selected anatomical points. The evaluation and analysis of posture changes is based on the set of vectors calculated from measurements results. Additionally, the horizontal vector will be analysed.

[Pro2] **Application of the terahertz spectroscopy to the investigation of the charge transport phenomena occurring in the electroactive materials** (Zastosowanie spektroskopii terahercowej w badaniu transportu ładunku w materiałach elektroaktywnych, Energytech 2 IDUB), project leader: Marcin Kaczkan, co-workers: Bartosz Fetliński, Piotr Garbat, January 2021–October 2022

The project concerns the use of terahertz spectroscopy for the study on charge carriers transport, which is one of the phenomena responsible for the operation of galvanic and fuel cells. Terahertz spectroscopy will be directly used to analyze changes in the basic parameters of electrochemical processes, e.g. the mobility of charge carriers. The project is realized in the collaboration of three research groups originating form three Faculties of Warsaw University of Technology. In addition to that an international partner DTU Energy Department of Energy Conversion and Storage, Technical University of Denmark will provide competencies in quantum mechanics-based modelling of the investigated systems. Finally, the outcome of the project will prove the applicability of the terahertz spectroscopy to the direct observation of the charge transport phenomena in the electrochemical systems and with the positive results achieved will open a new approach allowing for their characterization and optimization.

[Pro2] **Arrays of diffractive optical elements for applications in optical interface systems of photonic integrated circuits** (Macierze elementów dyfrakcyjnych do zastosowań w układach interfejsów optycznych układów scalonych, Fotech 2 IDUB), project leader: Andrzej Kaźmierczak, co-workers: Krzysztof Anders, Ryszard Piramidowicz, Stanisław Stopiński, January 2021–December 2022

This project aims on development of an innovative solution for the photonic integrated circuits (PICs) optical interfacing, requiring an efficient optical coupling mechanism between single-mode optical fibers (typically used in telecommunications and sensory systems) and strip waveguides of a semiconductor PIC. Typically this interface is implemented by using lensed or tapered fibers or by equipping PIC input waveguides with spot size converters. In each solution, bringing optical fibers close to the PIC facet ($<1\ \mu$m) is necessary. This is detrimental in a majority of real cases, limiting the PIC designer freedom and complicating design of PICs equipped with multiple optical ports (especially in the case of angled output waveguides, implemented to avoid parasitic reflections from the end facet).

This project assumes the use of properly designed diffraction optics elements (in the form of micro-optical diffraction elements arrays) constituting the interface between the SMFs array and PIC waveguides. The proposed solution ensures the proper distance between the optical interface and the PIC facet ($> 200\ \mu$m), while maintaining the acceptable optical coupling efficiency.

Diffraction elements are used to accurately depict the SMF cross-section of 5-9 μm diameter on the integrated waveguide face (having rectangular 2.0 μm$\times$0.32 μm cross-section). Consequently individual diffraction elements diameters are comparable with their distances from PIC and fiber array. Therefore, diffraction deflections are large, implicating the need of accurate off-axis design approach.

Designed diffraction elements will be produced using electron beam lithography allowing components shape 3D mapping with nanometer precision. Fabricated structures operation will be verified by implementing them in the PIC optical interface and checking the signal coupling efficiency and distance between PIC facet and the diffractive elements matrix.

[Pro4] **Diagnosis of skin cancer in the conditions of limited social mobility** (Diagnostyka zmian nowotworowych skóry w warunkach ograniczonej mobilności społecznej), project leader: Ryszard Piramidowicz, co-workers: Piotr Garbat, Anna Jusza, Krzysztof Anders, August 2020–February 2022

The freezing of social mobility for several months, implemented by the majority of governments as a method of stopping the migration of SARS-CoV-2 virus and focusing the effort of National Health Service on fighting against the COVID-19 pandemic, had dramatic side effects in the form of radical limitation of access to health care for patients affected by other diseases than COVID-19. In the case of malignant skin neoplasms, such as melanoma, a delay of several months in diagnostics allows the disease to develop into an advanced, difficult to treat or completely incurable form. This project is an attempt to solve this problem by proposing a device supporting the early diagnosis of cancer threats, using advanced numerical methods to recognize dangerous skin lesions that require urgent specialist consultation.

The main goal of the project is to develop a new solution for a comprehensive automated skin analysis system and classification of changes based on multimodal image data and deep machine learning models. The system will allow the implementation of initial screening diagnostics of patients in conditions of limited access to specialists and is dedicated to complement the portfolio of diagnostic tools of family doctors, but also as a supporting tool of tele-medicine, allowing systematic monitoring and remote consultation of disturbing skin changes.

The project fits well not only in the theme of the IDUB against COVID-19 competition but also in the National Oncological Strategy.

[Pro5] **Fiber optic electro-optical modulator for studying electromagnetic interactions caused by high-energy laser radiation** (Światłowodowy modulator elektro-optyczny do badania oddziaływań elektromagnetycznych wywołanych wysokoenergetycznym promieniowaniem laserowym, grant AEE), project leader: Marcin Koba, co-worker: Mateusz Śmietana, July 2021–December 2022

The aim of the project is to develop a fiber optic lossy mode resonance sensor that is capable of indicating the level and fluctuation of the electromagnetic field (at radio or microwave frequencies) in systems with high-energy laser radiation.

[Pro6] **Graphene as an indicator of the conditions of dielectric films technology on semiconductor substrates** (Grafen jako wskaźnik warunków technologii warstw dielektrycznych na podłożach półprzewodnikowych), project leader: Robert Mroczyński, July 2020–December 2021

Dielectric films perform numerous important functions in the technology of modern electronic and photonic devices. Several methods of dielectric layers formation are reported, however, in recent years low-temperature methods are the most important for the development of semiconductor technologies. The fabrication of a dielectric film is particularly critical for devices based on low-dimensional materials, such as graphene, molybdenum disulfide, or hexagonal boron nitride, as they are very sensitive to conditions of the dielectric layer formation. Effective passivation of two-dimensional materials is the major obstacle in the commercialization of fundamental studies related to structures and devices based on 2D materials.

The main aim of the proposed project is to use graphene as an indicator of conditions of the dielectric layer formation and the quality of a semiconductor/dielectric interface. Understanding the phenomenon during the formation of a dielectric film, and the correlation of the obtained structural and electrical properties of graphene with the parameters of the dielectric film technique is an extremely ambitious topic in the field of novel technologies based on 2D materials. In this project, the influence of specific conditions of typical oxides and nitrides formation on the electrical and structural properties of graphene will be examined. It will allow identifying the most favorable methods of 2D layer passivation. Atomic Layer Deposition (ALD) and Physical Vapor Deposition (PVD) techniques will be used as the methods for the passivation of 2D materials. Changes in graphene properties will be identified based on spectroscopic studies (Raman spectroscopy), structural investigations (AFM and SEM), and through the subtle electrical measurements of the fabricated test structures (Van der Pauw, Hall).

The planned research will be performed within the cooperation with a foreign partner – Center for Physical Sciences and Technology in Vilnius. As a result of the performed research, at least one publication in a scientific journal in the first decile on the JCR list related to material technologies will be published. The established cooperation will contribute to the preparation of the application for a joint research project carried out by Polish and Lithuanian teams, organized by the National Science Center (NCN) and Research Council of Lithuania (RCL) – DAINA 2. The indirect goal of this project is the integration of the competences of scientists and students carrying out research related to the technology and the characterization of materials and structures based on 2D materials, which will strengthen the interdisciplinary scientific team.

[Pro7] **Inactivation of SARS-CoV-2 viruses using UV-C radiation from the surface of air filters** (Dezaktywacja wirusów SARS-CoV-2 za pomocą promieniowania UV-C z powierzchni filtrów powietrza, COVID-19 IDUB), project leader: Krzysztof Anders, co-worker: Ryszard Piramidowicz, April 2021–February 2022

The project deals with developing and creation of an air filtering mask with a plant fiber filter. The filtration process will be supported by the virus inactivation with the use of radiation from the UV-C spectrum. The research will be carried out in cooperation with the creator of the masks (built from the plant fibers) who is very interested in applying the technology of irradiating with the use of UV-C spectrum in order to increase the effectivity. The use of UV radiation in that case has two meanings. The first – more intuitive – is the virus inactivation on the surface of the filter. The second is generating photosynthesis of plants that the lter is built from.

Electromagnetic radiation in the UV-C spectrum allows virus inactivation. Inactivation occurs mainly by damaging the DNA chain (which causes the viruses to be unable to multiply) and consequently its decay.

During the implementation of the project an illuminator emitting UV-C radiation will be constructed and characterized. The illuminator is going to consist of LEDs and placed within the mask structure. Radiation (which is destructive for living organisms) will illuminate the outer part of the lter and a specially designed enclosure will not allow radiation to escape from the mask. The whole mask will be designed and made using 3D printing technology.

The efficiency of the technology will be tested at the design stage by a team of scientists working in the field of microbiology. During the tests a specific number of virus colonies will be generated on the surface of the mask. Then, the mask will be exposed to UV-C radiation and after a certain exposure time the impact of radiation on the number of virus colonies will be calculated. Using this methodology one will be able to optimize both radiation power and exposure time what is very important while optimizing the device costs and electricity consumption.

The use of UV-C illuminator technology will increase both the life of the mask and its efficiency.

The final result of the project will be development of a complete product which allows to increase the safety of mask users who have regular contact with a large number of people. Another measurable result of the project will be the development of air filtering technology with the use of a hybrid system consisting of filter + UV-C illuminator which can be implemented in many everyday applications.

[Pro8] **Life inside an optical fiber – new opportunities for investigations and monitoring of cell cultures in micro-scale** (Życie wewnątrz światłowodu- nowe możliwości badania i monitorowania hodowli komórkowych w mikroskali), project leader: Mateusz Śmietana, August 2020–December 2021

Cell cultures have become a routine tool used in many fields. Cells obtained from human or animal organisms, cultured and propagated in appropriate conditions allow to answer a number of fundamental pharmacological as well as technological questions posed at the stage of preliminary toxicological or pharmacokinetic studies. Standard in vitro tests performed in biological laboratories are either two-dimensional (2D) cultures grown on a flat surface in the form of monolayers or three-dimensional (3D) cultures, where the cells are suspended in a polymer/hydrogel matrix. A proper selection of optimal growth conditions, medium or adhesive surface is extremely important and complex. The optimization of cell cultures therefore requires control over growth and real-time monitoring of cell properties. Usually, observations are made using an optical microscope and fluorescent staining, which in most cases fatal for the observed cells and, as a result, provides a limited amount of information. To avoid the staining method and enable non-invasive, real-time control of the culture, some solutions have been presented, among others, such as sensors based on impedance measurement. However, they have a couple of limitations, e.g., the substrate metal layer disturbs the adhesion of cultured cells, what hinders the measurements and disrupt its reliability. Moreover, such sensor design allows the observation of the 2D model only. The main goal of this project is to design and verify functional properties of miniaturized optical fiber sensor for non-invasive monitoring of cell cultures in both 2D and 3D models. We will demonstrate for the first time capability for precise optical analysis of cell cultures inside micro-cavity obtained in an optical fiber. The studies will focus on design and fabrication in the lateral surface of the optical fiber using femtosecond laser ablation of a micro-cavity-based sensor with dimensions of 40–60/60 μm and volume of pL. The task will include maximization of its sensitivity for 2D and 3D culture monitoring.

[Pro9] **Looking for yellow lasing – dysprosium doped active materials for lasers operating in VIS spectral range** (W poszukiwaniu żółtego promieniowania laserowego- domieszkowane dysprozem materiały aktywne do zastosowań w laserach na zakres widzialny), project leader: Anna Jusza, co-workers: Ryszard Piramidowicz, Krzysztof Anders, Paweł Komorowski, July 2020 –December 2021

The recent years observed the intensive development of optoelectronic devices and systems using a compact, highly efficient visible light sources, both coherent and incoherent. Market's interest results from a number of application areas, covering in particular imaging, recording and information processing techniques, medical diagnostic and therapy as well as optical telecommunications. At present the market of compact visible light sources is dominated by wide-bandgap semiconductor devices, based mainly on InGaN/GaN structures. Modern electroluminescent diodes (LEDs) allow obtaining the full palette of colors of visible light, while semiconductor laser diodes (LDs) fill this range partially, leaving unfilled ranges of blue-turquoise (490–510 nm), green and yellow-orange (520–630 nm) light. These missing wavelength ranges can be complimented by diode pumped solid state lasers (DPSSLs) with frequency conversion, offering discreet set of wavelengths (e. g. 561 nm, 589 nm, 593 nm), but suffering from lower efficiency and more complex design, associated with the necessity of nonlinear crystals working conditions stabilization. Furthermore, it should be noted that beam quality and of semiconductor lasers is incomparably worse than the parameters obtained in gas and solid state dielectric lasing media. The aim of this project is to investigate and analyze the luminescent properties in the visible, and specifically yellow part of the spectrum in a set of optically active materials doped with dysprosium ions. The investigated materials will cover mainly fluorozirconate ZBLAN glass and, additionally, low-phonon fluoride nanocrystalline materials.

Although several rare earth ions may be used as an active dopant for visible light emitters, the dysprosium seems to be particularly interesting as it offers the unique possibility of obtaining emission and lasing in yellow spectral range, hardly available to other laser types, including laser diodes. Despite many years of research on different glass materials doped with dysprosium ions, yellow lasing action reports are very rare as the result of investigations of only two

research groups – J. Limpert and Y. Fujimoto teams. This project assumes manufacturing and examination of several dysprosium doped materials (ZBLAN glass, fluoride nanocrystals) differing in dopant concentration.

So defined scope of work will allow the examination of the influence of doping concentration on possibilities of obtaining efficient emission of visible light, as well as the influence of thermal conditions on luminescent properties of dysprosium ions. Materials of the best luminescent properties will be examined with respect of possibility of obtaining laser action as well.

[Pro10] **Novel glassy and nanocrystalline phosphors for white LED lighting safe for human vision** (Nowe szkliste i nanokrystaliczne luminatory do białego oświetlenia LED bezpiecznego dla ludzkiego wzroku, Fotech 2 IDUB), project leader: Bartosz Fetliński, January 2021–December 2022

Within the scope of the project it is planned to synthesize vitreous and nanostructured materials containing rare earth elements (REE) oxides and study their optical properties by several complementary methods. The optical and related physicochemical properties of the materials will be studied and reported in detail. The main practical goal of the project is construction of a working prototype of a "natural" white LED light source based on a commercial near-UV/violet LED diode and a glassy/nanostructured phosphor, synthesized by us. The photoluminescent spectrum of this device should closely resemble that of the daylight, which is safe for sight. The research goal consists in explaining the major factors leading to white "natural" photoluminescence of the obtained materials.

Materials based on REE are widely used in many technology fields, e.g. in lighting industry as phosphors for white LEDs. Unfortunately, commonly used phosphors have a serious drawback. Their spectra substantially differ from that of the sunlight. In particular they contain a strong blue/violet component. This deviation from daylight is unhealthy for eyes and can even cause irreparable changes in human vision.

