WARSAW UNIVERSITY OF TECHNOLOGY
Faculty of Electronics and Information Technology

Institute of Microelectronics and Optoelectronics

annual report 2020

WARSAW UNIVERSITY OF TECHNOLOGY
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Institute of Microelectronics and Optoelectronics

annual report 2020

IMiO

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From the Director

This Annual Report summarizes the activities of the Institute of Microelectronics and Optoelectronics (IMiO) in the year 2020, 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, photovoltaics, and image processing. It is worth noting that 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.

Despite 2020 being the year of the Covid-19 pandemic which inevitably caused a slowdown in research activity, our staff authored and co-authored 65 publications, including 47 papers in scientific journals from the JCR list, and 2 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 main competences covering the major 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;
- microwaves, microwave photonics and microwave measurement techniques;
- new materials for high-temperature, high-power and high-frequency electronics;
- new materials for modern photonics.

The research activity is supported by a nu.mber of projects financed by 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.

Parallel to scientific activity also the didactic offer of the Institute has been recently enriched, which resulted in establishing a completely new specialization – "Integrated Electronics and Photonics,"elaborated 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, namely: technology, diagnostics and modelling of semiconductor structures, as well as applications of microcontrollers.

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Robert Mroczyński, Ph.D.,D.Sc.	Professor
Jakub Jasiński, Ph.D.	Assistant Professor
Jarosław Judek, Ph.D., D.Sc.	Research 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
Piotr Wiśniewski, M.Sc.	Ph.D. Student

Technical and administrative staff

Witold Ciemiewski
Kazimierz Dalbiak
Krzysztof Krogulski

To name a few examples of its research topics:

- Diagnostics and characterisation of properties of single and double insulating layers (gate stack including ultra thin oxide layers) by means of electrical measurements analysis;
- Wear-out and degradation processes in MOS structures (breakdown of dielectrics layers, hot carriers effects, radiation damage effects);
- Transport mechanism and quantum effects in MOS structures (transistor, tunnel diode) with ultra thin oxide;
- New materials (semiconductors and dielectrics) for microelectronics applications (e.g.: silicon carbide, gallium nitride, silicon-germanium, germanium);
- Theoretical studies on MOS-SOI (silicon-on-insulator) and Si:Ge (silicon-germanium) MOS structure physics (modelling of devices behaviour and modelling for characterisation and diagnostics);
- Nanoelectronic phenomena and devices (e.g. tunnel and resonance tunnel diodes and transistors, Coulomb blockade diode, single-electron transistors, memories);
- PECVD deposition of ultra thin dielectric layers for MOSFET gate dielectric (SiO_2, Si_3N_4, SiO_xN_y);
- Ultra shallow implantation from r.f. plasma;
- Very low temperature processing of test structures;
- Fabrication of ultrathin amorphous silicon layers by PECVD;
- Fabrication of double barrier (single and multilayer) structures and devices;
- MEMS/MOEMS processing;
- Silicon photonic devices fabrication.

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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.

Head of the Division

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Tomasz Borejko, Ph.D.	Assistant Professor
Zbigniew Jaworski, 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
Igor Butryn, M.Sc.	Ph.D. Student
Bartosz Dec, M.Sc.	Assistant
Dominik Kasprowicz, Ph.D.	Assistant
Daniel Pietroń, M.Sc.	Ph.D. Student
Szymon Reszewicz, M.Sc.	Ph.D. Student
Łukasz Wiechowski, M.Sc.	Ph.D. Student

Technical and administrative staff

Stanisław Jeszka, M.Sc.
Krzysztof Zielant, 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 innovative AD converters, data processing in physical experiments and medical equipment, RF front ends for wireless data transmission etc.,
- modeling 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.

Head of the Division

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Ryszard Kisiel, Ph.D., D.Sc.	Research Professor
Mateusz Śmietana, Ph.D., D.Sc.	Professor
Marcin Koba, Ph.D, D.Sc.	Research Assistant Professor
Monika Janik, Ph.D.	Research and Technical Specialist
Michał Borecki, Ph.D., D.Sc.	Assistant Professor
Piotr Firek, 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
Magdalena Dominik, M.Sc.	Ph .D. Student
Maciej Kamiński, M.Sc.	Ph.D. Student, Research and Technical Specialist
Kinga Kondracka, M.Sc.	Ph.D. Student
Agnieszka Martychowiec, M.Sc.	Ph.D. Student, Research and Technical Specialist
Anastasiia Veklych, M.Sc.	Ph.D. Student
Krzysztof Wilczyński, M.Sc	Ph.D. Student

Science, technical and administrative staff

Ryszard Biaduń
Norbert Kwietniewski, M.Sc.
Aleksander Nawrat, Ph.D., D.Sc.
Bartłomiej Stonio, 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;
- 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 activity of the Optoelectronics Division is concentrated on education as well as on various areas of optoelectronic research in the field of laser physics, new optical waveguide materials and structures, laser spectroscopy, laser construction and laser applications in medicine, air pollution monitoring, the technology of electronic imaging devices, digital image processing, propagative electronics and microwave photonics.
Photovoltaics laboratory, as a part of the Division, serves as a focal point for conducting and stimulating research and demonstration activities; educating students; organizing technical meetings, workshops, symposia and conferences; disseminating information and addressing environmental issues.

Head of the Division

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Senior academic staff

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Ryszard Piramidowicz, Ph.D., D.Sc.	Professor
Marcin Kaczkan, Ph.D. D.Sc.	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 Witoński, Ph.D.	Assistant Professor
Krzysztof Madziar, Ph.D.	Senior Lecturer
Marek Sutkowski, Ph.D.	Senior Lecturer
Agnieszka Szymańska, Ph.D.	Senior Lecturer
Piotr Warda, Ph.D.	Senior Lecturer

Junior academic staff

Krzysztof Anders, M.Sc.	Assistant
Paweł Bortnowski, M.Sc.	Ph.D. Student
Dawid Budnicki, M.Sc.	Ph.D. Student
Bartosz Janaszek, M.Sc.	Ph.D. Student, Research Assistant
Marcin Kieliszczyk, M.Sc.	Ph.D. Student, Research Assistant
Paweł Komorowski, M.Sc.	Ph.D. Student
Marcin Kowalczyk, M.Sc.	Ph.D. Student
Małgorzata Kuklińska, M.Sc.	Ph.D. Student
Aleksandra Paśnikowska, M.Sc.	Ph.D. Student
Andrzej Połatyński, M.Sc.	Ph.D. Student
Mateusz Słowikowski, M.Sc.	Ph.D. Student

Technical and administrative staff

Maciej Juźwik, M.Sc.

The academic staff of the Division gives lectures in photonics, laser physics, laser technology, laser applications, laser spectroscopy, integrated optoelectronics and optical computing, digital image processing, propagative electronics and microwave photonics, all of which are accompanied by appropriate laboratory class activities.
The main research activity of the Division comprises:

- solid state laser construction and their applications in materials processing;
- spectroscopic research of new laser materials, investigation of the excitation processes in rare earth doped dielectric materials, research of blue up-conversion laser structures, waveguide lasers;
- theoretical research of laser generation in planar, fibre and hollow waveguide gas lasers, analysis of light generation in DFB (distributed feedback) structures, photonic crystals structures and in lasers with non-linear optical elements, investigation of the statistical properties of the light generated in various laser structures;

- nano-optical structures and photonic band-gap materials;
- optimisation of the construction of ion gas lasers, investigation of the processes in discharge tube ceramic ion laser and laser operation in various cavity geometry, investigation of light generation in ion gas lasers for medical applications;
- spectroscopic and theoretical research of light generation in silicon photonic lasers;
- theoretical principles of image modelling, processing and analysis;
- application of image processing methods for diagnostic control and measurement systems in industry, medicine, research and commerce;
- image acquisition in polarization imaging systems and optical image processing;
- 3D Vision methods and algorithms;
- electro optic effects in liquid crystals and their applications to LCD and photo refractive phenomena in liquid crystals;
- an analysis of the oscillation conditions, frequency stabilisation and synthesis in microwave bands;
- measurement techniques of microwave circuits and devices parameters with emphasis on automation and computerisation of measurement methods;
- modelling and computer aided design of microwave devices and circuits;
- controlling of microwave circuits parameters by means of optical signals;
- investigations and modelling of optical-microwave frequency conversion processes;
- modelling of optically controlled microwave devices, as photodiodes, photo-varactors, phototransistors;
- modelling of optoelectronic and microwave devices for data transmission networks.

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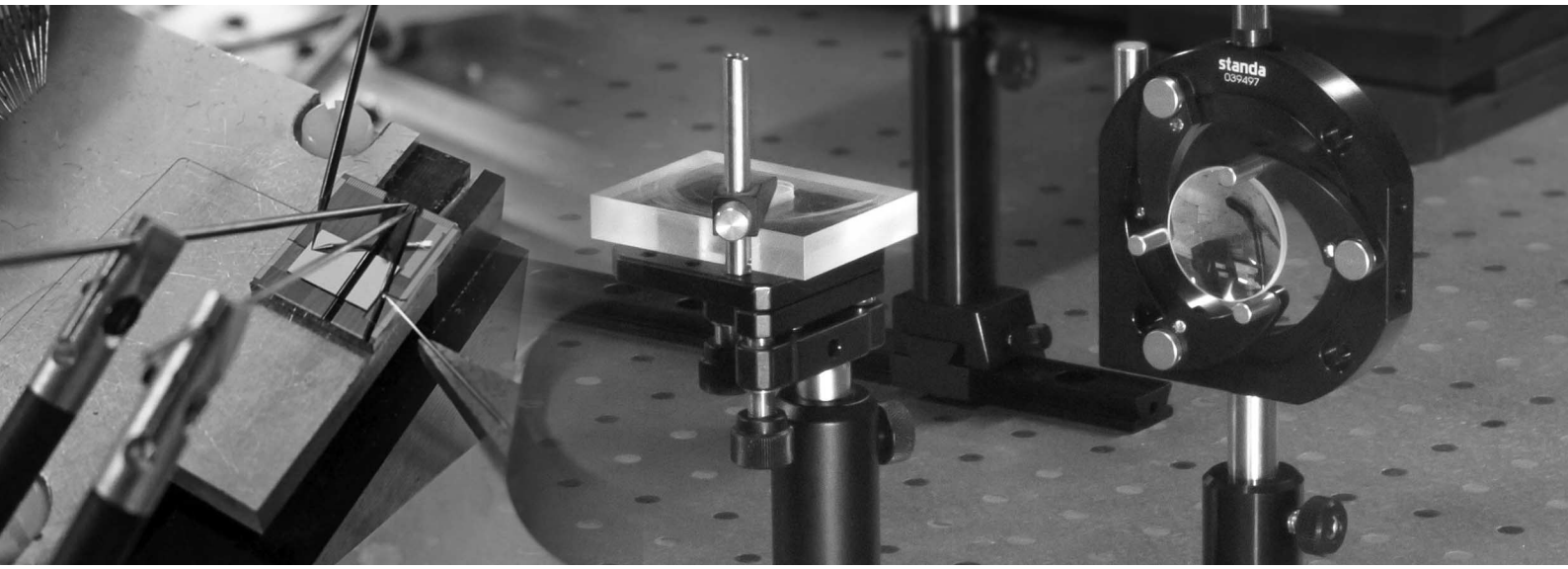