Recently, the research carried out by our group has shown that it is possible to synthesize Eu-doped glassy materials, whose photoluminescence spectra are smooth and close to that of daylight. We found out, that by controlling the synthesis parameters (time, temperature, atmosphere), one can modify the Eu^{3+}/Eu^{2+} ions concentration ratio. As a result, one can optimize the spectra of the phosphors' photoluminescence and liken them to that of daylight. It is worth emphasizing that the used methods of glass synthesis (melt-quenching), but also nanocrystallization (resulting in nanostructured materials) are cheap, simple and reproducible.

Based on our previous experience, as part of the project, we plan to synthesize innovative glassy phosphors doped with selected REEs in strictly controlled conditions (atmosphere, temperature, time), which are crucial for oxidation states of these elements. Further, the process will be optimized to obtain a smooth photoluminescence spectrum resembling that of the natural daylight. The optical and physicochemical properties of the best samples will be comprehensively studied. The crowning of the project will be the construction of a prototype of a white "natural" LED based on a commercial LED (near-UV/violet) source with a glassy/nanostructured phosphor produced during this project.

Due to the widespread use of high-efficiency lighting with white "unhealthy" LEDs, the final results of this project have a great application potential, both in Poland and internationally

[Pro11] **Opto-electrochemical effects in thin conductive oxides for sensing applications** (Efekty Opto-elektrochemiczne w cienkich tlenkach przwodzących na potrzeby zastosowań sensorycznych), project leader: Mateusz Śmietana, co-workers: Monika Janik, Marcin Koba, July 2020–December 2021

This project concerns transparent conductive oxides (TCO) as functional materials for a new class of sensors working simultaneously in optical and electrochemical domains. Our previously published studies on thin indium tin oxide (ITO) films deposited using magnetron sputtering on optical fiber sensors have shown, that the film facilitates lossy-mode resonance (LMR) optical effect and simultaneously can be applied as working electrodes in electrochemical setups. The optical effect enables monitoring of optical properties on the film surface, while electrochemical measurements deliver

information on changes of charge transfer at the ITO-electrolyte interface. In both domains, i.e. optical and electrochemical, after film surface functionalization it is possible to monitor specific binding of selected biomaterial and develop universal biosensors. These biosensors, thanks to simultaneous activation of both domains and investigation of the same analyte, deliver enhanced set of data and increase trust in the results. Developed concept is original and stands as a very attractive alternative to biosensing systems based on thin gold films. In contrast to gold coatings, optical and electrochemical properties of ITO can be broadly tuned by adjustment of deposition process parameters, what eases the determination of cross-domain influence. Separation of the influences allows for cross-verification of the results, and additionally, as found in our studies, electrochemical modulation of optical properties greatly enhances optical sensitivity of the sensors.

The main aim of this project is to identify mechanisms responsible for effective electrochemical modulation of optical response for sensing structures with TCO films, and in consequence increase sensitivity in optical domain to changes taking place on the film surface. Thanks to the knowledge on correlation between ITO film properties and magnetron sputtering deposition process parameters, we plan to establish analogous dependences also for other TCOs, especially for fluorine-doped tin oxide (FTO) and indium gallium zinc oxide (IGZO). This will let us identify general functional mechanisms of opto-electrochemical sensing structures. TCO films will be deposited on reference substrates (silicon, glass) and optical fibers. Next, properties of the films, e.g., optical, electrical, and structural ones will be determined and correlated with magnetron sputtering deposition parameters. The films on optical fiber sensing structures will be investigated for opto-electrochemical activity and its changes induced by the film surface modification. Acquired data will allow to develop a functional model of TCO-based opto-electrochemical devices and design highly sensitive sensing structures. The devices after surface functionalization and linking of e.g. bioreceptors, will stand as a universal platform for highly reliable detection of broad spectrum of biological targets such as DNA, proteins, viruses, or bacteria.

[Pro12] **Photonic integrated circuits for new generation of optical gyroscope systems** (Układy fotoniki scalonej dla systemów żyroskopów optycznych nowej generacji), project leader: Stanisław Stopiński, co-workers: Ryszard Piramidowicz, Sławomir Szostak, Krzysztof Anders, July 2020–December 2021

The main objective of the project is investigation on the feasibility of realizing a monolithically integrated optical gyroscope, designed and manufactured in an experimental generic technology on the indium phosphide (InP) platform. The scope of the project covers development of novel single-frequency laser light sources, integrated with a detection circuit of the beating signal. Electronic drivers for the photonic integrated circuits will be also designed and fabricated, which will enable setting up gyroscope experiments on a dedicated measurement setup. The second main objective of the project is development of a demonstrator of an interferometric fiber-optic gyroscope system, with the use of integrated interrogators, realized in the framework of previous research activities of the research team of the Institute of Microelectronics and Optoelectronics.

The scope of the project is inspired by a dynamic development of European integration platforms and a great application potential of novel gyroscope techniques. It is worth to mention that the scientific objectives of the project are very ambitious, to the author's best knowledge a fully integrated ring laser gyroscope has not been demonstrated yet, despite intense research effort in the field. Access to a unique integration technology is possible due to the collaboration of IMiO WUT with Eindhoven University of Technology and SMART Photonics, which allows to anticipate scientific results of a great publishable value. Successful realization of this project will enable application for grants for research and development works.

[Pro13] **Photonic integrated multi-channel transmitter for quantum key distribution** (Wielokanałowy nadajnik do kwantowej dystrybucji klucza kryptograficznego w technologii fotoniki scalonej), project leader: Stanisław Stopiński, July 2020–September 2021

The main goal of the project is focused on development of a photonic integrated multi-channel transmitter for quantum communications. In the framework of the project an application specific photonic integrated circuit (ASPIC) will be designed, manufactured and characterized with respect to its application as a transmitter for quantum key distribution. To realize the ASPIC an indium phosphide (InP) generic integration technology platform will be used. The design of the optical chip will utilize basic and customized building blocks provided by the foundry and manufactured in the framework of a multi-project wafer run. System-level tests will be performed in the quantum regime with the use of a dedicated measurement setup comprising single photon detectors.

[Pro14] **S^2EC – integration of optical and electrochemical techniques towards biochemical sensing with high sensitivity and selectivity** (S^2EC – integracja technik optycznych i elektrochemicznych w kierunku pomiarów biochemicznych o wysokiej czułości i selektywności), project leader: Mateusz Śmietana, co-workers: Monika Janik, Marcin Koba, July 2020–December 2021

This project concerns integration of spectrophotometric measurements with other optical and electrochemical (EC) measurement methods aiming for increase of sensitivity, selectivity, and reliability of biochemical analysis when compared to the methods applied separately. Our previously published studies on optically transparent and electrically conductive thin films, in particular indium tin oxide (ITO), deposited on optical fiber sensors have shown, that the film facilitates lossy-mode resonance (LMR) optical effect and simultaneously can be applied as working electrodes in EC setups. The optical effect enables monitoring of optical properties on the film surface, while electrochemical measurements deliver information on changes of charge transfer at the ITO-electrolyte interface. In both domains, i.e. optical and electrochemical, after film's surface functionalization it is possible to monitor specific binding of selected biomaterial and develop universal biosensors. These biosensors, thanks to simultaneous activation of both domains and investigation of the same analyte, deliver enhanced set of data and increase reliability of the results. Developed concept is original and stands as a very attractive alternative to biosensing systems based on thin gold films. It needs to be noted, that application of optically transparent film also makes spectrophotometric measurements (absorption, photoluminescence) possible transversally to axis of optical fiber sensor. Spectrophotometry allows for receiving additional information about products of chemical reactions and biological alternations in volume of the analyte.

The main aim of this project is to identify measurement capabilities resulting from application of simultaneous spectrophotometric, spectral LMR, and EC measurements (S 2 EC), in particular enhancement of sensitivity and selectivity when compared to separate measurements, as well as reliability of the results by their mutual verification. Unique capabilities of the merged techniques offer (developed by the team and optimized for opto-electrochemical measurements) ITO-coated optical fiber structures, that when their surfaces are functionalized, e.g., with a bioreceptor material, will stand as an universal sensing platform with a great reliability to broad spectrum of chemical compounds and biological materials, such as DNA, proteins, viruses or bacteria. Thanks to the knowledge on functioning of ITO-LMR structures, we will realize technological, design, and measurement tasks allowing for unique integration of ITO-LMR setups with other spectrophotometric techniques. We will also develop a designated software which will enable us to verify measurement capabilities of the S^2EC setups.

[Pro15] **Shaping optical properties of planar metamaterials for photonic structures of novel functionalities** (Kształtowanie właściwości optycznych materiałów planarnych pod kątem uzyskiwania struktur fotonicznych o nowych funkcjonalnosciach), project leader: Paweł Szczepański, co-workers: Robert Mroczyński, Bartosz Janaszek, Marcin Kieliszczyk, July 2020–December 2021

The project will be devoted to investigations of new electromagnetic phenomena occurring in metamaterial media exhibiting hyperbolic dispersion, with particular emphasis on the possibility of shaping the optical properties of bulk and waveguide structures, resulting from the presence of spatial dispersion. The implementation of planned research will

allow for obtaining preliminary results, which will be published in the form of an article in one of the renowned scientific journals, and will also be used to submit an application for an international research grant under the M-ERA.NET program, in cooperation with German partners specializing in the design and synthesis of DNA oligonucleotides (so-called DNA-origami). The partners' unique technological competences will enable to obtain an additional degree of freedom in shaping the optical properties of metamaterial media. The research activities will address the subject of the M-ERA.NET program in the area of Innovative surfaces, coatings and interfaces. The target project (under the working acronym MetaDNA) aims to establish a technology platform, based on DNA-origami technique, for plasmonic metamaterial devices with scalable properties. An international consortium, created by Polish and German research institutions, will provide the latest DNA-origami technology that enables the design and production of new nanophotonic plasmonic devices, which will constitute a new alternative paradigm for the further development of plasmonic-photonic nanostructures, which directly addresses the area of POB_FOTECH's activity in the field of new photonic materials dedicated to optoelectronic devices and systems as well as photonic sensors.

It is worth to emphasize that the concept of this project was created to address the ever-growing need for excellence and novelty in photonic applications. As such, it is expected to have a significant and lasting impact on the photonic industry, which is now a strategically important and rapidly growing area in the ecosystem of the European economy.

[Pro16] **Study on the charge transport mechanism and filament formation in Metal-Insulator-Metal (MIM) structures** (Badania mechanizmów transportu ładunków oraz formowania ścieżek przewodzących w strukturach typu metal-Izolator-Metal (MIM), Technologie-materiałowe-2 IDUB), project leader: Andrzej Mazurak, co-workers: Jakub Jasiński, Robert Mroczyński, January 2021–December 2022

The Resistive Random Access Memory (RRAM) devices are considered as a promising candidate to replace currently commercially available semiconductor memory devices. Due to its resistivity change process accumulative dynamics they are also used to implement the idea of a new generation computing, namely the neuromorphic computing. In the RRAM devices an insulator layer (or a multilayer stack of several insulator layers) is incorporated between the conductive electrodes. One RRAM device forms one memory cell, addressed with the outer electrodes of the device. The resistivity of the insulator layer is controlled by the bias implied to the electrodes, and thus a given logic state may be coded (set or erased). Several concepts of RRAM devices have been proposed and studied, however still there are several reliability issues that need to be addressed, e.g. the ones related to the limited switching speed or the retention time. The crucial subject that still remains not thoroughly understood is the mechanism of the resistivity modulation, which is the operation principle of such devices. In course of this project the effect of the electric field on the filament modulation (creation and reduction), and charge transport processes will be investigated. The study will be conducted for two types MIM (Metal-Insulator-Metal) structures: (1) the "classic" RRAIVI devices based on single- or periodical multi-layer insulators (several dielectric materials will be considered, and (2) the devices with metallic and semiconductor nanocrystals (NCs) incorporated in the insulator layer. The electrical and structural characterization will be conducted The idea of combining those two different and uncorrelated investigation techniques shall give insight into the effect of the electric field on the material structure and the obtained electrical parameters of the investigated devices. The project assumes the interdepartmental cooperation (the Faculty of Electronics and Information Technology and the Faculty of Material Science and Engineering) and it involves the contribution ofthree foreign scientific units. The knowledge gained with this project may lead in the future to additional studies related to neuromorphic (brain-inspired) computing in the hardware implementation context.

[Pro17] **System for measuring the noise parameters of mid-infrared photodetectors** (System do pomiarów parametrów szumowych fotodetektorów pracujących w zakresie średniej podczerwieni, Koło Naukowe Systemów Scalonych), project leader: Marek Niewiński, co-workers: Paweł Pieńczuk, Patryk Prusinowski, June 2021–June 2022

"Application-Specific Photonic Integrated Circuits, ASPIC" are wildly used not only in telecommunications, but also in medicine or chemical composition analysis. The PIC market is still rapidly growing but mid-infrared solutions have not yet been standardized. During develop of such a system, it is very useful to know the noise characteristics of the detectors. Often they are characterized by noises lower than the sensitivity of basic spectrum analyzers, although still important from the point of view of the system operation. The main aim of this work is design, implement and test a dedicated a measuring adapter in the form of a PCB utilizing a low-noise amplifier (current or transimpedance). To achieve this, we plan to use dedicated commercially available integrated circuits, eg LTC6560, HMC799LP3E, LMH32401. Additionally due to use of the Raspberry Pi platform, the process of the characteristic measurement will be partly automated.

[Pro18] **The study of the robustness of GNSS positioning against signal disturbances** (Badania odporności pozycjonowania GNSS na zakłócenia sygnału, BEYOND POB), project leader: Krzysztof Siwiec, March 2021–February 2023

Global Satellite Navigation Systems (GNSS) are widely used positioning tools to monitor and navigate an object in space. The dynamic development of geoinformation technologies, in which the object location component is an essential element, also forces the continuous development and improvement of GNSS positioning algorithms and methods. As part of this development, one of the most critical elements is the broadly understood security of the use of GNSS positioning technology, in particular, to protect system users against malfunctions of the GNSS system caused by intentional (jamming, spoofing) and accidental (e.g. interference, navigation data errors) disturbances of measurement signals.

The proposed project's subject is related to the study of the robustness of the measurement data acquisition and processing algorithms to signal disturbances and the analysis of the impact of individual sources of disturbances on the positioning quality. As part of the project, it is planned to use a unique research infrastructure in the form of the GNSS Spirent GSSQOOO signal generator and the NaviSoC receiver by ChipCraft Sp. 2 0.0. (a spin-off company of the Warsaw University of Technology). The research tasks will include: analysis of the resistance of individual components of signal acquisition and positioning models to observation errors and disturbances in the operation of the GNSS systems; improvement and development of algorithms that increase the accuracy and reliability of GNSS positioning; development of methods of warning system users against its malfunctioning. The international research team, consisting of both specialists in the field of error analysis of GNSS observation and positioning models, as well as scientists in the field of electronics, telecommunications and the construction of GNSS receivers, will enable comprehensive research at the highest world level. The work will also result in developing a methodology for testing and metrological control of GNSS measurement systems. The planned effects can significantly increase the possibility of using GNSS technology in positioning applications requiring high accuracy and reliability

4.2. Projects Granted by the Ministry of Science and Higher Education

[Pro19] **Research infrastructure for the fabrication and diagnostics of semiconductor structures and devices (SPUB)** (Zespół urządzeń do wytwarzania przyrządów i struktur półprzewodnikowych i ich charakteryzacji i diagnostyki wraz z niezbędną infrastrukturą, SPUB) Warsaw University of Technology, Institute of Microelectronics and Optoelectronics, project leader: Robert Mroczyński, June 2019–December 2021

The project is devoted to supporting the maintenance of the Laboratory of advanced semiconductor technologies and diagnostics of materials, structures, and devices that is unique domestically. The Laboratory offers access to the most advanced nanoelectronic and microsystem technologies, as well as novel interdisciplinary technologies of integrated nanoelectronics and photonics to all research teams and partners domestically and internationally. This allows for a clear indication of the potential of Polish science through the implementation of fundamental research (widely published in journals with high impact factor) and participation in national and international research projects. Importantly, access to the Laboratory is not limited only to research teams – the available research infrastructure of the Laboratory of IMiO

WUT also educate highly qualified engineering staff, crucial for the development of an innovative economy, based more and more on advanced material engineering, nanoelectronics, and photonics. The continuation of this type of support allows for further expansion of the research interest and tasks carried out with the use of available research tools. Moreover, the maintenance of such advanced equipment in the appropriate condition necessary to perform unique research and development studies will be also ensured.

4.3. Projects Granted by the National Science Centre for Research and Development

[Pro20] **Biopolymer materials with chemically and genetically programmed heavy metal selectivity for new generation ultra-sensitive biosensors** (Materiały biopolimerowe o programowanej chemicznie i genetycznie selektywności do metali ciężkich dla ultraczułych biosensorów nowej generacji), TECHMATSTRATEG III, Warsaw University of Technology, Institute of Microelectronics and Optoelectronics, project leader: Mateusz Śmietana, co-workers: Monika Janik, Marcin Koba, Norbert Kwietniewski, Katarzyna Lechowicz, Emil Pituła, Jakub Warszewski, Kinga Kondracka, January 2021––December 2023

The project concerns research and development and pre-implementation work which will result in the development of an ultra-sensitive and mobile device allowing for simultaneous and rapid water detection of at least 8 different heavy metals using electrochemical and optical measurements. The device will be able to detect the presence of contaminants at the source of water intended for human consumption in accordance with the standards of permissible concentrations of heavy metals recommended, among others, by the WHO and the Ministry of Health. Its implementation on the market will allow for quick and precise analysis of drinking water contamination and, after proper preparation of the sample, the analysis of environmental and waste water. To ensure the success of the project implementation, three independent strategies were proposed to obtain biological receptor layer interacting selectively with heavy metals in the form of DNA aptamers, oligopeptides and modified GFPs. To create the final version of the device, allowing for rapid detection, these biomolecules will be selected from the above-mentioned three types of biological elements, which will provide the highest stability and the best qualitative and quantitative measurements of the presence of heavy metals in water. Thanks to the integration of research from renowned scientific centres, representing both chemical sciences and technical sciences, i.e. microelectronics and micro optics, with the cooperation with the business unit, a unique on the global market mobile instrument will be created, allowing to monitor environmental pollution in an extremely simple, mobile way and ensuring simultaneous detection of at least 8 heavy metals. So far, no one has developed and marketed a solution, which enables almost immediate detection of several pollutants at once, and no mobile device combining both electrochemical and optical detection has been constructed, which guarantees its considerable market potential.

[Pro21] **Development and implementation of an artificial intelligence system of virtual characters allowing simulation of their realistic behaviour and interactions with the player based on an autonomous analysis of the game participants' image in real time** (Opracowanie i implementacja systemu sztucznej inteligencji wirtualnych postaci pozwalającego na symulację ich realistycznych zachowań i interakcji z graczem na podstawie autonomicznej analizy obrazu uczestników gry w czasie rzeczywistym), GAMEINN, Warsaw University of Technology, Institute of Microelectronics and Optoelectronics, project leader: Piotr Garbat, August 2020–June 2023

The aim of the project is to create a platform for the multiplayer – AR games (augmented reality multiplayer games) development based on cloud rendering and machine learning. The platform will be validated on an experimental test gameplay created for this purpose, making use of all functionalities of the system. The result of the project, i.e. a new product on the market – Pirxon platform, will be implemented directly in the company's activities of the consortium leader. The platform will be based on algorithms developed together with the consortium partner – Warsaw University of Technology (PW) and equipped with the first video system supporting augmented reality multiplayer games in real time.

[Pro22] **Development of a modular quantum computer infrastructure for special and military IT applications** (Opracowanie modularnej infrastruktury komputera kwantowego do specjalnych i wojskowych), TECHMATSTRATEG III, Warsaw University of Technology, Institute of Microelectronics and Optoelectronics, project leader: Jan Szmidt, December 2020–December 2024

The aim of the project is a prototype of a modular quantum computer infrastructure (MIKOK) for IX RTL for special and military purposes as well as general IT applications. The modularity of the infrastructure ensures a high degree of its versatility, availability, and security for a variety of implicit and explicit applications implemented by many independent users. The infrastructure created as part of the project's implementation consists of four basic modules: Quantum Computer Unit, Secure Multi-Access Platform, Quantum Computer Compiler, and Quantum Computer Simulator. The use of infrastructure enables multi-access testing and running quantum algorithms in both implicit and explicit modes. The adopted modular solution provides the opportunity to expand the infrastructure (e.g., multiplying modules) and their development (e.g., increasing the number of qubits).

[Pro23] **Nanostructured photonic crystal fibers for innovative few mode propagation** (Nanostrukturalne światłowody fotoniczne do kilkumodowej propagacji nowe generacji" w ramach programu „Nowoczesne technologie materiałowe" TECHMATSTRATEG), Warsaw University of Technology, Institute of Microelectronics and Optoelectronics, project leader: Ryszard Piramidowicz, June 2018–May 2021

The aim of the project is to develop innovative few-modes materials, thanks to which it will be possible to use the last undeveloped area of multiplexing – spatial multiplexing. The project will develop nanostructured anisotropic photonic fibers with defined polarization properties, shaped dispersion and distribution of the mode field or strongly nonlinear properties allowing for few-mode propagation of the new generation.

[Pro24] **New Versatile Platform for Illumination and Sensing – NewILUMIS** (Nowa uniwersalna platforma oświetleniowo-sensoryczna, M-ERA NET call 2019), Warsaw University of Technology, Institute of Microelectronics and Optoelectronics, project leader: Marcin Kaczkan, September 2020–August 2023

NewILUMIS project aims at developing a novel functional material based on a layered ceramic, associated to a surface plasmon resonance (SPR) structure and a mesoporous topcoat as an innovative photonic component for lighting/sensing. The target areas will be environmental protection and security, medical diagnostics, biosensing and chemical compound detection.

The core of the lightning structure will be a rare earth doped (RE^{3+}) ceramic (YAG). Its layered construction will allow tailoring the spectral and spatial characteristics of the light source under LED excitation. The ceramic composition (active dopants, scattering phase material, etc.) will be modified to obtain the desired colour rendering index and a high efficiency of the resulting source. This light source will be used for sensing when combined to SPR and functionalized mesoporous coatings. Packaging issues will also be considered to produce a demonstrator whose performance will be tested in relevant industrial applications.

[Pro25] **Photonics Integrated Circuits technologies for MIDIR** (Technologie układów fotoniki scalonej na zakres średniej podczerwieni – MIRPIC), TECHMATSTRATEG III, Warsaw University of Technology, Institute of Microelectronics and Optoelectronics, project leader: Ryszard Piramidowicz, co-workers: Krzysztof Anders, Anna Jusza, Aleksandra Paśnikowska, Stanislaw Stopiński, April 2020–March 2024

The result of the project will be a "product innovation" in the form of Application Specific Photonic Integrated Circuits (ASPIC) designed to work in the midinfrared range, MIR (3–5.5 μm). In particular, different building blocks necessary to define ASPICs will be designed, manufactured and tested, which will allow to design, manufacture and test the parameters of the ASPIC demonstrator. The demonstrator will reflect the typical characteristics of integrated photonics,

i.e. multi-channel, integration on a common substrate, electronic and optical interfaces, and packaging. The demonstrator will be a multi-channel receiver transmitter operating for least three wavelengths and designed for the detection of chemical compounds (e.g., CO_2, NO_x, SO_x) or for free-space optical communication. The result of the project will be "know-how" in the field of design and production of a basic set of functional blocks and their hybrid integration, which will allow to define the first in Poland technology platform of ASPIC circuits for the MIR range. Then as a result of the planned implementation will allow for the design and production of integrated photonics systems with different parameters corresponding to the changing needs of customers, in line with the concept of industry 4.0. Industry 4.0 assumes organization of production that allows reacting to changes in market demand for a product with specific parameters – "mass personalization". Strong competition and growing customer expectations mean that not only the systematic increase in production efficiency is needed but also the way to personalize it, i.e. produce short series of products designed according to the needs of a specific customer. Their price should not be higher than the price of mass-produced goods. Such flexibility is to be the result of the fourth industrial revolution and the product developed in the project is to meet these challenges.

4.4. Projects Granted by the National Science Centre

[Pro26] **Correlations between electromagnetic and magnetoelastic properties of thin ferromagnetic films** (Korelacje pomiędzy własnościami elektromagnetycznymi i magnetosprężystymi cienkich warstw ferromagnetycznych), Warsaw University of Technology, Institute of Microelectronics and Optoelectronics, project leader: Jerzy Krupka, June 2019––June 2022

Thin magnetic films have been the subject of study for several decades, but to this day this area of research remains highly active. Their popularity can be attributed to the presence of surfaces and material interfaces, which make the properties of magnetic films very different from their bulk forms. While bulk (i.e. of dimensions measured beyond the nanoscale) magnets have already become an inseparable part of modern-day technology, low-dimensional magnetic structures have a huge potential of widespread practical applications as well.

Magnetic recording and mass storage systems have been very popular since the very beginnings of the computer industry. However, despite numerous advantages, magnetic random access memory (MRAM) still has a long way to go before it will replace semiconductor volatile computer memories for at least two reasons. The first one is outstandingly large scale of integration needed to obtain huge memory capacity counted in GB, while the second reason is still relatively high power consumption, which decreases with the Gilbert damping factor, α, of the used conductive magnetic films. Nonetheless, bit switching time increases as $1/\alpha$. Therefore, practical MRAM designs incorporate both low- and high-damping materials and there is high demand for their better and better quality. Understanding the origin of various damping mechanisms and their relation to structural properties of such films remains one of the key challenges, which is still insufficiently understood, especially at a quantitative level needed to control the damping properties of the films.

In view of the described technological problems, the main goal of the project is to determine the fundamental correlations between different physical mechanisms responsible for magnetic losses occurring in ferromagnetic thin films at microwave and millimeter wave frequencies, contributing to the homogeneous and inhomogeneous broadening of the ferromagnetic linewidth, and structural parameters of the film, such as anisotropy, thickness, inhomogeneity, defects/doping, magnetoelasticity. As it is well known, magnetic loss mechanisms include Gilbert damping, two-magnon scattering, spin-orbital coupling, spin pumping (if non-magnetic electrically conductive layers are adjacent to the magnetic layer) or radiative damping, the contribution of which will need to be separated from each other in the course of the project. Special attention will be paid to the magnetoelastic effect, which can be usually correlated with strong spin-orbital coupling of the magnetic ions, while the latter one usually results also in strong magnetic damping, which manifests itself in the broadening of the ferromagnetic linewidth. However, the quantitative correlation between these two phenomena remains poorly understood.

In order to clarify the correlation between the magnetoelastic properties and magnetic damping in thin films, a rigorous quantitative study of various contributions to the magnetic damping occurring in thin films has to be undertaken in a broad electromagnetic spectrum. Commonly used methods, like VNA-FMR with a co-planar waveguide (CPW), suffer from low dynamics (i.e. poor accuracy) and does not allow easily de-embedding losses of the setup from the measurement in order to get a real FMR linewidth (i.e. unloaded from extrinsic losses of the measurement system). Much better performance can be achieved with resonant methods with the sample inserted in a hollow metallic cavity, as a rigorous (i.e. fully accurate) model of the electrodynamic phenomena occurring in the whole system, including the sample, can be developed. However, resonators operate at discrete frequencies (usually at just one frequency), providing substantially less information than is contained in a broad spectrum. Therefore, an auxiliary goal of the project will be to develop a rigorous broadband resonant method for FMR linewidth measurement of thin ferromagnetic films by means of a tunable cavity.

Thin films are most commonly studied with static and magnetic fields tangential its surface. However, interesting phenomena can be observed if the bias static magnetic field is normal to the film. In such a case, it is theoretically possible to excite surface modes in a thin ferromagnetic film, which may be also called magnetic plasmons in analogy to surface modes occurring in thin electrically conductive films. Such plasmons have been already discovered in spherical and cylindrical samples, however, it still lacks experimental confirmation in planar ferromagnetic structures. For those reasons, another auxiliary goal of research will be to find the necessary conditions for the excitation of a magnetic plasmon with the aid of rigorous electromagnetic modeling and, subsequently, confirm the existence of that kind of mode experimentally.

[Pro27] **Optical analysis of electrochemical reaction products in picoliter volumes** (Analiza optyczna pikolitrowych objętości produktów procesów elektrochemicznych), Warsaw University of Technology, Institute of Microelectronics and Optoelectronics, project leader: Mateusz Śmietana, February 2019–February 2022

The main objective of this project is to study the optical response to electrochemical reactions in picoliter volumes inside a microcavity inline Mach-Zehnder interferomenter (μIMZI) fabricated in an optical fiber. We will focus on determination of neurotransmitter concentrations that are difficult to be measured by optical or electrochemical means individually. The work will be performed by a consortium of the group at Institute of Microelectronics and Optoelectronics, Warsaw University of Technology led by Prof. Mateusz Śmietana, the Charge Transfer in Hydrodynamic Systems group at the Institute of Physical Chemistry PAS led by Prof. Martin Jönsson-Niedziółka, and Prof. Marcin Koba from National Institute of Telecommunications.