Optoelectronics Division

1.7. Statistical Data

SPECIFICATION	2019	2020	DIFFERENCE
Academic staff	**80**	**82**	**+2**
Tenured professors	8	8	0
Professors	7	7	0
Docent	1	1	0
Assistant professors	23	28	+5
Senior lecturers	8	8	0
Assistants	5	3	-2
Ph.D. Students	28	27	-1
Science, Technical and Administrative staff	**22**	**18**	**-4**
Teaching activities	**79**	**82**	**+3**
Basic courses	37	40	+3
Advanced courses	22	22	0
Special courses	20	20	0
Degrees awarded	**48**	**25**	**-23**
D.Sc. degrees	0	1	+1
Ph.D. degrees	1	0	-1
M.Sc. degrees	16	10	-6
B.Sc. degrees	31	14	-17
Research projects	**27**	**27**	**0**
Granted by the University	8	9	+1
Granted by State Institutions	14	15	+1
Granted by International Institutions	5	3	-2
Publications	**106**	**65**	**-41**
Sci.-tech. books	0	1	+1
Sci.-tech. papers in journals	48	53	+5
Sci.-tech. papers in conference proceedings	58	11	-47
Patents	**8**	**2**	**-6**
Reports	**66**	**50**	**-16**
Conferences	**22**	**11**	**-11**
Awards	**14**	**5**	**-9**

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, Professor, full time, Head of Microelectronics and Nanoelectronics Devices Division ('04–), 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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STAFF

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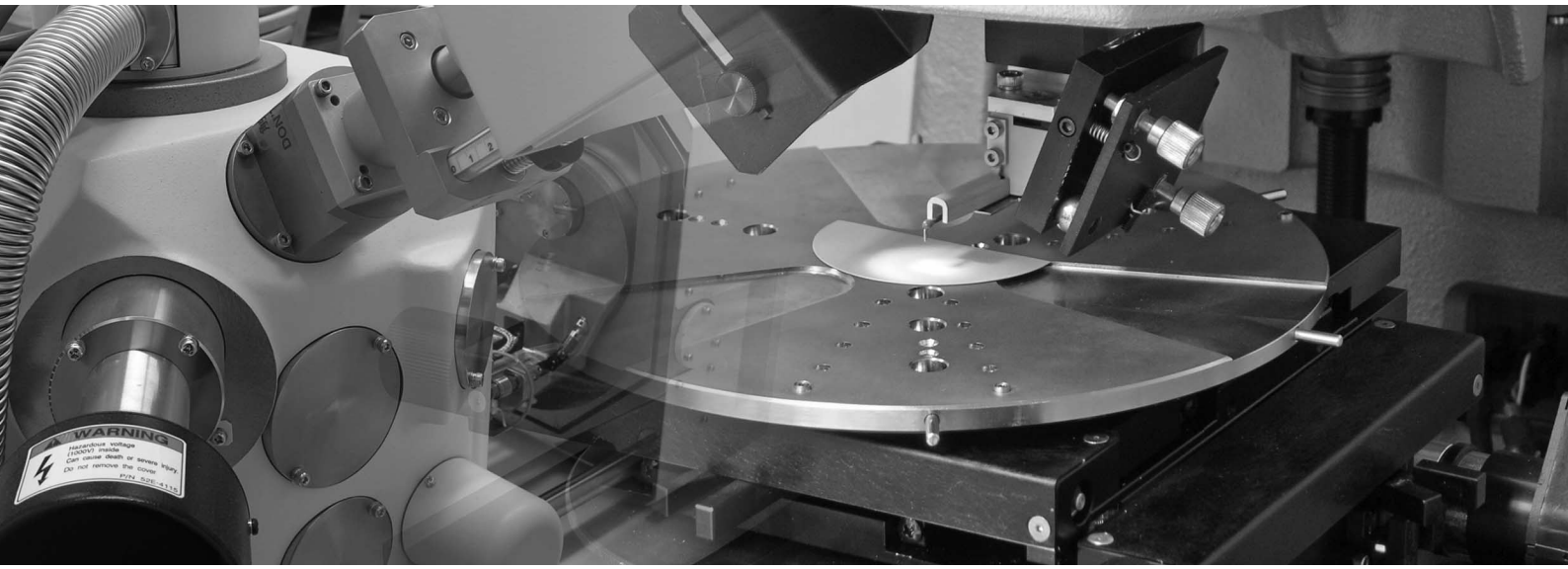

Electronic Materials and Microsystem Technology Division

2.2. Junior Research Staff

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VLSI Engineering
and Design Automation Division

3. TEACHING ACTIVITIES

3.1. Basic Courses

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

[Edu2] **Analog Circuit Design for VLSI Systems** (Projektowanie układów analogowych dla systemów VLSI) **PUAV**, Krzysztof Siwiec

[Edu3] **Application of Matlab in Calculation Methods** (Matlab w zastosowanych metodach obliczeniowych) **MZMO**, Krystian Król

[Edu4] **Computer-Aided Design of Printed-Board Circuits** (Projektowanie obwodów drukowanych), **PADS**, Jerzy Kalenik

[Edu5] **Digital Circuits** (Układy cyfrowe), **UCYF**, 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), **ELIUL**, Andrzej Pfitzner, Agnieszka Zaręba

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

[Edu9] **Equipment – Programming Synthesis of Digital Systems** (Synteza sprzętowo – programowa systemów cyfrowych), **SSP**, Elżbieta Piwowarska

[Edu10] **Fields and waves**, (Pola i fale), **POFA**, Jerzy Piotrowski

[Edu11] **Fundamentals of Circuit and System Technology** (Podstawy technologii układów i systemów), **PTUIS**, Robert Mroczyński, Romuald Beck

[Edu12] **Fundamentals of Electronic Devices and Circuits** (Podstawy elementów i układów elektronicznych) **PELEL**, Sławomir Szostak, Lidia Łukasiak

[Edu13] **Fundamentals of Lasers** (Lasery – kurs podstawowy), **LKP**, Paweł Szczepański

[Edu14] **Fundamentals of materials and constructions** (Podstawy Materiałów I Konstrukcji), **POMAK**, Piotr Firek, Jerzy Kalenik

[Edu15] **Fundamentals of Microprocessor Techniques** (Podstawy techniki mikroprocesorowej), **TMIK**, Lidia Łukasiak

[Edu16] **Fundamentals of Microwave Engineering** (Podstawy techniki w.cz.), **TWCZ**, Jerzy Piotrowski

[Edu17] **Fundamentals of Photonics** (Podstawy fotoniki), **FOT**, Michał Malinowski

[Edu18] **Fundamentals of Solid State Electronics** (Elektronika ciała stałego), **ELCS**, Jan Szmidt, Agnieszka Zaręba

[Edu19] **Image Processing – Models and Systems** (Modele i systemy przetwarzania obrazów) **MSPO**, Piotr Garbat

[Edu20] **Introduction to Microelectronics** (Podstawy mikroelektroniki), **PMK**, Andrzej Pfitzner

[Edu21] **Introduction to Microsystems** (Wstęp do mikrosystemów), **WMS**, Andrzej Mazurak, Robert Mroczyński

[Edu22] **Introduction to Numerical Methods** (Wstęp do metod numerycznych), **WNUM**, Krystian Król

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

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

[Edu25] **Ligthwave Telecommunication** (Telekomunikacja optofalowa), **TEOP**, Agnieszka Szymańska

[Edu26] **Logic Circuits** (Układy logiczne) **ULOG**, Andrzej Wielgus

[Edu27] **Meeting 1 – Fundamentals of Information Technology** (Zjazd 1 – Podstawy technologii informacyjnej), **ZJ1Z**, Krzysztof Madziar

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

[Edu36] **Physical Fundamentals of Information Processing** (Fizyczne podstawy przetwarzania informacji), **FPPI**, Jan Szmidt, Agnieszka Zaręba

[Edu37] **Programming for mobile Apple iOS and MacOS X** (Programowanie dla systemów: mobilnego iOS oraz MacOS X), **APIOS**, Adam Wojtasik

[Edu38] **Programming microcontrollers in C language** (Programowanie mikrokontrolerów w języku C), **PMIK**, Sławomir Szostak

[Edu39] **Semiconductor Devices** (Przyrządy półprzewodnikowe), **PP**, Lidia Łukasiak, Agnieszka Zaręba

[Edu40] **Semiconductor Physics in Electronics and Photonics** (Fizyka Półprzewodników w Elektronice i Fotonice), **FPEF**, Piotr Firek, Agnieszka Zaręba

3.2. Advanced Courses

[Edu41] **3D Vision Systems** (Systemy wizji 3D) **SWIZ**, Piotr Garbat

[Edu42] **Advanced Semiconductor Structures** (Zaawansowane struktury półprzewodnikowe) **ZSP**, Lidia Łukasiak, Tomasz Skotnicki

[Edu43] **Advanced Technologies for Silicon Microelectronics and Photonics** (Zaawansowane technologie mikroelektroniki i fotoniki krzemowej) **ZTM**, Robert Mroczyński, Romuald Beck