[Pro27] **Optical fiber biosensing systems for fast and early identification of inflammatory factors** (Światłowodowe systemy biosensoryczne do szybkiego i wczesnego wykrywania czynników zapalnych), OPUS 18, Warsaw University of Technology, Institute of Microelectronics and Optoelectronics, project leader: Mateusz Śmietana, July 2020–July 2023

Accurate and fast medical diagnostics are crucial for fighting with majority of health issues, which include fast-spreading bacterial or viral infection, as well as progressing cancer disease. In medical practice an advanced experience is essential for correct diagnosis, which almost always needs to be supported by a series of examinations and laboratory analysis. These are often very time-consuming, which leads to more rapid spread of the disease, its fast progress or makes the treatment less successful and more expensive. Thus, a great investments are made all over the world on development of novel, more effective, faster, and more functional biosensing architectures and procedures.

Out of available biosensors, these based on optical interactions between sensor and a target biological material are very often considered. The devices are designed for detection of changes in properties of liquids (typically refractive index – RI, absorption, or fluorescence) or changes at the interface of the liquid and the sensor active area (thickness, RI and absorption of the surface layer). When no florescent label is involved and only RI variation in proximity of the sensor surface is monitored, the sensing concept is often called as "label-free". These changes may result from formation of the bio-layer on the surface of the bio-sensor. Optical label-free biosensors offer greatly shortened vs florescent-based

sensors sampling to result time and possibility of target biomaterial binding kinetics measurements. Moreover, when they are based on optical fibers, they offer probe-like character of the sensor, allowing for direct in-vivo analysis, as well as when fiber end-face is used, a small active surface of the sensor that makes possible precise in-spot analysis. However, obtaining highly sensitive and selective optical fiber label-free biosensor is highly challenging, especially when mass production of the sensors is considered.

The main aim of this project is to study the optical response to changes in optical properties at the surface of optical fiber sensors with stack of nano-films at the end-faces. Due to biofunctionalized surface of the stack changes in the optical properties will correspond to concentration of selected inflammatory markers. We claim that optimized in properties stacks can be targeted towards certain size or character of the bound biomolecules, what makes possible their identification in complex biological liquids. In this project we will consider such biological targets as myeloperoxidase and neutrophil elastase that are well-known inflammatory markers belonging to the group of enzymes produced locally by the activated immune cell and play an important role in the inflammation process underlying many pathological conditions. These markers are different in size and character and that is why require different architecture of the stack, but can be tuned using the same "generic" and mass-applicable technology. Moreover, we claim that the sensors can be applicable for in-vivo measurements, even in locations inside human body distant to other sensors, what may be impossible or dangerous for the patient when other types of interrogation are considered.

The work will be performed by a consortium of the group at Institute of Microelectronics and Optoelectronics, Warsaw University of Technology led by Prof. Mateusz Śmietana, group at Division of Immunology, Medical University of Warsaw led by Dr. Tomasz Rygiel, and the group of Surface Nanoengineering at the Institute of Physical Chemistry Polish Academy of Sciences led by Prof. Joanna Niedziółka-Jönsson. The project will include numerical analysis of the nano-film stacks based on measured properties of the films, developing fabrication process, functionalization of the sensor surface, determination of sensing parameters, as well as comparison of the results with other label-based and label-free sensing techniques, and finally determination of the sensor performance in conditions as at in-vivo examinations. For fabrication of the sensors we plan to use advanced physical and chemical vapor deposition techniques tuned towards their application for deposition on optical fibers. As thin film materials will be examined various metal and semiconductor oxides, nitrides and oxy-nitrides, as well as carbon-based materials. Material selection will be determined by the film robustness when stay in contact with pH expected in environments typical for in-vivo experiments.

[Pro29] **Translucent titanium dioxide nanostructures deposited on substrates with complex geometry for photoconversion and sensorics** (Nanostruktury półprzezroczystego ditlenku tytanu osadzane na podłożach o złożonej geometrii do fotokonwersji i sensoryki), CEUS-UNISONO, Warsaw University of Technology, Institute of Microelectronics and Optoelectronics, project leader: Mateusz Śmietana, co-workers: Monika Janik, Emil Pituła, Mariusz Sochacki, April 2021–March 2024

The project aims on fundamental material research on semi-transparent nanostructured surfaces with complex 3D geometry for enhancement of light harvesting and label-free sensing. Titania nanotube arrays with tunable absorption light spectra due to tailoring of the band-gap and nanotube dimension will be in particular studied. Well-defined nanotube arrays will be formed on surfaces with complex geometry to achieve unique light-matter interacting systems. In particular, a double-faced nanotube-array-based system with sequential light absorption and an optical-fibre-based sensor coated with nanotube arrays for label-free sensing of various gases and liquid analytes will be fabricated and investigated.

4.5. Projects Granted by the Polish National Agency for Academic Exchange

[Pro30] **Integrated Electronics and Photonics – development (with the participation of industry representatives) of an M.Sc. program in the area of Electronics including novel educational techniques and taught in English** within the framework of the project "NERW PW Science-Education-Development-Cooperation" financed from Axis III Higher Education for the Economy and Development of the Operational Programme Science Education Development 2014–2020, („Zadanie 13 – Integrated Electronics and Photonics – opracowanie z udziałem przedstawicieli z otoczenia przemysłowego programu kształcenia wykorzystującego nowe formy dydaktyczne na studiach II stopnia na kierunku Elektronika prowadzonych w języku angielskim" w ramach projektu „NERW PW Nauka-Edukacja-Rozwój-Współpraca" finansowanego w marach Osi III Szkolnictwo wyższe dla gospodarki i rozwoju Operacyjnego Wiedza Edukacja Rozwój 2014–2020), project leader: Sławomir Szostak, March 2018–November 2021

[Pro31] **New generation of high thermal efficiency components packages for space** (Nowa generacja obudów podzespołów o wysokiej skuteczności chłodzenia do zastosowań kosmicznych) EU Horizon project – HEATPACK, project leader: Ryszard Kisiel, August 2019–March 2022

HEATPACK project aims to develop and validate critical technology building blocks for enabling transformative packages for space applications with very low thermal resistance. This is to fully exploit the potential of widebandgap technologies which are now being considered as critical in numerous sectors and for space applications in particular, as enhanced thermal management solutions beyond state-of-the-art need to be provided. Benefits will range from improved performance to increased components reliability and lifetime. HEATPACK concepts for achieving high power / high thermal efficiency packages include: – Diamond based composite materials with a thermal conductivity >600 W/m.K to be used as baseplate or insert; – Silver sintering based Thermal Interface Material (TIM 1) for components assembly – TIM2 for package to structure assembly with both electrical and thermal enhanced properties (in excess of 10 W/m.K); – Innovative cooling solutions with strategic implementation possibilities (baseplate, lid, structure…). Using these technologies, two different modules implementing Gallium Nitride (GaN) components will be developed: – A power supply switching module based on a multilayer ceramic substrate – A L-band High Power Amplifier based on a single hermetic micro package, delivering up to 400 W CW output power The main application targeted is the Galileo Second Generation satellite program since thermal management of the GaN HEMT based Solid State Power Amplifier and Electronic Power Conditioner sections currently provide a roadblock due to the very high power levels involved. Other needs are linked to power conditioning notably for digital transparent processor (DTP) targeting very high throughput satellite for telecommunication. To secure a fully European supply chain for high power components thermal management, the technologies developed will reach a TRL of 7, demonstrating commercial viable solutions providing reliability levels compliant with space environments.

9 partners from 7 different countries collaborate in the frame of HEATPACK. IMIO as the project partner is responsible for research and develop new advanced material for thermal interfaces at first level packages (TIM 1).

Microelectronics and Nanoelectronics Devices Division

5. DISSEMINATION OF KNOWLEDGE

5.1. Students Scientific Associations

5.1.1. Students Scientific Association of Microelectronic and Nanoelectronics (KNMiN) (Koło Naukowe Mikroelektroniki i Nanoelektroniki KNMiN)

Association Tutor: Mateusz Śmietana, Ph.D., D.Sc.

In the interests of the Students Scientific Group of Microelectronics and Nanoelectronics are issues mainly related to the technology, design instruments, characterization and application of new materials in the field of optoelectronics and microelectronics. Examples of topics dealt with by the members of the Student Scientific Associacion: preparation and characterization of semiconductor structures, the organization of trips to conferences, workshops and symposia (where group members can get acquainted with the latest achievements in the field of micro-, nano- and optoelectronics, meetings of eminent personalities from the world of modern science and to present the results of their own research).

5.1.2. Student Scientific Association of Optoelectronics (KNO) (Koło Naukowe Optoelektroniki KNO)

Association Tutor: Ryszard Piramidowicz, Ph.D, D.Sc.

Student Association of Optoelectronics formally started in May 2006, however, the custom of nonobligatory student seminar meetings – foundation of our Association – has been successfully continued since 2002. Presently, the Association consists of several students and Ph.D. students of Institute of Microelectronics and Optoelectronics, however graduate professionals complement our ranks, as well.

Main scientific interest covers:

- fiber lasers and amplifiers,
- photonic integrated circuits,
- special optical fibers and fiber components,
- new optically active materials for light sources (polymers, composites, glasses and nanocrystals doped with rare-earth ions).

The goals of Student Association of Optoelectronics:

- popularizing optoelectronics and photonics technology disciplines,
- conducting research and development works in the field of optoelectronics,
- supporting all forms of activity leading to the development of professional skills of KNO members.

5.1.3. Students Scientific Association of Microsystems (ONYKS) (Koło Naukowe Mikrosystemów ONYKS)

Association Tutor: Jakub Jasiński, Ph. D.

The members of the Students Scientific Association are involved in the implementation of various projects (analog, microcontrollers, FPGAs) and have necessary tools to accomplish circuit boards. The scientific interest also includes popularization of electronics among the youth and students.

5.1.4. Student Scientific Association of Integrated Systems (Koło Naukowe Systemów Scalonych)

Association Tutor: Marek Niewiński, Ph. D.

The main areas of interest are: developing mixed analog-digital system using SoC board, designing extension board for SoC, programming microcontrollers and Integrated Circuit design.

5.2. Cooperation with schools

After a one-year break related to the COVID-19 pandemic, the organizers of the STEM PW project in consultation with the community of secondary school teachers decided to organize the third edition of this competition. IMIO employees take an active part in the organization of this project. In December 2021, the first school stage was carried out, which was attended by 501 students from 47 schools from all over Poland. It is worth noting that schools from the top of the Perspektywy ranking entered the competition.

5.3. Photovoltaic Platform, Warsaw University of Technology (PVP) Platforma Fotowoltaiki Politechniki Warszawskiej (PF)

Coordinator:
Ryszard Piramidowicz, Ph.D, D.Sc. Warsaw University of echnology,
Institute of Microelectronics and Optoelectronics

The Photovoltaic Platform was established in 2014 at Warsaw University of Technology in order to increase utilization of the scientific potential and encouraging industry-oriented research services. The Photovoltaic Platform aims to bring together complementary competences of various research groups of WUT, thus creating strong multidisciplinary photovoltaic group capable of successful realization of both large research projects and development of complete solutions for the industry partners. The Photovoltaic Platform core consists of teams from the Faculty of Electronics and Information Technology and Faculty of Physics, as well as teams from other faculties involved in research on various aspects of photovoltaic technologies.

Range of competences of PVP covers all levels of photovoltaics – from physics of the solar cells, structure of modules, inverters and mounting large methods, design, development and performance evaluation of photovoltaic systems up to energy profiles prediction and assessment of grid integration issues. The Platform teams also help prospective investors to evaluate their models of engagement in the photovoltaic market, taking into consideration technical challenges, legal environment and economic feasibility.

Cooperation with industry partners is critical for long term development of photovoltaics at the Warsaw University of Technology. The Photovoltaic Platform cooperates closely with a number of companies interested in taking part in expected rapid development of photovoltaic market. Broad knowledge of Polish photovoltaic market provides the Photovoltaic Platform basis for further development of competences in connection with identified needs of the industry. In parallel with involvement in the cooperation with business partners the Photovoltaic Platform teams remain engaged in a number of research project.

6. DEGREES AWARDED

6.1. Ph.D. Degrees

[DSc1] Komorowski Paweł, **THz radiation multiplexing with the use of non-axial optical diffraction structures** (Multipleksacja promieniowania THz z wykorzystaniem nie-poosiowych optycznych struktur dyfrakcyjnych), June 29

6.2. M.Sc. Degrees

[MSc1] Bagłaj Mateusz, **Implementation of a dual band low noise amplifier (LNA) in 22FDX technology** (Projekt niskoszumnego wzmacniacz dwupasmowego w technologii 22FDX), advisor: Borejko Tomasz, March 12

[MSc2] Gabler Tomasz, **Microcavity Mach-Zehnder interferometer made in optical fiber for label-free detection of viruses with prove of concept verified on SARS-CoV-2** (Mikrownękowy interferometr Macha-Zehndera wytworzony we włóknie światłowodowym do bezznacznikowej detekcji obecności wirusów na przykładzie SARS-CoV-2), advisor: Śmietana Mateusz, February 26

[MSc3] Jęczmień Adam, **Project of the precise, low power voltage reference source (bandgap) in the CMOS 55nm technology** (Projekt niskomocowego źródła napięcia referencyjnego (bandgap) w technologii CMOS 55 nm), advisor: Pleskacz Witold, October 15

[MSc4] Karcz Maciej, **Development of a research platform for measuring QCM resonators for applications in biosensors** (Opracowanie platformy badawczej do pomiarów rezonatorów QCM do zastosowań w biosensorach), advisor: Szostak Sławomir, March 12

[MSc5] Lechowicz Katarzyna, **Investigation of the pressure influence during deposition of indium tin oxide thin films using magnetron sputtering on functional parameters of electrochemical fiber-optic biosensors manufactured with their participation** (Analiza wpywy ciśnienia podczas wytwarzania cienkich warstw tlenku cyny indu z wykorzystaniem rozpylania magnetronowego na parametry funkcjonalne wytworzonych z ich udziałem bioczujników opto-elektrochemicznych), advisor: Śmietana Mateusz, June 25

[MSc6] Lelit Marcin, **Early stage development of SiN-based Integrated Photonics Platform for visible spectral range**, advisor: Piramidowicz Ryszard, March 12

[MSc7] Ludwiniak Marcin, **Implementation of reconfigurable FIR filters in FPGAs with the use of distributed arithmetic** (Implementacja rekonfigurowalnych filtrów SOI w układach FPGA z wykorzystaniem arytmetyki rozproszonej), advisor: Piwowarska Elżbieta, October 8

[MSc8] Świnarski Grzegorz, **Software for simulation of multilayer MIS semiconductor structures** (Oprogramowanie do symulacji wielowarstwowych struktur półprzewodnikowych MIS), advisor: Król Krystian, March 12

[MSc9] Zaorski Wiktor, **A measurement method for determining heart rate and respiration rate with the use of fiber Bragg gratings** (Metoda pomiaru parametrów życiowych na podstawie sygnałów ze światłowodowych siatek Bragga), advisor: Stopiński Stanisław, February 26

6.3. B.Sc. Degrees

[BSc1] Basior Krzysztof, **Implementation of selected diagnostic algorithms for analog electronic circuits** (Implementacja wybranych algorytmów diagnostyki analogowych układów elektronicznych), advisor: Kasprowicz Dominik, June 25

[BSc2] Dąbrowski Piotr, **Multi-platform application for communication with measuring devices using the IEEE-488 standard** (Wieloplatformowa aplikacja do komunikacji z urządzeniami pomiarowymi z wykorzystaniem standardu IEEE-488), advisor: Niewiński Marek, June 30

[BSc3] Harbaszewski Kamil, **Program for automatic calibration of transistor models** (Program do automatycznej kalibracji modeli tranzystorów), advisor: Kasprowicz Dominik, September 23

[BSc4] Hayder Maria, **Algorithms detecting plagiarism in integrated circuit layouts** (Algorytmy wykrywające plagiaty topografii układów scalonych), advisor: Kasprowicz Dominik, June 25

[BSc5] Jabłoński Patryk, **Analysis of nonlinear parity-time symmetric Bragg gratings** (Analiza nieliniowych siatek braggowskich wykazujących parzystą symetrię), advisor: Mossakowska-Wyszyńska Agnieszka, February 5

[BSc6] Jerominiak Maciej, **Optical power limiter based on the structure of hyperbolic metamaterial** (Optyczny organicznik mocy oparty na strukturze metamateriału hiperbolicznego), advisor: Tyszka-Zawadzka Anna, September 23

[BSc7] Kaczmarski Robert, **Dispersion properties of hyperbolic metamaterials** (Właściwości dyspersyjne metamateriałów hiperbolicznych), advisor: Tyszka-Zawadzka Anna, September 23

[BSc8] Leszczyński Łukasz, **Air quality meter** (Miernik jakości powietrza), advisor: Jaworski Zbigniew, June 25

[BSc9] Łysomirski Damian, **Production and characterization of anti-reflection coatings for the needs of photovoltaics** (Wytwarzanie i charakteryzacja powłok antyrefleksyjnych na potrzeby fotowoltaiki), advisor: Firek Piotr, June 25

[BSc10] Markowski Andrzej, **Desing of integrated circuit of power amplifier for FMCW radar working in a Ka band** (Projekt scalonego wzmacniacza mocy dla radaru FMCW pracującego w paśmie Ka), advisor: Pleskacz Witold, September 23

[BSc11] Miazek Mikołaj, **Stand for time-resolved excitation spectra measurements** (Stanowisko do pomiarów rozdzielczych w czasie widm wzbudzeniowych), advisor: Kaczkan Marcin, October 8

[BSc12] Pierzchała Adam, **Website for training and testing in Occupational Safety and Health involving e-learning** (Projekt witryny internetowej do przeprowadzania szkoleń i testów z zakresu Bezpieczeństwa i Higieny Pracy z wykorzystaniem e-learningu), advisor: Witoński Piotr, February 5

[BSc13] Pietrusiewicz, **Structures based on two dimensional materials – technology and characterization** (Struktury bazujące na materiałach dwuwymiarowych – technologia i charakteryzacja), advisor: Mroczyński Robert, September 30

[BSc14] Polański Konrad, **Dedicated programming library to control the operation of OLED displays on the Cypress PSoC platform** (Dedykowana biblioteka programistyczna do sterowania pracą wyświetlaczy OLED na platformie Cypress PSo), advisor: Niewiński Marek, February 18

[BSc15] Popowski Dominik, **System for archivizing and taking measurments in the orchid** (System do pomiaru i archiwizacji danych w gospodarstwie sadowniczym), advisor: Szostak Sławomir, February 12

[BSc16] Stępniewski Kamil, **A temperature sensor implemented in HHGrace 90 nm technology** (Projekt układu scalonego do pomiaru temperatury w technologii HHGrace 90 nm), advisor: Siwiec Krzysztof, September 30

[BSc17] Sudowski Dawid, **Costas digital loop for carrier frequency recovery in QPSK modulations** (Cyfrowy układ pętli Costasa do odtwarzania częstotliwości nośnej w modulacjach QPSK), advisor: Pleskacz Witold, February 12

[BSc18] Szczerek Wiktor, **Microprocessor-based system for detection of selection of gasses with a notify function** (Mikroprocesorowy system do detekcji wybranych gazów z funkcją powiadamiania), advisor: Niewiński Marek, February 18

[BSc19] Warszewski Jakub, **Thin metal oxides films deposited with magnetron sputtering for application in optical fiber sensing** (Cienkie warstwy tlenków metali wytwarzane metodą rozpylania magnetronowego na potrzeby czujników światłowodowych), advisor: Śmietana Mateusz, June 25

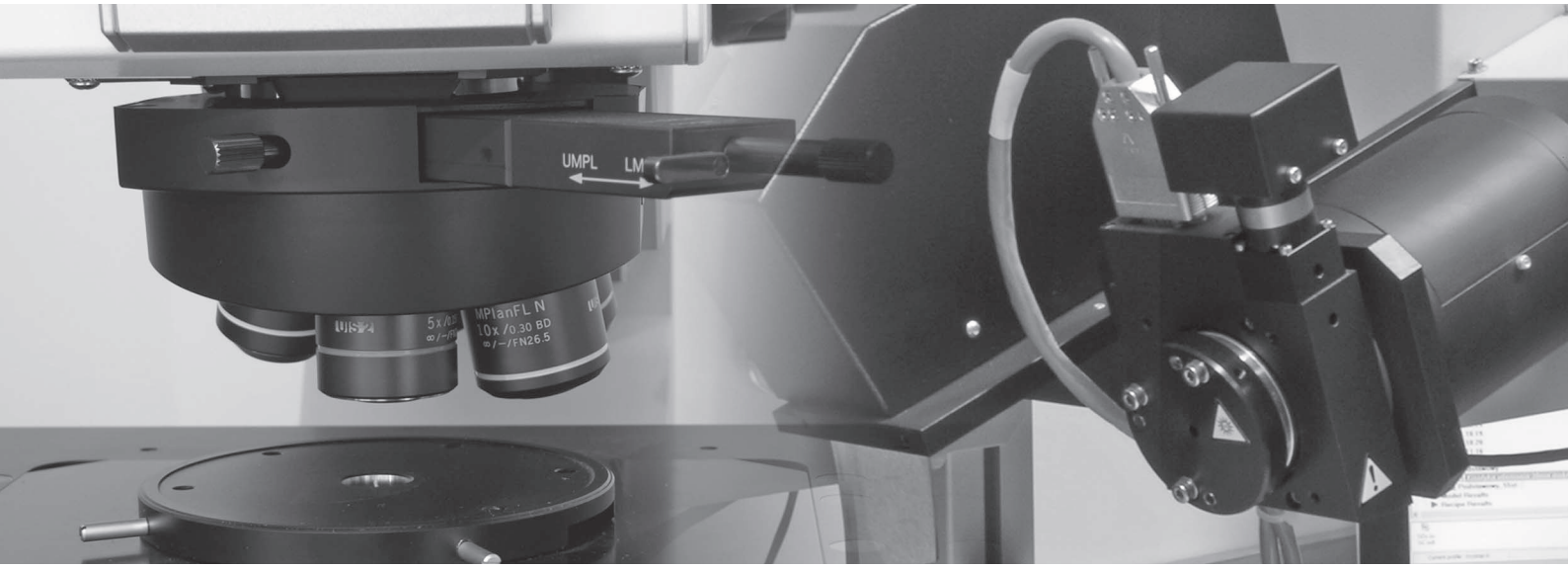
[BSc20] Waśkiewicz Julia, **Design of a sequential digital fuzzy logic controller in nanoscale CMOS technology** (Projekt cyfrowego sterownika rozmytego o architekturze szeregowej w nanometrowej technologii CMOS), advisor: Wielgus Andrzej, September 23

[BSc21] Wierzchowski Jacek, **Application to remote work on PyBoard systems** (Aplikacja do zdalnej pracy z układami PyBoard), advisor: Niewiński Marek, October 8

[BSc22] Wolski Krzysztof, **Finding the image center of mass of objects using image processing and analysis techniques** (Wyznaczanie środka ciężkości obiektów z wykorzystaniem technik przetwarzania i analizy obrazów), advisor: Sutkowski Marek, October 8

[BSc23] Woźniak Patryk, **Wireless monitoring with dedicated mobile application** (Bezprzewodowy monitoring z dedykowaną aplikacją mobilną), advisor: Niewiński Marek, June 30

[BSc24] Zawadzki Krzysztof, **Development of an autonomous driver for semiconductor probe station** (Opracowanie autonomicznego sterownika dla ostrzowego stanowiska do pomiaru struktur półprzewodnikowych), advisor: Król Krystian, October 8



Electronic Materials and Microsystem Technology Division

7. PUBLICATIONS

7.1. Scientific and Technical Papers published in Journals Included in the JCR[1] Database

NUMBER	JOURNAL	AUTHORS	TITLE	DOI	VOLUME	PAGES
[Pub1]	Acta Physica Polonica A	Wiśniewski P., Majkusiak B.	Theoretical Study of Current-Voltage Characteristics of Electron-Hole Bilayer Tunnel Field Effect Transistors of Different Channel Semiconductors	10.12693/aphyspola.140.186	140	186–191
[Pub2]	Applied Optics	Zdanowicz M., Mroczyński R., Szczepański P.	Strong second-harmonic response from semiconductor-dielectric interfaces	10.1364/AO.414255	60	1132––1136
[Pub3]	Applied Physics Letters	Salski B., Cuper J., Karpisz T., Kopyt P., Krupka J	Complex permittivity of common dielectrics in 20-110 GHz frequency range measured with a Fabry-Perot open resonator	10.1063/5.0054904	vol. 119 no 052902	1–5
[Pub4]	Applied Sciences-Basel	Komorowski P., Czerwińska P., Kałuża M., Surma M.J., Zagrajek P., Sobczyk A., Ciurapiński W., Piramidowicz R., Siemion A.	Frequency Division Multiplexing of Terahertz Waves Realized by Diffractive Optical Elements	10.3390/app11146246	vol. 11 no 6246	
[Pub5]	Biomedical Optics Express	Krej M., Osuch T., Anuszkiewicz A., Stopiński S.T., Anders K.P., Matuk K., Weigl A., Tarasow E., Piramidowicz R., Dziuda Ł.	Deep learning-based method for continuous detection of heart rate in signals from a multi-fiber Bragg grating sensor compatible with magnetic resonance imaging	10.1364/boe.441932	12	7790––7806
[Pub6]	Bulletin of The Polish Academy of Sciences, Technical Sciences	Mossakowska-Wyszyńska A., Witoński P., Szczepański P.	Operation of Fabry-Perot laser with nonlinear PT-symmetric mirror	10.24425/bpasts.2021.139202	vol. 69 no 139202	1–11
[Pub7]	Electronics (Switzerland)	Butryn I., Siwiec K., Pleskacz W.	Hybrid Cross Coupled Differential Pair and Colpitts Quadrature Digitally Controlled Oscillator Architecture	10.3390/electronics10101132	vol. 10 no 1132	1–14
[Pub8]	Electronics (Switzerland)	Butt M.A., Kaźmierczak A., Kazanskiy N.L., Khonina S.N.	Metal-Insulator-Metal Waveguide-Based Racetrack Integrated Circular Cavity for Refractive Index Sensing Application	10.3390/electronics10121419	vol. 10 no 1419	1–12
[Pub9]	Electronics (Switzerland)	Karasiński P., Kaźmierczak A., Zięba M., Tyszkiewicz C., Wojtasik K., Kielan P.	Highly Sensitive Sensor Structure Based on Sol-Gel Waveguide Films and Grating Couplers	10.3390/electronics10121389	vol. 10 no 1389	1–18
[Pub10]	Electronics (Switzerland)	Kasprowicz D.K., Hayder M.	Net-Shape-Based Automated Detection of Integrated-Circuit Layout Plagiarism	10.3390/electronics10243181	vol. 10 no 3181	1–14

[1] Journal Citation Reports; https://jcr.clarivate.com

PUBLICATIONS

[Pub11]	Electronics (Switzerland)	Kazanskiy N.L., Khonina S.N., Butt M.A., Kaźmierczak A., Piramidowicz R.	State-of-the-Art Optical Devices for Biomedical Sensing Applications–A Review	10.3390/electronics 10080973	vol. 10 no 973	1–29
[Pub12]	Electronics (Switzerland)	Khonina S.N., Volotovskiy Sergey G., Dzyuba A.P., Serafimovich P.G., Popov S.B., Butt M.A.	Power Phase Apodization Study on Compensation Defocusing and Chromatic Aberration in the Imaging System	10.3390/electronics 10111327	vol. 10 no 1327	
[Pub13]	Electronics (Switzerland)	Kuźmicz W.	Linearization Technique of Low Power Opamps in CMOS FD-SOI Technologies	10.3390/electronics 10151800	vol. 10 no 1800	1–12
[Pub14]	Electronics (Switzerland)	Pietroń D., Borejko T., Pleskacz W.	Active Balun with Center-Tapped Inductor and Double-Balanced Gilbert Mixer for GNSS Applications	10.3390/electronics 10111351	vol. 10 no 1351	1–20
[Pub15]	Frontiers in Materials	Li J., Choi D., Śmietana M.	Editorial: Novel Smart Materials for Optical Fiber Sensor Development	10.3389/fmats. 2021.671086	vol. 8 no 671086	1–2
[Pub16]	International Journal of Electrical Engineering Education	Kuźmicz W.	Introduction to microelectronic design in a distance learning program	10.1177/002072092 1996588		1–12
[Pub17]	Journal of Magnetism And Magnetic Materials	Krupka J., Pacewicz A., Salski B.W., Kopyt P., Bourhill J., Goryachev M., Tobar M.E.	Resonances in large ferrimagnetic YIG samples – Electrodynamic analysis	10.1016/j.jmmm. 2020.167536	vol. 521 no 167536	1–8
[Pub18]	Journal Of Optics	Khonina S.N., Butt M.A., Kazanskiy N.L.	Numerical investigation of metasurface narrowband perfect absorber and a plasmonic sensor for a near-infrared wavelength range	10.1088/2040-8986/abf890	vol. 23 no 065102	
[Pub19]	Journal of Thermal Analysis And Calorimetry	Głuchowska H., Łyszczek R., Jusza A.M., Piramidowicz R.	Effect of N,N -dimethylformamide solvent on structure and thermal properties of lanthanide(III) complexes with flexible biphenyl-4,4 -dioxydiacetic acid	10.1007/s10973-020-10435-1	vol. 147	1187––1200
[Pub20]	Lab on A Chip	Gabler T., Krześniak A., Janik M., Myśliwiec A.K., Koba M., Buczyńska J., Jonsson-Niedziolka M., Śmietana M.J.	Electrochemistry in an Optical Fiber Microcavity – Optical Monitoring of Electrochemical Processes in Picoliter Volumes	10.1039/D1LC0 0324K	vol. 21	2763––2770
[Pub21]	Lab on A Chip	Janik M., Hamidi S.V., Koba M., Perreault J., Walsh R., Bock W.J., Śmietana M.J.	Real-time isothermal DNA amplification monitoring in picoliter volumes using an optical fiber sensor	10.1039/D0LC0 1069C	vol. 21	397–404
[Pub22]	Materials	Fetliński B., Turczyński S., Malinowski M., Szczepański P.	Down-Shifting in the YAM: Ce^{3+} + Yb^{3+} System for Solar Cells	10.3390/ma141 12753	vol. 14 no 2753	1–13