[Edu44] **Analog Integrated Circuit Design for VLSI Systems** (Projektowanie bloków analogowych dla systemów VLSI) **PSSA**, Tomasz Borejko

[Edu45] **Characterization of Materials for Microelectronics** (Charakteryzacja materiałów dla mikroelektroniki) **CHA**, Aleksander Werbowy, Piotr Firek

[Edu46] **Computational Methods in Microelectronics and Photonics** (Metody obliczeniowe w mikroelektronice i fotonice), **MOBI**, Andrzej Pfitzner, Dominik Kasprowicz, Agnieszka Mossakowska-Wyszyńska

[Edu47] **Digital Image Processing** (Cyfrowe przetwarzanie obrazów), **CPOO**, Piotr Garbat

[Edu48] **Fiber-Optic Communication** (Komunikacja światłowodowa), **KOS**, Ryszard Piramidowicz

[Edu49] **Fundamentals of Nanoelectronics and Nanophotonics** (Podstawy nanoelektroniki i nanofotoniki), **NANO**, Bogdan Majkusiak, Paweł Szczepański

[Edu50] **Fundamentals of Photovoltaics** (Podstawy fotowoltaiki) **PFOT**, Michał Malinowski

[Edu51] **Introduction to Digital VLSI System Design** (Projektowanie scalonych systemów cyfrowych), **PSSC**, Zbigniew Jaworski

[Edu52] **Laboratory of Fundamentals of Nanoelectronics and Nanophotonics** (Pracownia podstaw nanoelektroniki i nanofotoniki), **PNAN**, Bogdan Majkusiak, Paweł Szczepański

[Edu53] **Lasers** (Lasery) **LAS**, Paweł Szczepański

[Edu54] **Microsystems Engineering** (Inżynieria mikrosystemów) **MIK**, Piotr Firek

[Edu55] **Monte Carlo Methods** (Metody Monte Carlo) **MMC**, Dominik Kasprowicz, Marek Niewiński

[Edu56] **Nanotechnologies** (Nanotechnologie), **NAN**, Jan Szmidt, Aleksander Werbowy

[Edu57] Optoelectronic Techniques for Imaging Devices (Optoelektroniczne techniki zobrazowania informacji) OTZI, Marek Sutkowski

[Edu58] **Photonic Integrated Circuits for Optical Logic** (Zintegrowane optoelektroniczne układy logiczne) **ZOUL**, Michał Malinowski, Agnieszka Mossakowska-Wyszyńska

[Edu59] **Photovoltaic Systems** (Systemy fotowoltaiczne), **SFOT**, Mateusz Śmietana

[Edu60] **Semiconductor Photonic Devices** (Fotoniczne przyrządy półprzewodnikowe) **FPP**, Marcin Kaczkan

[Edu61] **Spectroscopic Methods** (Techniki spektroskopowe) **TSP**, Michał Malinowski

[Edu62] **VLSI System Design** (Projektowanie systemów scalonych w technice VLSI), **PSSV**, Zbigniew Jaworski

3.3. Courses in English

[Edu63] **Electronics 1, EELE1**, Bogdan Majkusiak, Jakub Walczak, Andrzej Mazurak

3.4. Courses for other Faculties

[Edu64] **Electromagnetic Compatibility, Faculty of Management** (Kompatybilność elektromagnetyczna, Wydział Zarządzania), **KOMEL**, Jerzy Piotrowski

[Edu65] **Electronic Circuits and the Introduction to Microelectronics, Faculty of Management** (Układy elektroniczne i wstęp do mikroelektroniki, Wydział Zarządzania), **UEMIK**, Sławomir Szostak

[Edu66] **Electronic Devices, Faculty of Management** (Elementy elektroniczne, Wydział Zarządzania), **ELEME**, Lidia Łukasiak

[Edu67] **Electronics 1, Faculty of Mechatronics** (Elektronika 1, Wydział Mechatroniki), **ELE1**, Sławomir Szostak

[Edu68] **Electronics 2, Faculty of Mechatronics** (Elektronika 2, Wydział Mechatroniki), **ELE2**, Jakub Jasiński

[Edu69] **Energy Conditioning and Storage Laboratory, Faculty of Physics** (Laboratorium przetwarzania i magazynowania energii, Wydział Fizyki) **LPME**, Michał Malinowski

[Edu70] **Introduction to Microprocessor Systems, Faculty of Management** (Wstęp do systemów mikroprocesorowych, Wydział Zarządzania), **WSYMI**, Jakub Jasiński

[Edu71] **Laboratory of Nanotechnology, Faculty of Physics** (Laboratorium nanotechnologii, Wydział Fizyki), **NAN**, Robert Mroczyński

[Edu72] **Laboratory of Photonics, Faculty of Physics** (Laboratorium fotoniki, Wydział Fizyki), **FOT**, Ryszard Piramidowicz

[Edu73] **Laboratory of Physics 2, Faculty of Physics** (Laboratorium Fizyki 2, Wydział Fizyki), **FIZ2**, Janusz Parka

[Edu74] **Logic Circuits, Faculty of Management** (Układy logiczne, Wydział Zarządzania), **UKLO**, Piotr Firek

[Edu75] **Laser Technology, Faculty of Physics** (Technika Laserów, Wydział Fizyki), **TL**, Ryszard Piramidowicz

[Edu76] **Photonic Devices, Faculty of Management** (Elementy fotoniczne, Wydział Zarządzania), **ELFOT**, Ryszard Piramidowicz

3.5. Courses in English for other Faculties

[Edu74] **Fiber Optic Communication Systems, Faculty of Physics, FOCS,** Ryszard Piramidowicz

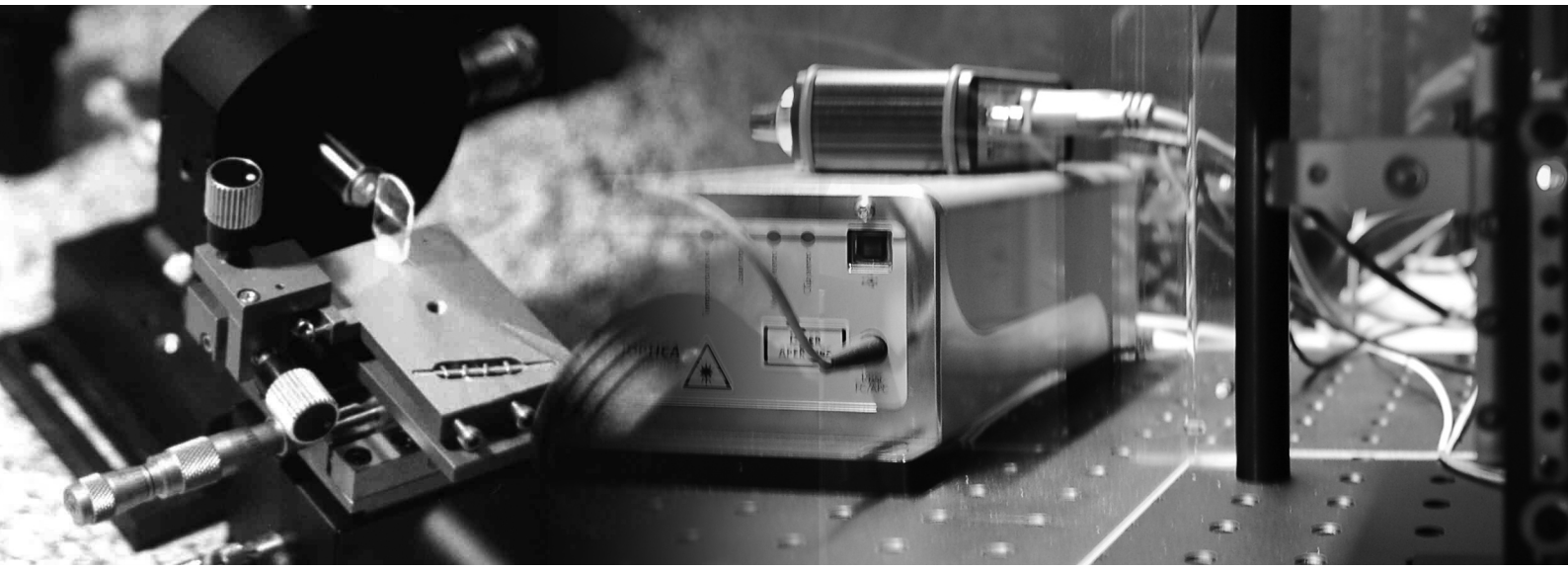
[Edu75] **Laser Technique, Faculty of Physics, LT,** Ryszard Piramidowicz

[Edu76] **Optical Fiber Technology, Faculty of Mechatronics, OFT,** Ryszard Piramidowicz

[Edu77] **Photographic Techniques in Image Acqusition, Faculty of Mechatronics, PTIA,** Marek Sutkowski

[Edu78] **Photonic Integrated Circuits, Faculty of Physics, PIC,** Ryszard Piramidowicz

[Edu79] **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] **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 ghting 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, dif cult 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.

[Pro2] **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.

[Pro3] 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.

[Pro4] 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.

[Pro5] **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.

[Pro6] **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.

[Pro7] **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.

[Pro8] **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.

[Pro9] **Shaping optical properties of planar metamaterials for photonic structures of novel functionalities** (Kształtowanie właściwości optycznych materiałów planarnych pod kątem uzyskiwania struktur fotonicznych o nowych funkcjonalnościach), 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.

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

[Pro10] **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

[Pro11] **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.

[Pro12] **DIAMSEC – ultrasensitive sensing platform for rapid detection of epidemiological and pandemic threats** (DIAMSEC – ultraczuła platforma sensoryczna do szybkiej detekcji zagrożeń epidemiologicznych i pandemicznych), Warsaw University of Technology, Institute of Microelectronics and Optoelectronics, project leader: Mateusz Śmietana, co-workers: Marcin Koba, Emil Pituła, December 2017–November 2020.

The aim of the project is to develop and prepare for implementation an innovative sensing platform for rapid detection of pandemic and epidemic conditions. The project proposes a development of a technology for synthesis and modification of sensing structures based on thin films of diamond, titanium oxide, ITO and graphene towards medium-scale production of ultrasensitive tests for detection of viruses and pathogenic bacteria. DIAMSEC platform can be used directly by a patient, as well as to assist in diagnosis-making process for people in emergency rooms, small clinics, and doctors' offices, in ambulances to the scene of the accident in order to rapid diagnostics of patients. It can also be used to conduct screening tests towards detection of sources and avoid spreading of infectious diseases. Thanks to the universal approach it can be also used in veterinary medicine. Use of the platform DIAMSEC comparing to the currently used methods lead to a shorter measurement time, a reduction in amount required analyte, higher sensitivity and lower cost of a single test.

[Pro13] **Innovative, hardware-software component, based on a dedicated integrated circuit and software to perform various cryptographic application, with the particular attention paid to electronic identification systems with the high level of confidence** (Innowacyjny komponent sprzętowo-programowy, wykorzystujący specjalizowany układ scalony oraz oprogramowanie, realizujący różne funkcje kryptograficzne, ze szczególnym uwzględnieniem zastosowań w systemach identyfikacji elektronicznej z wysokim poziomem pewności IDSoC), Warsaw University of Technology, Institute of Microelectronics and Optoelectronics, project leader: Witold Pleskacz, co-workers: A. Łuczyk, L. Łukasiak, P. Szczepański, S. Reszewicz, A. Borkowski, M. Derlecki, J. Bęczkowski, September 2017–August 2020.

The aim of the project is to develop and manufacture an innovative single-chip secure processor – IDSoC. The developed system on chip will be composed of a proprietary application processor with an increased fault tolerance and security level. The processor will include a non-volatile memory area dedicated to storing both embedded software and sensitive user data, such as biometric data. Thanks to the appropriate error detection and correction systems as well as hardware encryption, the non-volatile memory will ensure data integrity and confidentiality. In addition, the integrated IDSoC system will be equipped with a set of peripherals for hardware cryptographic support. During the project, it is planned to develop a true random number generator (TRNG) and to carry out research on the possibility of the physical unclonable function (PUF) utilization for the purpose of identification and authentication. It is also anticipated to develop a set of sensors for the monitoring of the integrated circuit's environmental conditions (e.g. temperature, supply voltage, clock frequency). The mechanisms of the external interference detection in the system's physical structure will also be employed, which will significantly protect the system features against unauthorized access attempts and will prevent from the acquisition of sensitive data. The IDSoC system, to be developed during the project, might be utilized in the applications in which the storage and processing of sensitive data is required, e.g. in electronic identification systems (electronic identity card, e-passport). The inherent part of the IDSoC system will be its dedicated firmware, developed in the course of the project. The firmware will support and enable all the system's functions, most notably the electronic identification with high level of confidence and other advanced cryptographic procedures.

[Pro14] **Methods and means of protection and defense against high power microwave pulses** (Metody i sposoby ochrony i obrony przed impulsami HPM), Warsaw University of Technology, Institute of Microelectronics and Optoelectronics, project leader: Mariusz Sochacki, co-workers: Jan Szmidt, Piotr Firek, December 2014–December 2020.

The protection and defense system against high power microwave pulses will be equipped with limiting diodes. The protection semiconductor devices will be designed, manufactured and characterized in the Institute of Microelectronics and Optoelectronics. Wide bandgap semiconductors can be used in such kind of application, primarily the silicon carbide (SiC) wafers. The diodes will be characterized by means of current-voltage and capacitance-voltage measurements. Finally, the microwave properties of the devices will be studied, which is important especially in the context of their application in microwave transceiver circuits.

[Pro15] **Miniature, dual-frequency, system-on-a-chip for precise satellite navigation GPS/Galileo integrated with application processor dedicated to IoT devices with low power consumption** (Miniaturowy, dwuczęstotliwościowy, jednoukładowy system scalony do precyzyjnej nawigacji satelitarnej GPS/Galileo zintegrowany z procesorem aplikacyjnym dedykowany do urzadzen IoT o niskim poborze mocy NaviSoC), Warsaw University of Technology (WUT), Institute of Microelectronics and Optoelectronics, project leader: Witold Pleskacz, co-workers: P. Narczyk, K. Marcinek, T. Mrozek, I. Butryn, D. Pietroń, Ł. Wiechowski, November 2017–October 2020.

The development concept of specialized microcontroller for precise satellite navigation meets the growing needs of many sectors of the world economy, where according to estimates 6–7% of European GDP depends on satellite navigation applications. The aim of the project is to develop, produce, test and demonstrate the dual-frequency, system-on-a-chip

for precise GPS/Galileo satellite navigation. The system will be integrated with application processor and will allow for a significant increase in the accuracy of mobile devices. The consortium was established to realize this project. It consists of one scientific entity (WUT) and the two entrepreneurs (ChipCraft Sp. z o.o. and Inowatronika –Tomasz Radomski).

Within the project NCBiR NR02-0096-10/2011 "Dual-mode blocks of the integrated circuit GALILEO and GPS signal receiver in nanometer CMOS technology for precise positioning of mobile objects" realized in 2011–2014, applicant has developed, produced and characterized integrated circuits forming the so-called chipset – three circuits of complete analogue path of the satellite navigation receiver, which can receive two frequency bands from both constellations Galileo and GPS. Due to its size and the lack of the full integration on the one silicon die the technology did not extend beyond the area of laboratory demonstrations.

The miniaturization of the chipset will be achieved by development of NaviSoC system-on-a-chip by the ChipCraft company in cooperation with the Warsaw University of Technology and with the Inowatronika company. Experience of Warsaw University of Technology from the previous project mentioned above will be utilized. The developed technology will be examined and demonstrated in operational conditions, i.e. in IoT class devices (Internet-of-Things) produced in the course of this project thanks to the cooperation and exploiting experience of Inowatronika company.

[Pro16] **Nanostructured photonic crystal fibers for innovative few mode propagation** (Nanostrukturalne światłowody fotoniczne do kilkumodowej propagacji nowej 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.

[Pro17] **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.

[Pro18] **Technologies of semiconductor materials for high power and high frequency electronics** (Technologie materiałów półprzewodnikowych dla elektroniki dużych mocy i wysokich częstotliwości WidePOWER), Warsaw University of Technology, Institute of Microelectronics and Optoelectronics, project leader: Jan Szmidt, co-workers: Piotr Firek, Krystian Król, Aleksander Werbowy, Michał Waśkiewicz, Kinga Kondracka, Jakub Szarafiński, Andrzej Taube, Norbert Kwietniewski, Mariusz Sochacki, Kazimierz Dalbiak, Witold Ciemiewski, December 2017–November 2020.

The overall aim of this project is to develop technology of silicon carbide (SiC) homoepitaxy and gallium nitride (GaN) heteroepitaxy towards production grade device epitaxial structures. Silicon carbide and AlGaN/GaN/SiC wafers for

fabrication of 1.7 kV/3.3 kV devices and vertical HEMTs are expected as basic product for the implementation. Quality of the wafers will be verified by the fabrication of 1.7 kV PiN diode and VHEMTs that will be ready for the implementation in advanced power electronics. The processing of SiC PiN diode will be upgraded up to 3.3 kV devices to investigate main barriers of implementation in the case of high voltage bipolar SiC devices. Comprehensively characterized and certified epitaxial structures will be the subject of market analysis on the day of completion of the project in order to assess the competitiveness and scale of production giving real rate of investment return. The findings from the demonstration pilots of power converters and aviation band amplifiers will be widely published among companies and further stakeholders. The key performance measurement of these applications is that companies outside the consortium have specific knowledge to make better informed decisions about future R&D strategies and investments for the uptake of advanced power electronics. It will support the commercialization of wafers and devices efficiently.

[Pro19] **Tunable hyperbolic metamaterials for photonic devices of novel generation** (Przestrajalne metamateriały hiperboliczne na potrzeby nowej generacji przyrządów fotonicznych HYPERMAT), Warsaw University of Technology, Institute of Microelectronics and Optoelectronics, project leader: Michał Malinowski, co-workers: Robert Mroczyński, Ryszard Piramidowicz, Anna Jusza, Krzysztof Anders, Anna Tyszka-Zawadzka, Bartosz Janaszek, Marcin Kieliszczyk, Bartosz Fetliński, December 2017–November 2020.

The main objective of this project is to develop an innovative technology of tunable multilayer hyperbolic metamaterials (THMMs) operating in NIR and MIR frequency ranges. Such structures exhibit extraordinary features unprecedented in commercially available state-of-the-art photonic solutions, resulting from unusual dispersion characteristics which can be controlled by an external electric field. THMMs can be used as efficient, adaptive antireflective coatings (AR) or as tunable edge-filters in photonic components commercially offered by our large industrial partner, i.e., PCO S.A. The development of the technology of tunable hyperbolic metamaterials, demonstration of the proof of concept, and transfer of the technology to PCO S.A. could become the foundation for the technological platform of a novel class of photonic components, which would significantly enrich PCO S.A.'s commercial offer and become a strong impulse for the development of innovative national photonics industry, offering products globally. We expect that project results will contribute to the development of science related to nanotechnology and photonics. An intensive cooperation between Consortium partners will emerge to advance scientific leadership of the Polish scientific units as the leaders in the modeling, technology and characterization of photonic devices including nanostructures based on THMMs.

4.4. Projects Granted by the National Science Centre

[Pro20] **Active Tunable Hyperbolic Metamaterials** (Aktywne przestrajalne metamateriały hiperboliczne), Warsaw University of Technology, Institute of Microelectronics and Optoelectronics, project leader: Bartosz Janaszek, co-worker: Marcin Kieliszczyk, July 2017–July 2020.

The main objective of this project is to investigate Active Tunable Hyperbolic Metamaterial's properties. Full characterization of such structures requires not only performing a series of numerical simulations, but also derivation of theoretical models of light interaction with the considered structure. Theoretical analysis will cover classical as well as semi-classical approach allowing for obtaining crucial optical parameters, such as reflection, transmission and Photonic Density of States (PDOS). In particular, PDOS forms an especially useful framework for obtaining an effective gain of an active structure. Further investigations will include supporting calculations based on standard effective medium theory (EMT), nonlocal-effect-corrected EM, as well as transfer-matrix method (TMM). The crucial point of the analysis comprises complex numerical simulation based on Finite Difference Time Domain (FDTD) method. Such an approach allows for observation and investigation of wave propagation in any pre-defined medium, including periodical nanostructures, e.g. Active Tunable Hyperbolic Metamaterials.