[Pub23]	Materials	Gil-Kowalczyk M., Łyszczek R., Jusza A.M., Piramidowicz R.	Thermal, Spectroscopy and Luminescent Characterization of Hybrid PMMA/Lanthanide Complex Materials	10.3390/ma14 123156	vol. 14 no 3156	1–20
[Pub24]	Materials	Janaszek B., Szczepański P.	Distributed Feedback Laser Based on Tunable Photonic Hypercrystal	10.3390/ma14 154065	vol. 14 no 4065	1–13
[Pub25]	Materials	Janaszek B., Tyszka-Zawadzka A., Szczepański P.	Influence of Spatial Dispersion on Propagation Properties of Waveguides Based on Hyperbolic Metamaterial	10.3390/ma14 226885	vol. 14 no 6885	1–16
[Pub26]	Materials	Janaszek B., Kieliszczyk M., Szczepański P.	Nonlocality-Enabled Magnetic Free Optical Isolation in Hyperbolic Metamaterials	10.3390/ma14 112865	vol. 14 no 2865	1–12
[Pub27]	Materials	Judek J., Wróbel P., Michałowski P. Piotr, Ożga M., Witkowski B.S., Seweryn A., Struzik M., Jastrzębski C., Zberecki K.	Titanium Nitride as a Plasmonic Material from Near-Ultraviolet to Very-Long-Wavelength Infrared Range	10.3390/ma14 227095	vol. 14	7095
[Pub28]	Materials	Kaczkan M.P., Malinowski M.	Optical Transitions and Excited State Absorption Cross Sections of $SrLaGaO_4$ Doped with Ho^{3+} Ions	10.3390/ma14 143831	vol. 14 no 3831	1–14
[Pub29]	Materials	Krupka J.	Microwave Measurements of Electromagnetic Properties of Materials	10.3390/ma14 175097	vol. 14 no 5097	1–21
[Pub30]	Materials	Schiavon D., Mroczyński R., Kafar A., Kamler G., Levchenko I., Najda S., Perlin P.	Refractive Index of Heavily Germanium-Doped Gallium Nitride Measured by Spectral Reflectometry and Ellipsometry	10.3390/ma14 237364	vol. 14 no 7364	1–10
[Pub31]	Materials	Seweryn A., Ławniczak--Jabłońska K., Kuzmiuk P., Gierałtowska S., Godlewski M., Mroczyński R.	Investigations of Structural and Electrical Properties of ALD Films Formed with the Ozone Precursor	10.3390/ma14 185395	vol. 14 no 5395	1–14
[Pub32]	Materials	Wiśniewski P., Jasiński J., Mazurak A., Stonio B., Majkusiak B.	Investigation of Electrical Properties of the $Al/SiO_2/n++$-Si Resistive Switching Structures by Means of Static, Admittance, and Impedance Spectroscopy Measurements	10.3390/ma14 206042	vol. 14 no 6042	1–13
[Pub33]	Materials Research Express	Świniarski M., Wróblewska A., Dużyńska A., Zdrojek M., Judek J.	Kinetics of the thermal reduction process in graphene oxide thin films from in-situ transport measurements	10.1088/2053-1591/abdc50	vol. 8 no 015601	1–8
[Pub34]	Materials Science in Semiconductor Processing	Pągowska K., Kozubal M., Taube A., Kruszka R., Kamiński M., Kwietniewski N., Juchniewicz M., Szerling A.	The interplay between damage- and chemical-induced isolation mechanism in Fe+-implanted AlGaN/GaN HEMT structures	10.1016/j.mssp. 2021.105694	vol. 127 no 105694	1–6
[Pub35]	Materials Science in Semiconductor Processing	Taube A., Kamiński M., Ekielski M., Kruszka R., Jankowska-Śliwińska J., Michałowski P., Zdunek J., Szerling A.	Selective etching of p-GaN over Al0.25Ga0.75N in Cl_2/Ar/O2 ICP plasma for fabrication of normally-off GaN HEMTs	10.1016/j.mssp. 2020.105450	vol. 122 no 105450	1–7

[Pub36]	Measurement	Borecki M., Rychlik A., Vrublevskyi O., Olejnik A., Korwin-Pawlowski M.L.	Method of Non-Invasive determination of wheel rim technical condition using vibration measurement and artificial neural network	10.1016/j.measurement.2021.110050	vol. 185 no 110050	1–8
[Pub37]	Measurement	Judek J., Wilczyński K., Piotrowski J.	Measurements of optical properties of liquids in a quartz cuvette: Rigorous model, uncertainty analysis and comparison with popular approximations	10.1016/j.measurement.2021.109069	vol. 174 no 109069	1–11
[Pub38]	Nanomaterials	Kazanskiy N.L., Khonina S.N., Butt M.A., Kaźmierczak A., Piramidowicz R.	A Numerical Investigation of a Plasmonic Sensor Based on a Metal-Insulator-Metal Waveguide for Simultaneous Detection of Biological Analytes and Ambient Temperature	DOI:10.3390/nano11102551	vol. 11 no 2551	1–14
[Pub39]	Optica Applicata	Butt M.A., Kazanskiy N.L.	Nanoblocks embedded in L-shaped nanocavity of a plasmonic sensor for best sensor performance	10.37190/oa210109	vol. 51	109–120
[Pub40]	Optics And Laser Technology	Kazanskiy N.L., Butt M.A., Khonina S.N.	Silicon photonic devices realized on refractive index engineered subwavelength grating waveguides-A review	10.1016/j.optlastec.2020.106863	vol. 138 no 106863	
[Pub41]	Optics and Laser Technology	Pituła E., Koba M., Śmietana M.	Which smartphone for a smartphone-based spectrometer?	10.1016/j.optlastec.2021.107067	vol. 140 no 107067	1–8
[Pub42]	Optics Express	Khonina S.N., Kazanskiy N.L., Butt M.A., Kaźmierczak A., Piramidowicz R.	Plasmonic sensor based on metal-insulator-metal waveguide square ring cavity filled with functional material for the detection of CO_2 gas	10.1364/oe.423141	vol. 29	16584––16594
[Pub43]	Optics Express	Komorowski P., Czerwińska P., Surma M.J., Zagrajek P., Piramidowicz R., Siemion A.	Three-focal-spot terahertz diffractive optical element-iterative design and neural network approach	10.1364/OE.418059	vol. 29	11243––11253
[Pub44]	Optics Express	Starobrat J., Fiderkiewicz S., Kołodziejczyk A., Sypek M., Beck R., Pavłov K., Słowikowski M., Kowalczyk A., Suszek J., Makowski M.	Suppression of spurious image duplicates in Fourier holograms by pixel apodization of a spatial light modulator	10.1364/oe.441489	vol. 29	40259––40273
[Pub45]	Optics Letters	Meng F., Zhao X., Ding J., Niu Y., Zhang X., Śmietana M., Buczyński R., Lin B., Tao G., Yang L., Wang X., Lou S., Sheng X., Liang S.	Use of machine learning to efficiently predict the confinement loss in anti-resonant hollow-core fiber	10.1364/ol.422511	vol. 46	1454––1457
[Pub46]	Optoelectronics and Advanced Materials-Rapid Communications	Kazanskiy N.L., Kaźmierczak A., Butt M.A.	Why slot and hybrid plasmonic waveguides are ideal candidates for sensing applications?		vol. 15	195–206
[Pub47]	Photonic Sensors	Yang X., Gong C., Liu Y., Rao Y., Śmietana M., Gong Y.	Recent Progress in Fiber Optofluidic Lasing and Sensing	10.1007/s13320-021-0622-9	vol. 11	262–278

[Pub48]	Photonics And Nanostructures-Fundamentals And Applications	Butt M.A., Khonina S.N., Kazanskiy N.L.	2D-Photonic crystal heterostructures for the realization of compact photonic devices	10.1016/j.photonics.2021.100903	vol. 44 no 100903	
[Pub49]	Physica Scripta	Khonina S.N., Kazanskiy N.L., Butt M.A.	Spectral characteristics of broad band-rejection filter based on Bragg grating, one-dimensional photonic crystal, and subwavelength grating waveguide	10.1088/1402-4896/abe6be	vol. 96 no 055505	
[Pub50]	Przegląd Elektrotechniczny	Kamiński M., Brzozowski E., Taube A., Sadowski O., Król K.B., Guziewicz M.	Wpływ procesów utleniania i wygrzewania w atmosferze zawierającej fosfor lub azot na jakość międzypowierzchni dielektryk/półprzewodnik w strukturze MOS Ti/SiO_2/4H-SiC	10.115199/48.2021.02.23	vol. 97	99–104
[Pub51]	Przegląd Elektrotechniczny	Kisiel R., Śpiewak P., Kruszewski M.J.	Technologia SLID w montażu GaN-on-Si do podłoży Cu	10.15199/48.2021.02.15	vol. 97	60–63
[Pub52]	Przegląd Elektrotechniczny	Stonio B., Kwietniewski N., Firek P., Sochacki M.	Reactive ion etching of 4H-SiC with BCl 3 plasma	10.15199/48.2021.02.14	vol. 97	57–59
[Pub53]	Sensors	Butt M.A., Kaźmierczak A., Tyszkiewicz C., Karasiński P., Piramidowicz R.	Mode Sensitivity Exploration of Silica –Titania Waveguide for Refractive Index Sensing Applications	10.3390/s2122 7452	vol. 21 no 7452	1–14
[Pub54]	Sensors	Kazanskiy N.L., Butt M.A., Khonina S.N.	Carbon Dioxide Gas Sensor Based on Polyhexamethylene Biguanide Polymer Deposited on Silicon Nano-Cylinders Metasurface	10.3390/s21020378	vol. 21 no 378	
[Pub55]	Sensors	Khonina S.N., Karpeev S.V., Butt M.A.	Spatial-Light-Modulator-Based Multichannel Data Transmission by Vortex Beams of Various Orders	10.3390/s21092988	vol. 21 no 2988	
[Pub56]	Sensors	Khonina S.N., Kazanskiy N.L., Khorin P.A., Butt M.A.	Modern Types of Axicons: New Functions and Applications	10.3390/s21196690	vol. 21 no 6690	1–30
[Pub57]	Sensors	Słowikowski M., Kaźmierczak A., Stopiński S., Bieniek M., Szostak S., Matuk K., Augustin L., Piramidowicz R.	Photonic Integrated Interrogator for Monitoring the Patient Condition during MRI Diagnosis	10.3390/s21124238	vol. 21 no 4238	
[Pub58]	Sensors And Actuators B - Chemical	Janik M., Brzozowska E., Czyszczoń P., Celebańska A., Koba M., Gamian A., Bock W.J., Śmietana M.J.	Optical fiber aptasensor for label-free bacteria detection in small volumes	10.1016/j.snb.2020.129316	vol. 330 no 129316	1–10
[Pub59]	Sensors And Actuators B – Chemical	Sezemsky P., Burnat D., Kratochvil J., Wul H., Kruth A., Lechowicz K., Janik M., Bogdanowicz R., Cada M., Hubicka Z., Niedziałkowski P., Białobrzeska W., Stranak V., Śmietana M.	Tailoring properties of indium tin oxide thin films for their work in both electrochemical and optical label-free sensing systems	10.1016/j.snb.2021.130173	vol. 343 no 130173	1–11
[Pub60]	Solid-State Electronics	Mazurak A., Majkusiak B.	Investigation of the anomalous effect of the AC-signal frequency on flat-band voltage of Al/HfO_2/SiO_2/Si structures	10.1016/j.sse.2021.108107	vol. 183 no 108107	1–5

[Pub61]	The Journal of Physical Chemistry Part C: Nanomaterials, Interfaces And Hard Matter	Gertych A.P., Czerniak-Łosiewicz K., Łapińska A., Świniarski M., Ojrzyńska M., Judek J., Zdrojek M.	Phonon and Thermal Properties of Thin Films Made from WS2 Mono- and Few-Layer Flakes	10.1021/acs.jpcc.1c02842	vol. 125	14446–14452
[Pub62]	Thin Solid Films	Okrasa S., Wilczopolska M., Strzelecki G., Nowakowska-Langier K., Chodun R., Minikayev R., Król K., Skowroński Ł., Namyślak K., Wicher B., Wiraszka A., Zdunek K.	The influence of thermal stability on the properties of Cu_3N layers synthesized by pulsed magnetron sputtering method	10.1016/j.tsf.2021.138889	vol. 735 no 138889	1–8
[Pub63]	Ultramicroscopy	Jóźwik I., Jagielski J., Dumiszewska E., Kamiński M., Kentsch U.	Resistivity contrast imaging in semiconductor structures using ultra-low energy scanning electron microscopy	10.1016/j.ultramic.2021.113333	vol. 228 no 113333	1–6

7.2. Scientific and Technical Papers Published in Journals not Included in the JCR Database

NUMBER	JOURNAL	AUTHORS	TITLE	DOI	ARTICLE NUMBER	PAGES
[Pub64]	arXiv	Sujecki S., Sojka L., Bereś-Pawlik E., Piramidowicz R., Sakr H., Tang W. Z., Barney E., Furniss D., Benson T.M., Seddon A.B.	A study of MIR photoluminescence from Pr^{3+} doped chalcogenide fibers pumped at near-infrared wavelengths		2104.14983	1–7
[Pub65]	Chemrxiv	Gabler T., Krześniak A., Janik M., Myśliwiec A.K., Koba M., Buczyńska J., Jonsson-Niedziolka M., Śmietana M.J.	Electrochemistry in an Optical Fiber Microcavity – Optical Monitoring of Electrochemical Processes in Picoliter Volumes	10.26434/chemrxiv.14330384		1–12

7.3. Scientific and Technical Papers Published in Conference Proceedings

NUMBER	PROCEEDINGS OF CONFERENCE / ISBN	AUTHORS	TITLE	DOI, ARTICLE NUMBER	PAGES
[Pub66]	Conference on Lasers and Electro-Optics (CLEO) ISBN 978-1-943580-91-0	Mroczyński R., Kosińska D.	Tailoring optical properties of conductive/dielectric layers and their periodic stacks using DoE method	10.1364/cleo_at.2021.jth3a.74, JTh3A.74	1–1
[Pub67]	IEEE MTT-S International Microwave Symposium (IMS) ISBN 978-1-6654-3141-5	Cuper J., Salski B., Krupka J., Kopyt P.	Measurement of Dielectric Materials of High Anisotropy Ratio with TM0n0 Cavity	10.1109/IMS19712.2021.9574977	1–5
[Pub68]	International Conference on Advances in Electronic and Photonic Technologies ISBN 978-80-554-1806-3	Grochowska M., Pleskacz W.	The Impact of Well-Edge Proximity Effect on MOS Threshold Voltage in Submicron CMOS Technologies		99–102