[Pro21] **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.

[Pro22] **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.

[Pro23] **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.

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

[Pro24] **Optical fibre based biosensor of Lyme borreliosis spirochetes** (Biosensor światłowodowy krętków boreliozy z Lyme), Warsaw University of Technology, Institute of Microelectronics and Optoelectronics, project leader: Mateusz Śmietana, January 2019–December 2020.

Our motivation is to study and to develop an optical fiber sensor based on lossy-mode resonance phenomenon for detection of Lyme borreliosis. This motivation is strongly supported by already existing cooperation between both project applying laboratories/universities. While the team of University of South Bohemia is experienced with deposition of thin films and bioscience, the team at Warsaw University of Technology is performing long-term running and successful research of sensors, detection techniques and diagnostics of detector materials.

4.6. Projects Granted by the International Institutions

[Pro25] **Convergence of Electronics and Photonics Techologies for Enabling Terahertz Applications CELTA** (CELTA – Konwergencja elektroniki i technik fotonicznych na rzecz rozwoju zastosowań techniki terahercowej), EU Horizon 2020 project, (Projekt realizowany w ramach Horyzont 2020: MSCA-ITN-2015-ETN – Marie Skłodowska-Curie Innovative Training Networks (ITN-ETN)), project leader: Krzysztof Madziar, March 2016–February 2020.

CELTA aims to produce the next generation of researchers who will enable Europe to take a leading role in the multidisciplinary area of utilising Terahertz technology for applications involving components and complete systems for sensing, instrumentation, imaging, spectroscopy, and communications. All these technologies are keys to tackling challenges and creating solutions in a large number of focus areas relevant for the societal challenges identified in the Horizon 2020 programme. To achieve this objective, CELTA is comprised of 11 leading research institutions and has assembled a comprehensive research training programme for all the 15 early-stage researchers (ESRs). CELTA integrates multidisciplinary scientific expertise, complementary skills, and experience working in academia and industry to empower ESRs to work in interdisciplinary teams, integrate their activities, share expertise, and promote a vision of a converged co-design and common engineering language between electronics and photonics for Terahertz technologies.

[Pro26] **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.

[Pro27] **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 (TIM1).

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

In 2019, the first nationwide STEM PW competition was organized. IMiO employees were the main initiators of this competition on behalf of PW. The idea turned out to be a great success. Nearly 1,000 students from all over Poland took part in it. As a result, Rabyte was also created – a team of over 20 high school students. In February 2020, this team took part in the international FIRST Robotics Competitions in Istanbul. The team is under the patronage of the Faculty of Electronics and Information Technology.

In January 2020, the 2nd stage of the 2nd edition of the STEM competition took place. Nearly 200 students took part in it. STEM provided also workshops and trainings for teachers. Due to the outbreak of the epidemic, the third stage of the competition was cancelled. The winners and finalists were selected on the basis of the results of the 2nd stage.

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

Coordinator:

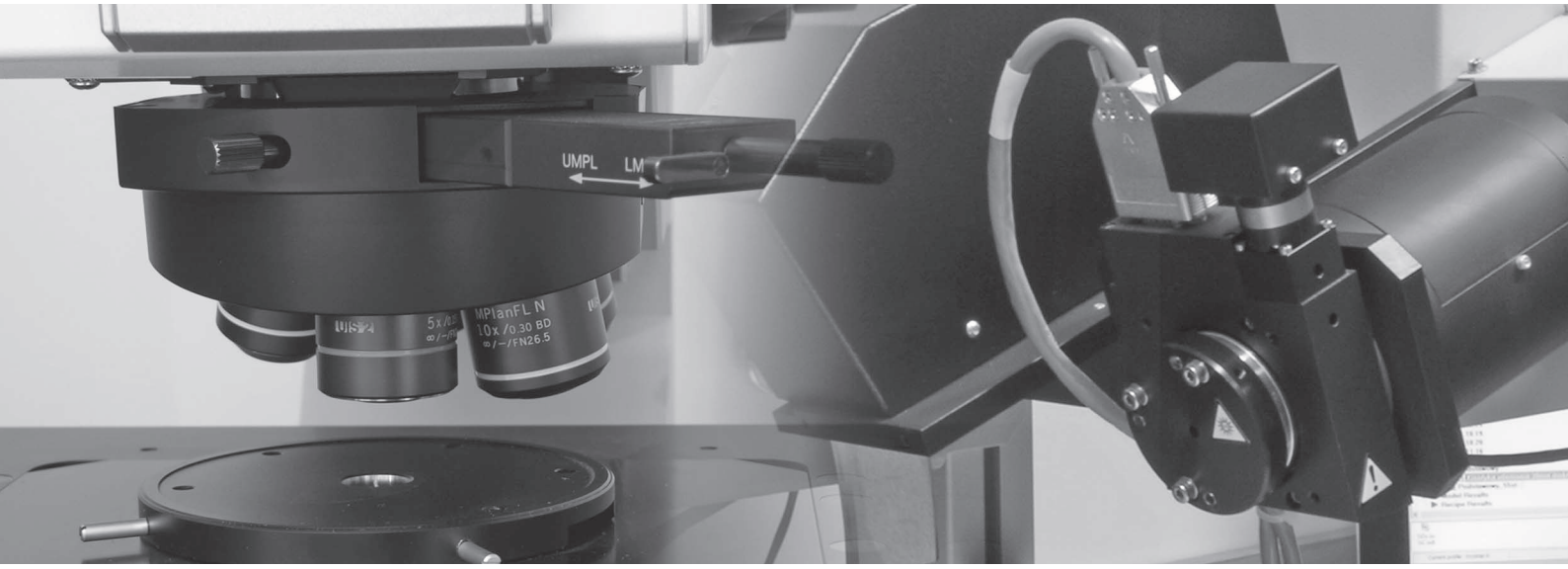
Ryszard Piramidowicz, Ph.D, D.Sc. Warsaw University of echnology,

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.



Electronic Materials and Microsystem
Technology Division

6. DEGREES AWARDED

6.1. D.Sc. Degrees

[DSc1] Marcin Kaczkan, **Photonic properties of Y4Al2O9 (YAM) oxide crystals doped with rare earth ions** (Właściwości fotoniczne kryształów tlenkowych $Y_4Al_2O_9$ (YAM) domieszkowanych jonami ziem rzadkich), 14 January 2020

6.2. M.Sc. Degrees

[MSc1] Mateusz Bieniek, **Research and development of an intelligent system for monitoring patient's vital functions with the usage of deep neural networks** (Badanie i rozwój inteligentnego systemu monitoringu funkcji życiowych pacjenta z wykorzystaniem głębokich sieci neuronowych), advisor: Sławomir Szostak, October 23

[MSc2] Piotr Chrzan, **Analysis of mode coupling in a directional coupler with a waveguide built on the basis of hyperbolic metamaterial** (Analiza sprzężenia międzymodowego w sprzęgaczu kierunkowym z falowodem zbudowanym na bazie metamateriału hiperbolicznego), advisor: Paweł Szczepański, July 3

[MSc3] Michał Długoszewski, **Detection of motion artifacts in the single-channel EEG signal** (Detekcja artefaktów ruchowych w jednokanałowym sygnale EEG), advisor: Elżbieta Piwowarska, October 23

[MSc4] Jacek Gazda, **Memory controller with memory scrubber module** (Kontroler pamięci operacyjnej ze sprzętowym odświeżaniem), advisor: Witold Pleskacz, March 6

[MSc5] Piotr Grabiński, **Implementation of the phase lock loop optimised for low phase noise and low power consumption, in CMOS 90 nm technology** (Implementacja układu pętli synchronizacji fazy pod kątem optymalizacji szumów fazowych i poboru mocy, w technologii CMOS 90 nm), advisor: Krzysztof Siwiec, July 9

[MSc6] Filip Michalak, **Asynchronous dual-rail transmission in digital circuits: properties and design techniques** (Asynchroniczna transmisja dwuszynowa w układach cyfrowych: właściwości i techniki projektowania), advisor: Elżbieta Piwowarska, October 23

[MSc7] Joanna Olas, **Luminescence properties in short wavelength spectral range of ZBLAN glasses doped with Ho^{3+} ions** (Badanie właściwości luminescencyjnych w zakresie krótkofalowym szkieł ZBLAN domieszkowanych jonami Ho^{3+}), advisor: Ryszard Piramidowicz, July 10

[MSc8] Michalina Pszczółkowska, **Spatial analysis and object recognition in satellite imagery** (Analiza przestrzenna i rozpoznanie obiektów na zdjęciach satelitarnych), advisor: Marek Sutkowski, September 7

[MSc9] Maciej Smyl, **Small objects detection and classification using deep learning methods** (Wykrywanie i klasyfikacja małych obiektów z wykorzystaniem metod głębokiego uczenia), advisor: Piotr Garbat, July 7

[MSc10] Anna Warejko, **Research on the feasibility of a pixel sensor in VESTIC technology** (Badania możliwości realizacji czujnika pikselowego w technologii VESTIC), advisor: Andrzej Pfitzner, November 13

6.3. B.Sc. Degrees

[BSc1] Maciej Bejm, **Optic fiber safe-switch – transmission protection system in case of breaking the continuity of the optic fiber line** (Bezpiecznik światłowodowy – układ zabezpieczenia transmisji w przypadku przerwania ciągłości traktu światłowodowego), advisor: Krzysztof Anders, September 18

[BSc2] Kamil Bogucki, **Comparative analysis of the hardware implementations of the Blowfish cryptographic algorithm for chosen architectures** (Analiza porównawcza realizacji sprzętowych algorytmu kryptograficznego Blowfish dla wybranych architektur), advisor: Elżbieta Piwowarska, February 14

[BSc3] Jakub Dąbkowski, **Geolocation system with mobile application** (System geolokalizacji obiektów z aplikacją mobilną), advisor: Niewiński Marek, September 25

[BSc4] Leonard Franaszczuk, **Device control for linear CCD** (Układ sterowania linijką CCD), advisor: Marek Sutkowski, September 25

[BSc5] Alicja Grochocka, **Solar radiation prediction methods depending on atmospheric and time conditions** (Metody predykcji natężenia promieniowania słonecznego w zależności od warunków atmosferycznych i czasowych), advisor: Piotr Garbat, February 20

[BSc6] Karol Gutowski, **Design of the RAM controller with error correction for PW-Sat3 satellite** (Projekt sterownika pamięci RAM z mechanizmem korekcji błędów dla satelity PW-Sat3), advisor: Zbigniew Jaworski, February 14

[BSc7] Karol Jaszczyk, **Comparative analysis of the hardware implementations of the Twofish cryptographic algorithm for chosen architectures** (Analiza porównawcza realizacji sprzętowych algorytmu kryptograficznego Twofish dla wybranych architektur), advisor: Elżbieta Piwowarska, February 14

[BSc8] Adam Jęczmień, **Implementation of the precise, low power voltage reference source (bandgap) in the CMOS 55nm technology** (Implementacja dokładnego, niskomocowego źródła napięcia referencyjnego (bandgap) w technologii CMOS 55 nm), advisor: Witold Pleskacz, February 7

[BSc9] Oleksandr Krasnyi, **Digital image processing for underwater bottom detection** (Cyfrowe przetwarzanie obrazów dla wykrycia linii dna), advisor: Marek Sutkowski, October 23

[BSc10] Marcin Ludwiniak, **Comparison of FIR filter hardware implementations** (Porównanie realizacji sprzętowych filtra SOI), advisor: Elżbieta Piwowarska, February 14

[BSc11] Sebastian Miecielica, **Intelligent flow control system in beer lines** (Inteligentny system kontroli przepływu cieczy w liniach piwnych), advisor: Sławomir Szostak, September 25

[BSc12] Paweł Misiak, **Wood classification and anomaly detection system** (System rozpoznawania anomalii i klasyfikacji wyrobów drewnianych), advisor: Piotr Garbat, February 20

[BSc13] Jakub Sadowski, **Remote platform for building vibration measurement** (Projekt zdalnej platformy do pomiarów drgań obiektów budowlanych), advisor: Marcin Kaczkan, October 23

[BSc14] Damian Woliński, **The modification of Long-Period Fiber Grating based sensors' operation by using thin layers of hafnium oxide** (Modyfikacja warunków pracy czujników opartych na światłowodowych siatkach długookresowych z wykorzystaniem cienkich warstw tlenku hafnu), advisor: Mateusz Śmietana, March 6

7. PUBLICATIONS

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

NUMBER	JOURNAL	AUTHORS	TITLE	DOI	VOLUME	PAGES
[Pub1]	AIP Advances	Krupka J., Pacewicz A., Salski B., Kopyt P.	Electrodynamic theory of ferromagnetic resonance and its applications in precise measurements of ferromagnetic linewidth, permeability tensor and saturation magnetization	10.1063/1.5127859	vol. 10 no 1	1–6
[Pub2]	APL Photonics	Markiewicz K., Kaczorowski J., Yang Z., Szostkiewicz Ł., Dominguez-Lopez A., Wilczyński K., Napierała M., Nasiłowski T., Thévenaz L.	Frequency scanned phase sensitive optical time-domain reflectometry interrogation in multimode optical fibers	10.1063/1.5138728	vol. 5	1–5
[Pub3]	Applied Sciences-Basel	Komorowski P., Surma M., Walczakowski M., Zagrajek P., Siemion A.	Off-axis diffractive optics for compact terahertz detection setup	10.3390/app102 38594	vol. 10 no 23	1–10
[Pub4]	Biosensors & Bioelectronics	Śmietana M., Koba M., Sezemsky P., Szot-Karpińska K., Burnat D., Stranak V., Niedziółka-Jönsson J., Bogdanowicz R.	Simultaneous optical and electrochemical label-free biosensing with ITO-coated lossy-mode resonance sensor	10.1016/j.bios. 2020.112050	vol. 154 no Apr.15	1–8
[Pub5]	Bulletin of the Polish Academy of Sciences, Technical Sciences	Rąbkowski J., Król K., Zdanowski M., Sochacki M.	GaN-based soft-switched active power buffer operating at ZCS – problems of start-up and shut-down	10.24425/bpasts. 2020.134175	vol. 68 no 4	785–792
[Pub6]	Bulletin of the Polish Academy of Sciences, Technical Sciences	Taube A., Sochacki M.	Edge termination design for 1.7 kV silicon carbide p-i-n diodes	10.24425/bpasts. 2020.133108	vol. 68 no 2	367–375
[Pub7]	Chinese Optics Letters	Paśko S., Sutkowski M., Bakanas R.	Use of focus stacking and SfM techniques in the process of registration of a small object hologram	10.3788/COL 202018.060901	vol. 18 no 6	1–5
[Pub8]	Circuit World	Kisiel R., Guziewicz M., Taube A., Kamiński M., Sochacki M.	Development of Assembly Techniques for Connection of AlGaN/GaN/Si Chips to DBC substrate	10.1108/CW-12-2019-0186		1–7
[Pub9]	Crystals	Janaszek B., Kieliszczyk M., Tyszka-Zawadzka A., Szczepański P.	Influence of Nonlocality on Transmittance and Reflectance of Hyperbolic Metamaterials	10.3390/cryst 10070577	vol. 10 no 7	1–14
[Pub10]	Crystals	Kieliszczyk M., Janaszek B., Tyszka-Zawadzka A., Szczepański P.	Guided Optical Modes in Metal-Cladded Tunable Hyperbolic Metamaterial Slab Waveguides	10.3390/cryst 10030176	vol. 10 no 3	1–13

[1] Institute for Scientific Information (Philadelphia, USA)

[Pub11]	Crystals	Kowalczyk M., Ramazanova T., Grigoryeva V., Shlegel V., Kaczkan M., Fetliński B., Malinowski M.	Optical investigation of Eu^{3+} doped bi12geo20 (BGO) crystals	10.3390/cryst 10040285	vol. 10 no 4	1–14
[Pub12]	Crystals	Mroczyński R., Iwanicki D., Fetliński B., Ożga M., Świniarski M., Gertych A., Zdrojek M., Godlewski M.	Optimization of Ultra-Thin Pulsed-DC Magnetron Sputtered Aluminum Films for the Technology of Hyperbolic Metamaterials	10.3390/cryst 10050384	vol. 10 no 5	10–12
[Pub13]	IEEE Journal of the Electron Devices Society	Knoch J., Lemme M., Beck R., Łukasiak L.	Guest Editorial	10.1109/JEDS. 2020.3009974	vol. 8	738–739
[Pub14]	IEEE Photonics Journal	Bandyopadhyay S., Shao L., Śmietana M., Wang C., Hu J., Wang G., Wei-Te H., Gu G., Tao Y.	Employing higher order cladding modes of fiber Bragg grating for analysis of refractive index change in volume and at the surface	10.1109/JPHOT. 2019.2963125	vol. 12 no 1	1–13
[Pub15]	IEEE Transactions on Electron Devices	Wiśniewski P., Majkusiak B.	Modeling the Current–Voltage Characteristics of $Ge_{1-x}Sn_x$ Electron–Hole Bilayer TFET With Various Compositions	10.1109/TED. 2020.2993817	vol. 67 no 7	2738– –2744
[Pub16]	IEEE Transactions on Microwave Theory and Techniques	Salski B., Karpisz T., Kopyt P., Krupka J.	Rigorous Scattering Matrix Analysis of a Fabry-Perot Open Resonator	10.1109/TMTT. 2020.3021716	vol. 68 no 12	5093– –5102
[Pub17]	Journal of Alloys and Compounds	Kaczkan M., Malinowski M., Suchocki A., Pawlak D., Turczyński S	Temperature and concentration dependent luminescence of Yb^{3+} centers in YAM	10.1016/j.jallcom. 2020.155893	vol. 842	1–8
[Pub18]	Journal of Applied Physics	Gelczuk Ł., Dąbrowska-Szata M., Kolkovsky V., Sochacki M., Szmidt J., Gotszalk T.	Origin and anomalous behavior of dominant defects in 4H-SiC studied by conventional and Laplace deep level transient spectroscopy	10.1063/1.514 0731	vol. 127 no 6	1–6
[Pub19]	Journal of Applied Physics	Pacewicz A., Krupka J., Pavlo A., Salski B., Kopyt P., Frender R.	Broad-ferromagnetic-linewidth non-metallic gyromagnetic spheres: A comparison of linewidth characterization methods	110.1063/5.000 4027	vol. 127 no 16	1–12
[Pub20]	Journal of Electronic Packaging	Szałapak J., Kiełbasiński K., Dybowska-Sarapuk Ł., Krzemiński J., Teodorczyk M., Kowaluk T., Jakubowska M.	Influence of Carbon Nanoparticles Additives on Nanosilver Joints in LTJT Technology	10.1115/1.404 9240	vol. 143 no 3	1–4
[Pub21]	Journal of Lightwave Technology	Budnicki D., Parola I., Szostkiewicz Ł., Markiewicz K., Hołdyński Z., Wójcik G., Makara M., Poturaj K., Kuklińska M., Mergo P., Napierała M., Nasiłowski T.	All-fiber vector bending sensor based on a multicore fiber with asymmetric air-hole structure	10.1109/JLT. 2020.3012769	vol. 38	6685– –6690
[Pub22]	Journal of Luminescence	Piramidowicz R., Jusza A., Lipińska L., Baran M., Polis P., Olszyna A.	UV-blue luminescent properties of Tm^{3+}:Y_2O_3 nanocrystals and PMMA-based composites	10.1016/j.jlumin. 2020.117458	vol. 226 no Oct.	1–7