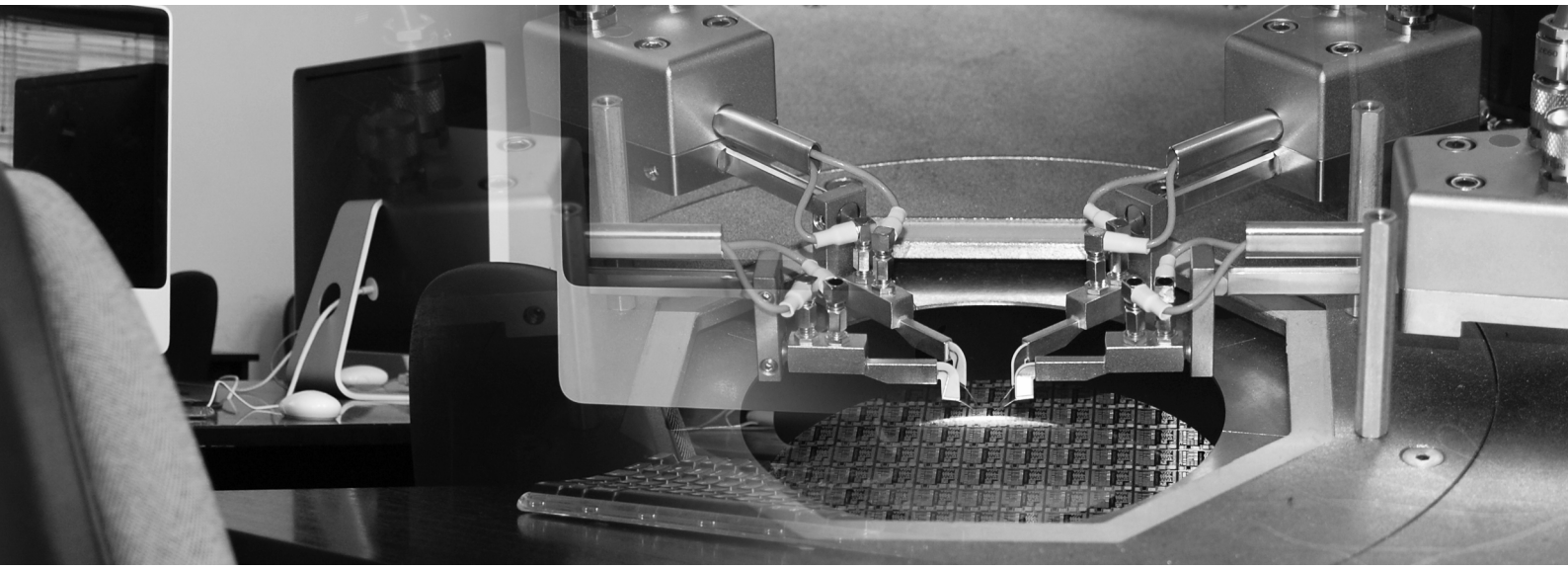
[Pub69]	International Conference on Advances in Electronic and Photonic Technologies ISBN 978-80-554-1806-3	Stępniewski K., Siwiec K.	A Precise Temperature Sensor with Polynomial Calibration		159–162
[Pub70]		Wiechowski Ł., Pleskacz W.	Fully-Integrated Intermediate Frequency Stage of Dual-Frequency Multi-System Global Navigation Satellite System (GNSS) Receiver in CMOS 110 nm Technology		171–174
[Pub71]	Joint International EUROSOI Workshop and International Conference on Ultimate Integration on Silicon (EUROSOI-ULIS) ISBN 978-1-6654-3746-2	Mroczyński R.	Incorporation of silicon-carbide (SiC) nanocrystals in the MIM structures based on pulsed-DC reactively sputtered HfO_x layers	10.1109/EuroSOI-ULIS53016.2021.9560175	1–4
[Pub72]		Wiśniewski P., Jasiński J., Mazurak A.	Conductance modulation in Al/SiO_2/n-Si MIS resistive switching structures	10.1109/EuroSOI-ULIS53016.2021.9560674	1–4
[Pub73]	SPIE International Congress on Optics and Optoelectronics: Metamaterials XIII, vol. 11769 ISBN 9781510643727	Janaszek B., Kieliszczyk M., Tyszka-Zawadzka A., Szczepański P.	Strong nonlocality in hyperbolic metamaterials	10.1117/12.2591851, 117690J	1–7
[Pub74]		Janaszek B., Szczepański P.	Analysis of threshold generation in DFB laser based on hypercrystal	10.1117/12.2591850, 117690I	1–5
[Pub75]	SPIE Optical Metrology: Optics for Arts, Architecture, and Archaeology VIII, vol. 11784 ISBN 9781510644021	Papanikolaou A., Garbat P., Kujawińska M.	Colour digital image correlation method for monitoring of cultural heritage objects with natural texture	10.1117/12.2592549, 1178418	1–12
[Pub76]	13th International Conference on Electromagnetic Wave Interaction with Water and Moist Substances (ISEMA) ISBN 978-1-7281-8738-9	Krupka J., Salski B., Kopyt P., Derzakowski K., Czekała P., Mazierska J.	Complex Permittivity of Mixtures of Sand With Aqueous NaCl Solutions Measured at 2.5 GHz	10.1109/ISEMA49699.2021.9508327	1–3
[Pub77]		Skierucha W., Kafarski M., Wilczek A., Szypłowska A., Jones S., Sabouroux P., Robinson D., Krupka J., Lewandowski A.	Towards standardization of electromagnetic soil moisture measurements	10.1109/isema49699.2021.9508309	1–4
[Pub78]	28th International Conference Mixed Design of Integrated Circuits and Systems MIXDES, vol. CFP21MIX-CDR ISBN 978-83-63578-19-0	Niewiński M., Szczerek W.	A Microcontroller Based System for the Selected Gases Detection with Alert Feature	10.23919/mixdes52406.2021.9497544	257–260
[Pub79]		Pieńczuk P., Pleskacz W., Teodorowski M.	Class AB Operational Amplifier in CMOS 55 nm Technology	10.23919/MIXDES52406.2021.9497543	90–93
[Pub80]		Wojtasik A.	Queuing Parallel Computing CAD Tasks in the Design and Optimization of IC Topography	10.23919/mixdes52406.2021.9497623	132–136
[Pub81]	44th International Spring Seminar on Electronics Technology (ISSE) ISBN 978-1-6654-3061-6	Kisiel R., Śpiewak P., Kruszewski M.	Ag-based Thermal Interface Materials for GaN-on-Si Assembly Chips in Power Applications	10.1109/isse51996.2021.9467637	1–4

7.4. Scientific and Technical Books

NUMBER	AUTHORS	PUBLISHER / ISBN	TITLE	PAGES
[Pub82]	Kasprowicz G., Szmidt J., Kuś M., Poźniak K., Wawrzyniak Z., Kulpa K., Nowicka D., Sowiński M., Szczepański P., Życzkowski M., Paweł M., Markowski P., Fiderkiewicz S., Pakuła A., Nawrat A., Miszczak J., Jędrasiak K., Daniec K., Borecki M., Kuczerski T., Kawałek R., Sadowski M., Suleja W., Witkowski P.	Fotonika w wojskowej i cywilnej rewolucji technologicznej XXI wieku / Andrzejczak Mariusz (eds.), Wydawnictwo Wojskowego Instytutu Technicznego Uzbrojenia ISBN 978-83-962484-4-2	Koncepcja modularnej infrastruktury komputera kwantowego do cywilnych i specjalnych zastosowań informatycznych (rozdział XIV)	217–245
[Pub83]	Kosiel K., Śmietana M.	Optical Fibre Sensors: Fundamentals for Development of Optimized Devices / Villar Ignacio Del, Matias Ignacio R. (eds.), IEEE Press Series on Sensors, John Wiley & Sons ISBN 978-1-119-53476-1	Detection in Harsh Environments, DOI:10.1002/9781119534730.ch13	441–476
[Pub84]	Sutkowski M. research team member, author of photographs 69–77	Polskie Wydawnictwo Fotograficzne ISBN 978-83-924694-8-3	Dederko W., Dybowski C., O fotografowaniu architektury	1–272

8. PATENTS

[Pat1]	Kuźmicz Wiesław, Tatarkiewicz Jan, **Method and Apparatus for highly effective on-chip true random number generator utilizing beta decay**, Invention, Protected, Application number: US 011249725, Application date: 24-08-2021
[Pat2]	Słowikowski Mateusz, **A six-channel transmitting circuit in integrated photonics technology on an indium phosphide platform** (Sześcio-kanałowy układ nadawczy w technologii fotoniki scalonej na platformie fosforku indu), Topography of integrated circuits, Patent/rights number: S.0074, Patent (decision) date: 15-09-2021
[Pat3]	Sutkowski Marek, Zacharovas Stanislovas, **Method of generating a document with safety element and a secured document** (Sposób generowania dokumentu z zabezpieczeniem oraz zabezpieczony dokument), Patent/rights numer: PL 239606, Patent (decision) date: 15-10-2021
[Pat4]	Tatarkiewicz Jan, Borodziński Janusz, Kuźmicz Wiesław, **Apparatus, systems, and methods for beta decay based true random number generator**, Invention, Protected, Application number: US 202017062037, Patent/rights number: US 11036473, Patent (decision) date; 15-06-2021
[Pat5]	Tatarkiewicz Jan, Borodziński Janusz, Kuźmicz Wiesław, Tatarkiewicz Krystyna: **Method and Apparatus for tritium-based true random number generator**, Invention, Protected, Application number: US 202017126265, Patent/rights number: US 11048478, Patent (decision) date: 29-06-2021
[Pat6]	Tatarkiewicz Jan, Borodziński Janusz, Kuźmicz Wiesław: **Apparatus, systems, and methods for beta decay based true random number generator**, Invention, Protected, Application number: US 202016990087, Patent/rights number: US 10901695, Patent (decision) date: 26-01-2021



VLSI Engineering
and Design Automation Division

9. REPORTS

NUMBER	AUTHORS	TITLE	TYPE
[Rep1]	Anders K.	Inactivation of SARS-CoV-2 viruses using UV-C radiation from the surface of air filters	**scientific report** from the project granted by the University
[Rep2]	Beck R., Wielec M.	Centrum Zaawansowanych Materiałów i Technologii CEZAMAT jako kluczowy element warunkujący uruchomienie w Polsce produkcji bezpiecznych układów scalonych	**presentation:** III Konferencja Naukowa – Przestępczość Teleinformatyczna XXI wieku
[Rep3]	Cuper J., Salski B., Krupka J., Kopyt P.	Measurement of Dielectric Materials of High Anisotropy Ratio with TM0n0 Cavity	**presentation:** IEEE MTT-S International Microwave Symposium (IMS) 2021
[Rep4]	Fetliński B.	Novel glassy and nanocrystalline phosphors for white LED lighting safe for human vision	**scientific report** from the project granted by the University
[Rep5]	Garbat P.	Development and implementation of an artificial intelligence system of virtual characters allowing simulation of their realistic behaviour and interactions with the player based on an autonomous analysis of the game participants' image in real time	**scientific report** from the project granted by the National Centre for Research and Development
[Rep6]	Grochowska M., Pleskacz W.	The Impact of Well-Edge Proximity Effect on MOS Threshold Voltage in Submicron CMOS Technologies	**presentation:** International Conference on Advances in Electronic and Photonic Technologies 2021
[Rep7]	Janaszek B.	Exploring electromagnetic response of nanostructural metamaterials	**presentation:** Culture-Education-Science Conference under the auspices of Warsaw University of Technology (WUT) and Beijing Jiaotong University (BJTU) 2021
[Rep8]	Janaszek B., Kieliszczyk M., Tyszka-Zawadzka A., Szczepański P.	Strong nonlocality in hyperbolic metamaterials	**presentation:** SPIE International Congress on Optics and Optoelectronics: Metamaterials XIII
[Rep9]	Janaszek B., Szczepański P.	Analysis of threshold generation in DFB laser based on hypercrystal	**presentation:** SPIE International Congress on Optics and Optoelectronics: Metamaterials XIII
[Rep10]	Kaczkan M.	Application of the terahertz spectroscopy to the investigation of the charge transport phenomena occurring in the electroactive materials	**scientific report** from the project granted by the University
[Rep11]	Kaczkan M.	New Versatile Platform for Illumination and Sensing – NewILUMIS	**scientific report** from the project granted by the National Centre for Research and Development
[Rep12]	Kaźmierczak A.	Arrays of diffractive optical elements for applications in optical interface systems of photonic integrated circuits	**scientific report** from the project granted by the University
[Rep13]	Kisiel R.	New generation of high thermal efficiency components packages for space	**scientific report** from the project granted by the EU Horizon project – HEATPACK