[Pub23]	Journal of Magnetism and Magnetic Materials	Krupka J., Pacewicz A., Salski B., Kopyt P., Bourhill J., Goryachev M., Tobar M.	Resonance in Large Ferrimagnetic YIP Samples – Electrodynamic Analysis	10.1016/j.jmmm.2020.167536	vol. 521 no Part 1	1–8
[Pub24]	Journal of Vacuum Science and Technology B	Ekielski M., Wzorek M., Gołaszewska-Malec K., Domanowska A., Taube A., Sochacki M.	Implementation of the inductively coupled plasma etching processes for forming gallium nitride nanorods used in ultraviolet light-emitting diode technology	10.1116/6.0000133	vol. 38 no 4	1–6
[Pub25]	Materials	Łapińska A., Kuźniewicz M., Gertych A., Czerniak-Łosiewicz K., Żerańska-Chudek K., Wróblewska A., Świniarski M., Dużyńska A., Judek J., Zdrojek M.	Study of structural and optoelectronic properties of thin films made of a few layered ws2 flakes	10.3390/ma13235315	vol. 13 no 23	1–9
[Pub26]	Materials & Design	Wicher B., Zdunek K., Chodun R., Haj Ibrahim S., Kubiś M., Lachowski A., Król K., Jaroszewicz J., Minikayev R., Nowakowska-Langier K.	Surface sintering of tungsten powder targets designed by electromagnetic discharge: A novel approach for film synthesis in magnetron sputtering	10.1016/j.matdes.2020.108634	vol. 191	1–8
[Pub27]	Metrology and Measurement Systems	Firek P., Krawczyk S., Wronka H., Czerwosz E., Szmidt J.	Hydrogen sensor based on field effect transistor with C-Pd layer	10.24425/mms.2020.132777	vol. 27 no 2	313–321
[Pub28]	Microelectronic Engineering	Puźniak M., Gajewski W., Żelechowski M., Jamroz J., Gertych A., Zdrojek M., Mroczyński R.	Technology and optimization of hafnium oxynitride (HfO_xN_y) thin-films formed by pulsed-DC reactive magnetron sputtering for MIS devices	10.1016/j.mee.2020.111332	vol. 228, no May 1	1–10
[Pub29]	Microelectronics International	Firek P., Szarafiński J., Głuszko G., Szmidt J..	Field effect transistor with thin AlO_xN_y film as gate dielectric	10.1108/MI-11-2019-0074	vol. 37 no 2	103–107
[Pub30]	Nano Energy	Haras M., Markiewicz M., Monfray S., Skotnicki T.	Pulse mode of operation – A new booster of TEG, improving power up to X2.7 – to better fit IoT requirements	10.1016/j.nanoen.2019.104204	vol. 68 no Feb.	1–8
[Pub31]	Nanomaterials	Mazurak A., Mroczyński R., Beke D., Gali A.	Silicon-Carbide (SiC) Nanocrystal Technology and Characterization and Its Applications in Memory Structures	10.3390/nano10122387	vol. 10 no 12	1–11
[Pub32]	Optica Applicata	Kaźmierczak A., Słowikowski M., Pavłov K., Filipiak M., Vervaeke M., Tyszkiewicz C., Ottevaere H., Piramidowicz R., Karasiński P.	Efficient, low-cost optical coupling mechanism for TiO_2-SiO_2 sol-gel derived slab waveguide surface grating coupler sensors	10.37190/oa200403	vol. 50 no 4	1–11
[Pub33]	Optical Materials	Kaczkan M., Kowalczyk M., Szostak S., Majchrowski A., Malinowski M.	Transition intensity analysis and emission properties of Eu^{3+}: $Bi_2ZnOB_2O_6$ acentric biaxial single crystal	10.1016/j.optmat.2020.110045	vol. 107 no Sep.	1–7
[Pub34]	Optics Express	Hoang V., Dobrakowski D., Stępniewski G., Kasztelanic R., Pysz D., Dinh K., Klimczak M., Śmietana M., Buczyński R.	Antiresonant fibers with single- and double-ring capillaries for optofluidic applications	10.1364/OE.404701	vol. 28 no 22	32483–32498

[Pub35]	Optics Express	Janaszek B., Szczepański P.	Effect of nonlocality in spatially uniform anisotropic metamaterials	10.1364/OE. 392596	vol. 28 no 10	15447– –15458
[Pub36]	Optics Express	Janik M., Niedziałkowski P., Lechowicz K., Koba M., Sezemsky P., Stranak V., Ossowski T., Śmietana M.	Electrochemically directed biofunctionalization of a lossy-mode resonance optical fiber sensor	10.1364/OE. 390780	vol. 28 no 11	15934– –15942
[Pub37]	Optics Express	Siemion A., Komorowski P., Surma M., Ducin I., Sobotka P., Walczakowski M., Czerwińska E.	Terahertz diffractive structures for compact in-reflection inspection setup	10.1364/OE. 382272	vol. 28 no 1	715–723
[Pub38]	Optics Express	Tyszka-Zawadzka A., Janaszek B., Kieliszczyk M., Szczepański P.	Controllable intermodal coupling in waveguide systems based on tunable hyperbolic metamaterials	10.1364/OE. 413825	vol. 28 no 26	40044– –40059
[Pub39]	Opto-Electronics Review	Ciszewski P., Sochacki M.	Processing of printed circuit boards using a 532 nm green laser	10.24425/opelre. 2020.135258	vol. 28	197–202
[Pub40]	Results in Physics	Vainshtein S., Duan G., Rahkonen T., Taylor Z., Zemlyakov V., Egorkin V., Smolyanskaya O., Skotnicki T., Knap W.	Self-damping of the relaxation oscillations in miniature pulsed transmitter for sub-nanosecond-precision, long-distance LIDAR	10.1016/j.rinp. 2020.103509	vol. 19 no Dec.	1–8
[Pub41]	Sensors	Borecki M., Rychlik A., Olejnik A., Prus P., Szmidt J., Korwin-Pawlowski M.	Application of wireless accelerometer mounted on wheel rim for parked car monitoring	10.3390/s20216088	vol. 20 no 21	1–19
[Pub42]	Sensors	Borejko T., Marcinek K., Siwiec K., Narczyk P., Borkowski A., Butryn I., Łuczyk A., Pietroń D., Plasota M., Reszewicz S., Wiechowski Ł., Pleskacz W.	NaviSoC: High-Accuracy Low-Power GNSS SoC with an Integrated Application Processor	10.3390/s20041069	vol. 20 no 4	1–19
[Pub43]	Sensors	Eftimov T., Janik M., Koba M., Śmietana M., Mikulic P., Bock W.	Long-period gratings and microcavity in-line mach zehnder interferometers as highly sensitive optical fiber platforms for bacteria sensing	10.3390/s20133772	vol. 20 no 13	1-18
[Pub44]	Sensors	Janczuk-Richter M., Gromadzka B., Richter Ł., Panasiuk M., Zimmer K., Mikulic P., Bock W., Maćkowski S., Śmietana M., Niedziolka-Jonsson J.	Immunosensor Based on Long-Period Fiber Gratings for Detection of Viruses Causing Gastroenteritis	10.3390/s20030813	vol. 20 no 3	1–11
[Pub45]	Sensors	Janik M., Koba M., Król K., Mikulic P., Bock W., Śmietana M.	Combined Long-Period Fiber Grating and Microcavity In-Line Mach–Zehnder Interferometer or Refractive Index Measurements with Limited Cross-Sensitivity	10.3390/s20082431	vol. 20 no 8	1–13
[Pub46]	Sensors	Marcinek K., Pleskacz W.	GNSS-ISE: Instruction Set Extension for GNSS Baseband Processing	10.3390/s20020465	vol. 20 no 2	1–20

[Pub47]	Thin Solid Films	Jędrzejczak A., Batory D., Prowizor M., Dominik M., Śmietana M., Cichomski M., Kisielewska A., Szymański W., Kozlowski W., Dudek M.	Titanium(IV) isopropoxide as a source of titanium and oxygen atoms in carbon based coatings deposited by Radio Frequency Plasma Enhanced Chemical Vapour Deposition method	10.1016/j.tsf.2019.137697	vol. 693 no Jan. 1	1–7

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

NUMBER	JOURNAL	AUTHORS	TITLE	DOI	VOLUME	PAGES
[Pub48]	Archives of Civil Engineering	Wierzbicki S., Pióro Z., Osiniak M., Antoszkiewicz E.	Inclinometer Method of Displacement Measurements as an Alternative to Optical Measurements in Structural Health Monitoring – Laboratory Tests	10.24425/ace.2020.131802	vol. 66 no 2	147–164
[Pub49]	arXiv	Zhao Z., Goryachev M., Krupka J., Tobar M.	Emergence of dielectric anisotropy of crystalline Strontium Titanate due to temperature-dependent phase transitions	arXiv:1508.07550	17 Aug.	1–9
[Pub50]	Journal of Physics – Conference Series	Korzeniewska E., Szczęsny A., Kasprowicz D.	IDEs structures created in the physical vacuum deposition process on textile substrates	10.1088/1742-6596/1534/1/012004	vol. 1534	1–8
[Pub51]	Photonics Letters of Poland	Michalak B., Sezemsky P., Stranak V., Śmietana M.	Effect of thermal annealing on sensing properties of optical fiber sensors coated with indium tin oxide nano-overlays	10.4302/plp.v12i2.1024	vol. 12 no 2	58–60
[Pub52]	Photonics Letters of Poland	Surma M., Komorowski P., Neneman M., Siemion A.	Chocolate terahertz fresnel lens	10.4302/plp.v12i4.1046	vol. 12 no 4	103–105
[Pub53]	Sensing and Bio-Sensing Research	Bandyopadhyay S., Shao L., Wang C., Shuaiqi L., Wu Q., Gu G., Hu J., Liu Y., Xiaolong C., Song Z., Song X., Bao Q., Śmietana M.	Study on optimization of nano-coatings for ultra-sensitive biosensors based on long-period fiber grating	10.1016/j.sbsr.2019.100320	vol. 27 no Feb.	1–11