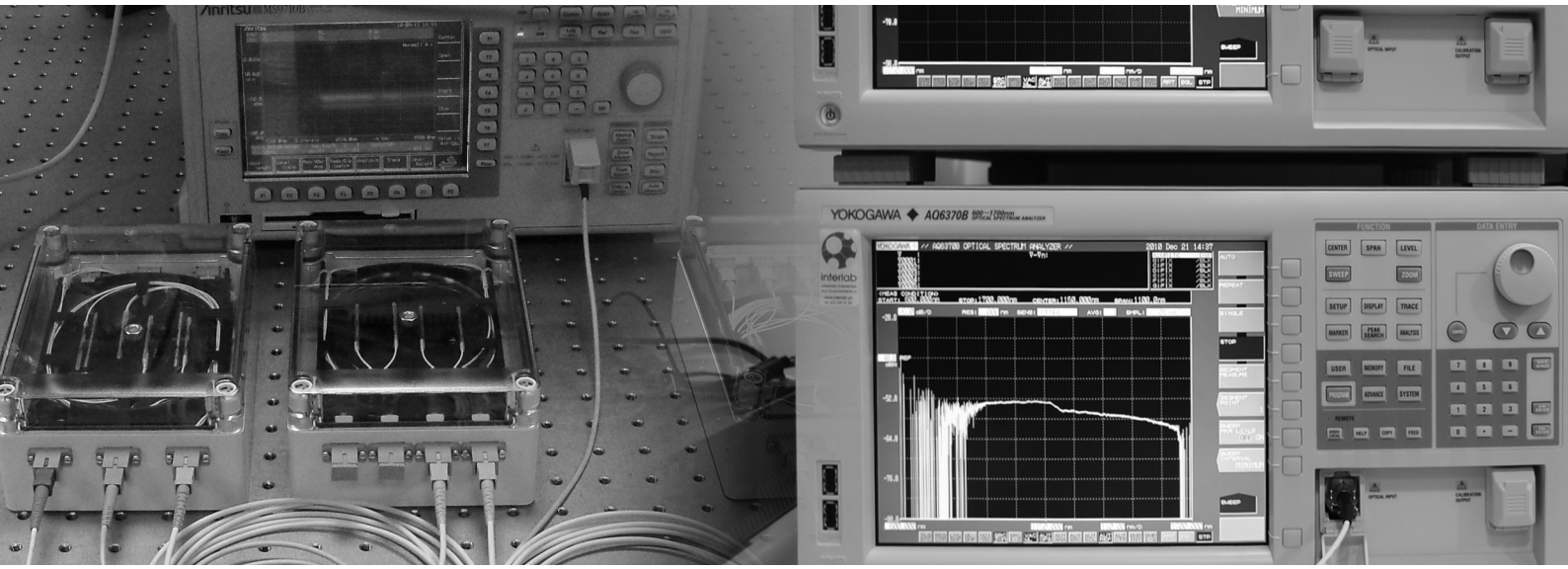
[Rep14]	Kisiel R., Śpiewak P., Kruszewski M.	Ag-based Thermal Interface Materials for GaN-on-Si Assembly Chips in Power Applications	**presentation:** 44th International Spring Seminar on Electronics Technology (ISSE)
[Rep15]	Koba M.	Fiber optic electro-optical modulator for studying electromagnetic interactions caused by high-energy laser radiation (Światłowodowy modulator elektro-optyczny do badania oddziaływań elektromagnetycznych wywołanych wysokoenergetycznym promieniowaniem laserowym, grant AEE)	**scientific report** from the project granted by the University
[Rep16]	Krupka J.	Correlations between electromagnetic and magnetoelastic properties of thin ferromagnetic films	**scientific report** from the project granted by the National Science Centre
[Rep17]	Krupka J., Salski B., Kopyt P., Derzakowski K., Czekała P., Mazierska J.	Complex Permittivity of Mixtures of Sand With Aqueous NaCl Solutions Measured at 2.5 GHz	**presentation:** 13th International Conference on Electromagnetic Wave Interaction with Water and Moist Substances (ISEMA)
[Rep18]	Lelit M., Słowikowski M., Filipiak M., Juchniewicz M., Stonio B., Michalak B., Pavlov K., Myśliwiec M., Wiśniewski P., Kaźmierczak A., Anders K., Stopiński S., Beck R., Piramidowicz R.	Krajowa platforma fotoniki scalonej na bazie azotku krzemu do zastosowań sensorycznych	**presentation:** XX Krajowa Konferencja Elektroniki 2021
[Rep19]	Mazurak A.	Study on the charge transport mechanism and filament formation in Metal-Insulator-Metal (MIM) structures	**scientific report** from the project granted by the University
[Rep20]	Mazurak A., Majkusiak B.	Investigation of the anomalous effect of the AC-signal frequency on flat-band voltage of Al/HfO_2/SiO_2/Si structures	**paper presented:** 22nd Conference of Insulting Films on Semiconductors 2021
[Rep21]	Mroczyński R.	Graphene as an indicator of the conditions of dielectric films technology on semiconductor substrates	**scientific report** from the project granted by the University
[Rep22]	Mroczyński R.	Incorporation of silicon-carbide (SiC) nanocrystals in the MIM structures based on pulsed-DC reactively sputtered HfOx layers	**presentation:** Joint International EUROSOI Workshop and International Conference on Ultimate Integration on Silicon 2021
[Rep23]	Mroczyński R.	Research infrastructure for the fabrication and diagnostics of semiconductor structures and devices	**scientific report** from the project granted by the Ministry of Science and Higher Education
[Rep24]	Mroczyński R.	Shaping optical properties of planar metamaterials for photonic structures of novel functionalities	**scientific report** from the project granted by the University
[Rep25]	Mroczyński R., Kosińska D.	Tailoring optical properties of conductive/dielectric layers and their periodic stacks using DoE method	**presentation:** Conference on Lasers and Electro-Optics (CLEO) 2021
[Rep26]	Niewiński M.	System for measuring the noise parameters of mid-infrared photodetectors (System do pomiarów parametrów szumowych fotodetektorów pracujących w zakresie średniej podczerwieni, Koło Naukowe Systemów Scalonych)	**scientific report** from the project granted by the University

[Rep27	Niewiński M., Szczerek W.	A Microcontroller Based System for the Selected Gases Detection with Alert Feature	**presentation:** 28th International Conference Mixed Design of Integrated Circuits and Systems MIXDES
[Rep28]	Papanikolaou A., Garbat P., Kujawińska M.	Colour digital image correlation method for monitoring of cultural heritage objects with natural texture	**presentation:** SPIE Optical Metrology: Optics for Arts, Architecture, and Archaeology VIII
[Rep29]	Pieńczuk P., Pleskacz W., Teodorowski M.	Class AB Operational Amplifier in CMOS 55 nm Technology	**presentation:** 28th International Conference Mixed Design of Integrated Circuits and Systems MIXDES
[Rep30]	Piramidowicz R.	Diagnosis of skin cancer in the conditions of limited social mobility	**scientific report** from the project granted by the University
[Rep31]	Piramidowicz R.	Looking for yellow lasing – dysprosium doped active materials for lasers operating in VIS spectral range	**scientific report** from the project granted by the University
[Rep32]	Piramidowicz R.	Nanostructured photonic crystal fibers for innovative few mode propagation	**scientific report** from the project granted by the National Centre for Research and Development
[Rep33]	Piramidowicz R.	Photonics Integrated Circuits technologies for MIDIR	**scientific report** from the project granted by the National Centre for Research and Development
[Rep34]	Siwiec K.	The study of the robustness of GNSS positioning against signal disturbances	**scientific report** from the project granted by the University
[Rep35]	Skierucha W., Kafarski M., Wilczek A., Szypłowska A., Jones S., Sabouroux P., Robinson D., Krupka J., Lewandowski A.	Towards standardization of electromagnetic soil moisture measurements	**presentation:** 13th International Conference on Electromagnetic Wave Interaction with Water and Moist Substances (ISEMA)
[Rep36]	Słowikowski M., Lelit M., Juchniewicz M., Michalak B., Stonio B., Filipiak M., Pavłov K., Wiśniewski P., Piramidowicz R., Beck R.	Silicon nitride photonic integrated circuits platform for life science applications	**poster:** Worldwide conference for the presentation of innovations in chemical & biochemical optical sensing 2021
[Rep37]	Śmietana M.	Biopolymer materials with chemically and genetically programmed heavy metal selectivity for new generation ultra-sensitive biosensors	**scientific report** from the project granted by the National Centre for Research and Development
[Rep38]	Śmietana M.	Life inside an optical fiber – new opportunities for investigations and monitoring of cell cultures in micro-scale	**scientific report** from the project granted by the University
[Rep39]	Śmietana M.	Optical analysis of electrochemical reaction products in picoliter volumes	**scientific report** from the project granted by the National Science Centre
[Rep40]	Śmietana M.	Optical fiber biosensing systems for fast and early identification of inflammatory factors	**scientific report** from the project granted by the National Science Centre

[Rep41]	Śmietana M.	Opto-electrochemical effects in thin conductive oxides for sensing applications	**scientific report** from the project granted by the University
[Rep42]	Śmietana M.	S2EC – integration of optical and electrochemical techniques towards biochemical sensing with high sensitivity and selectivity	**scientific report** from the project granted by the University
[Rep43]	Śmietana M.	Translucent titanium dioxide nanostructures deposited on substrates with complex geometry for photoconversion and sensorics	**scientific report** from the project granted by the National Science Centre
[Rep44]	Sochacki M., Kwietniewski N., Kamiński M., Myśliwiec M., Szmidt J.	Technologia wytwarzania i charakteryzacja diod pin na SiC w klasie napięciowej 1,7kV	**paper presented:** XX Krajowa Konferencja Elektroniki 2021
[Rep45]	Stępniewski K., Siwiec K.	A Precise Temperature Sensor with Polynomial Calibration	**presentation:** International Conference on Advances in Electronic and Photonic Technologies 2021
[Rep46]	Stonio B., Wiśniewski P., Haras M., Sochacki M.	Technologia wytwarzania sub-mikrometrowych diod tunelowych typu MIM	**presentation:** XX Krajowa Konferencja Elektroniki 2021
[Rep47]	Stopiński S.	Photonic integrated circuits for new generation of optical gyroscope systems	**scientific report** from the project granted by the University
[Rep48]	Stopiński S.	Photonic integrated multi-channel transmitter for quantum key distribution	**scientific report** from the project granted by the University
[Rep49]	Sutkowski M.	Analysis of the posture of female soccer players, participating in the Polish Women's Extraleague (Analiza postawy zawodniczek uprawiających piłkę nożną kobiet, uczestniczących w rozgrywkach Ekstraligi Kobiet PZPN, Inżynieria Biomedyczna),	**scientific report** from the project granted by the University
[Rep50]	Szmidt J.	Development of a modular quantum computer infrastructure for special and military IT applications	**scientific report** from the project granted by the National Centre for Research and Development
[Rep51]	Szostak S.	Integrated Electronics and Photonics – development (with the participation of industry representatives) of an M.Sc. program in the area of Electronics including novel educational techniques and taught in English within the framework of the project "NERW PW Science--Education-Development-Cooperation"	**scientific report** from the project granted by the Axis III Higher Education for the Economy and Development of the Operational Programme Science Education Development 2014–2020
[Rep52]	Wiechowski Ł., Pleskacz W.	Fully-Integrated Intermediate Frequency Stage of Dual-Frequency Multi-System Global Navigation Satellite System (GNSS) Receiver in CMOS 110 nm Technology	**presentation:** International Conference on Advances in Electronic and Photonic Technologies 2021
[Rep53]	Wiśniewski P., Jasiński J., Mazurak A.	Conductance modulation in Al/SiO_2/n-Si MIS resistive switching structures	**presentation:** Joint International EUROSOI Workshop and International Conference on Ultimate Integration on Silicon 2021
[Rep54]	Wiśniewski P., Majkusiak B.	Modeling of InAs/Si Electron-Hole BilayerTunnel Field Effect Transistor	**presentation:** XX Krajowa Konferencja Elektroniki 2021
[Rep55]	Wojtasik A.	Queuing Parallel Computing CAD Tasks in the Design and Optimization of IC Topography	**presentation:** 28th International Conference Mixed Design of Integrated Circuits and Systems MIXDES

10. CONFERENCES, SEMINARS AND MEETINGS

NUMBER	CONFERENCE, SEMINARS AND MEETINGS	PARTICIPANTS
[Con1]	Conference on Lasers and Electro-Optics, CLEO 2021, San Jose, USA, May 9–14, 2021	Mroczyński R.
[Con2]	IEEE MTT-S International Microwave Symposium, IMS 2021, Online, USA. June 6–11, 2021	Krupka J.
[Con3]	Joint International EUROSOI Workshop and International Conference on Ultimate Integration on Silicon, EUROSOI-ULIS 2021, Online, France, September 1–3, 2021	Jasiński J., Mazurak A., Mroczyński R.
[Con4]	SPIE Optical Metrology, SOM 2021, Online, Germany, June 21–26, 2021	Garbat P.
[Con5]	SPIE Optics + Optoelectronics 2021, SPIE O+O 2021, Online, Czech Republic, April 19–24, 2021	Janaszek B., Kieliszczyk M., Tyszka-Zawadzka A., Szczepański P.
[Con6]	9th International Conference on Advances in Electronic and Photonic Technologies, ADEPT 2021, Podbanské, Slovakia, September 20–23, 2021	Grochowska M., Pleskacz W., Siwiec K., Stępniewski K., Wiechowski Ł.
[Con7]	13th International Conference on Electromagnetic Wave Interaction with Water and Moist Substances, ISEMA 2021, Kiel, Germany, July 26–30, 2021	Krupka J.
[Con8]	28th International Conference Mixed Design of Integrated Circuits and Systems, MIXDES 2021, Online, Poland, June 24–26, 2021	Niewiński M., Pieńczuk P., Pleskacz W., Szczerek W., Wojtasik A.
[Con9]	44th International Spring Seminar on Electronics Technology "Advances in Printed and Ceramic Microsystems", ISSE 2021, Online, Germany, May 5–7, 2021	Kisiel R.



Optoelectronics Division

11. AWARDS

[Award1] Bęben Andrzej, Firek Piotr, Kaleta Mariusz, Kołakowski Jerzy, Korpas Przemysław, Kowalski Henryk, Kożuszek Rajmund, Kraśniewski Andrzej, Maciejewska Gabriela, Manujło Andrzej, Markowski Konrad, Marzęcki Michał, Ojrzeńska-Wójter Danuta, Paczesny Daniel, Prugarewicz Jan, Sosnowski Maciej, Szczygieł Aleksandra, Szczypiorski Krzysztof, Tarasiuk Halina, Wiśniewski Piotr, **WUT Rector's Collective Award for Didactic Achievements in the 2019/2020 Academic Year (1st stage)** (Nagroda zespołowa I stopnia JM Rektora PW za osiągnięcia dydaktyczne w roku akademickim 2019/20200, 2021

[Award2] Janik Monika, Koba Marcin, Śmietana Mateusz, **WUT Rector's Collective Award for Scientific Achievements (1st stage)** (Nagroda zespołowa I stopnia JM Rektora PW za osiągnięcia naukowe), 2021

[Award3] Krupka Jerzy, Kopyt Paweł, Salski Bartłomiej Wacław, Karpisz Tomasz, Pacewicz Adam, Krysicki Mateusz, Cuper Jerzy, Czekała Piotr, **WUT Rector's Collective Award for Scientific Achievements (1st stage)** (Nagroda zespołowa I stopnia JM Rektora PW za osiągnięcia naukowe), 2021

[Award4] Malinowski Michał, **WUT Rector's Individual Award (2nd stage)** (Nagroda indywidualna II stopnia JM Rektora PW), 2021

[Award5] Mroczyński Robert, **WUT Rector's Individual Award for Scientific Achievements (1st stage)** (Nagroda indywidualna I stopnia JM Rektora PW za osiągnięcia naukowe), 2021

[Award6] Sochacki Mariusz, **President's of the Republic of Poland Bronze Cross of Merit** (Brązowy Krzyż Zasługi), 2021

[Award7] Sochacki Mariusz, **WUT Rector's Individual Award for Scientific Achievements (1st stage)** (Nagroda indywidualna I stopnia JM Rektora PW za osiągnięcia naukowe), 2021

[Award8] Szmidt Jan, **WUT Rector's Individual Award for Lifetime Achievements (1st stage)** (Nagroda indywidualna I stopnia JM Rektora PW za całokształt dorobku), 2021