7.3. Scientific and Technical Papers Published in Conference Proceedings

NUMBER	PROCEEDINGS OF CONFERENCE / ISBN	AUTHORS	TITLE	DOI	PAGES
[Pub54]	11th International Conference on Image Processing and Communications, Advances in Intelligent Systems and Computing, vol. 1062 ISBN 978-3-030-31253-4	Garbat P., Olszewska A.	Remote Heart Rate Monitoring Using a Multi-band Camera	10.1007/978-3-030-31254-1_13	101–107
[Pub55]		Garbat P., Sadura P., Olszewska A., Maciejewski P.	Vision System for Pit Detection in Cherries	10.1007/978-3-030-31254-1_20	158–165

[Pub56]	11th International Conference on Image Processing and Communications, Advances in Intelligent Systems and Computing, vol. 1062 ISBN 978-3-030-31253-4	Nasarzewski Z., Garbat P.	Initial Research on Fruit Classification Methods Using Deep Neural Networks	10.1007/978-3-030-31254-1_14	108–113
[Pub57]	Proceedings of 23rd International Microwave and Radar Conference (MIKON 2020) ISBN 978-83-949421-7-5	Kopyt P., Krupka J., Salski B.	Measurement of the Complex Anisotropic Permittivity of Microwave Lamnates	10.23919/MIKON 48703.2020. 9253851	114–117
[Pub58]		Pacewicz A., Salski B., Krupka J., Kopyt P., Nabiałek A., Chumak O.	Broadband Microwave Characterization of Mono-And Polycrystalline Magnetic Garnet Sheres	10.23919/MIKON 48703.2020. 9253968	105–110
[Pub59]		Siemion A., Melaniuk A., Zagrajek P., Komorowski P., Walczakowski M., Surma M., Sobotka P., Ducin I., Czerwinska E.	THz diffractive lens manufactured using 3D printer working for 0.6 THz	10.23919/MIKON 48703.2020. 9253821	225–228
[Pub60]	Proceedings of the 2020 IEEE 23rd International Symposium on Design and Diagnostics of Electronic Circuits and Systems, vol. CFP20DDE-ART ISBN 978-1-7281-9938-2	Reszewicz S., Siwiec K., Pleskacz W	CMOS Differential Amplifier as a Physically Unclonable Function	10.1109/DDECS 50862.2020. 9095749	1–4
[Pub61]	SPIE Conference Optical Engineering + Applications: Terahertz Emitters, Receivers, and Applications XI, vol. 11499 ISBN: 9781510638044	Siemion A., Surma M., Komorowski P., Ducin I., Sobotka P.	Terahertz diffractive optics: Different way of thinking	10.1117/12. 2568849	1–7
[Pub62]	SPIE Conference Photonics Applications in Astronomy, Communications, Industry, and High Energy Physics Experiments, vol. 11581 ISBN 9781510639874	Martychowiec A., Kwietniewski N., Kondracka K., Werbowy A., Sochacki M.	Ti and TiAl-based ohmic contacts to 4H-SiC	10.1117/12. 2580518	1–8
[Pub63]		Olejnik A., Borecki M., Rychlik A.	A simple detection method of movement of clouds at the sky	10.1117/12. 2580555	1–8
[Pub64]	SPIE Conference Photonics Europe: Integrated Photonics Platforms: Fundamental Research, Manufacturing and Applications, vol. 11364	Karasiński P., Tyszkiewicz C., Piramidowicz R., Kaźmierczak A.	Development of integrated photonics based on SiO_2:TiO_2 sol-gel derived waveguide layers: state of the art, perspectives, prospective applications	10.1117/12. 2559059	1–8

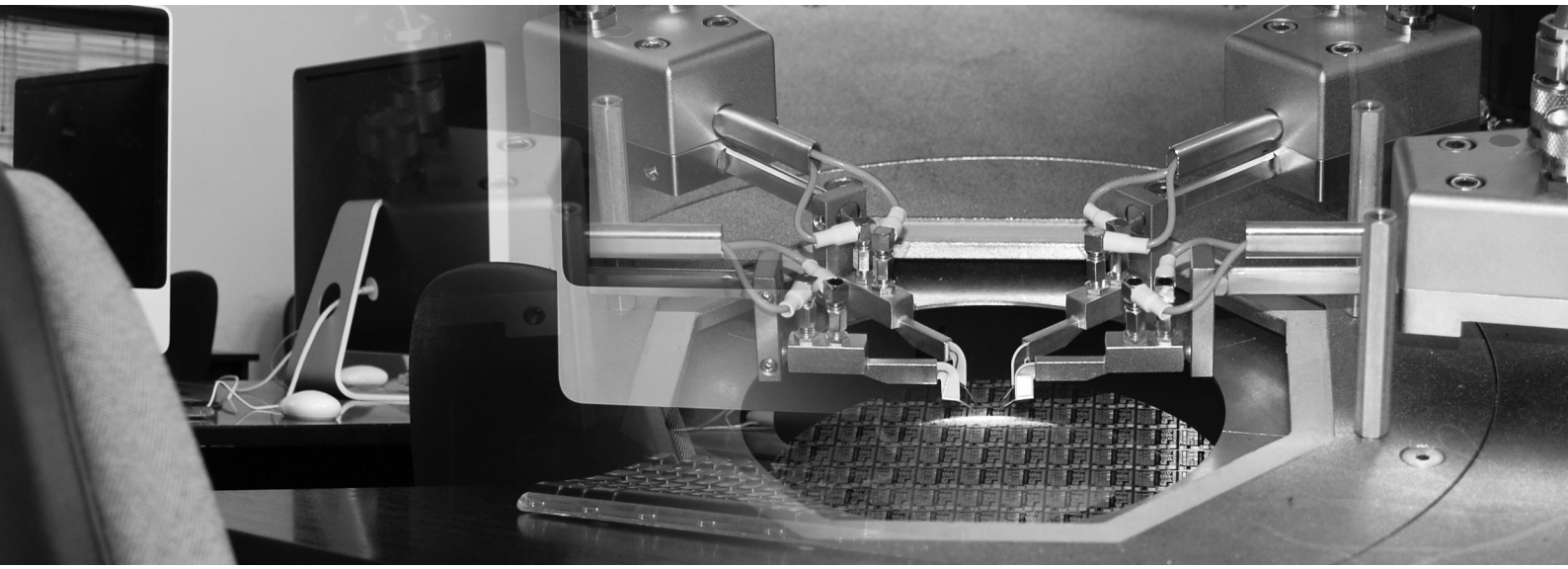
7.4. Scientific and Technical Books

NUMBER	AUTHORS	PUBLISHER / ISBN	TITLE	PAGES
[Pub65]	Galwas B.	Oficyna Wydawnicza Politechniki Warszawskiej ISBN 978-83-8156-145-7	Panorama e-edukacji w Polsce	382

8. PATENTS

[Pat1] Czerwosz Elżbieta, Wronka Halina, Krawczyk Sławomir, Firek Piotr, Szmidt Jan, **Transistor-based gas sensor and the method of its production** (Tranzystorowy czujnik gazowy i sposób jego wytwarzania), Application number: P.427569, Patent/rights number: PL 235878, Application date: 29-10-2018, Patent (decision) date: 08-06-2020

[Pat2] Tatarkiewicz Jan, Borodziński Janusz, Kuźmicz Wiesław, **Apparatus, systems, and methods for beta decay based true random number generator**, Invention, Protected, Application number: 63/062,672, Patent/rights number: US 10,901,695 B1, Application date: 07-08-2020



VLSI Engineering
and Design Automation Division

9. REPORTS

NUMBER	AUTHORS	TITLE	TYPE
[Rep1]	Butryn I.	Development of all digital phase locked loop bandwidth shaping method in FMCW radar transceiver	**scientific report** from the project granted by the University
[Rep2]	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, GAMEINN	**scientific report** from the project granted by the National Centre for Research and Development
[Rep3]	Janaszek B.	Active Tunable Hyperbolic Metamaterials	**scientific report** from the project granted by the National Science Centre
[Rep4]	Jusza A.	Looking for yellow lasing – dysprosium doped active materials for lasers operating in VIS spectral range	**scientific report** from the project granted by the University
[Rep5]	Kaczkan M.	New Versatile Platform for Illumination and Sensing – NewILUMIS	**scientific report** from the project granted by the National Centre for Research and Development
[Rep6]	Karasiński P., Tyszkiewicz C., Piramidowicz R., Kaźmierczak A.	Development of integrated photonics based on SiO_2:TiO_2 sol-gel derived waveguide layers: state of the art, perspectives, prospective applications	**presentation**: SPIE Conference Photonics Europe: Integrated Photonics Platforms: Fundamental Research, Manufacturing and Applications, 2020
[Rep7]	Karolina P., Kozubal M., Taube A., Kamiński M., Kwietniewski N., Juchniewicz M., Szerling A.	Stabilna termicznie izolacja elektryczna tranzystorów HEMT AlGaN/GaN wytwarzana metodą implantacji jonów Fe+	**presentation**: XIX Krajowa Konferencja Elektroniki 2020
[Rep8]	Karpisz T., Salski B., Krupka J., Kopyt P.	Measurement of In-Plane Anisotropy of Dielectric Materials with a Fabry-Perot Open Resonator	**presentation**: 23rd International Microwave and Radar Conference, MIKON 2020
[Rep9]	Kisiel R.	New generation of high thermal efficiency components packages for space	**scientific report** from the project granted by the EU Horizon project – HEATPACK
[Rep10]	Kopyt P., Krupka J., Salski B.	Measurement of the Complex Anisotropic Permittivity of Microwave Laminates	**presentation**: 23rd International Microwave and Radar Conference, MIKON 2020
[Rep11]	Krupka J.	Correlations between electromagnetic and magnetoelastic properties of thin ferromagnetic films	**scientific report** from the project granted by the National Science Centre
[Rep12]	Lelit M., Słowikowski M., Kaźmierczak A., Anders K., Stopiński S., Juchniewicz M., Stonio B., Michalak B., Filipiak M., Pavłov K., Wiśniewski P., Beck R., Piramidowicz R.	Silicon nitride based building blocks for integrated photonics – design, technology and characterization	**presentation**: 15th Conference Integrated Optics – Sensors, Sensing Structures and Methods 2020
[Rep13]		Silicon nitride passive photonic platform for applications at visible wavelengths: design, fabrication and characterization	**poster**: 22nd European Conference on Integrated Optics 2020

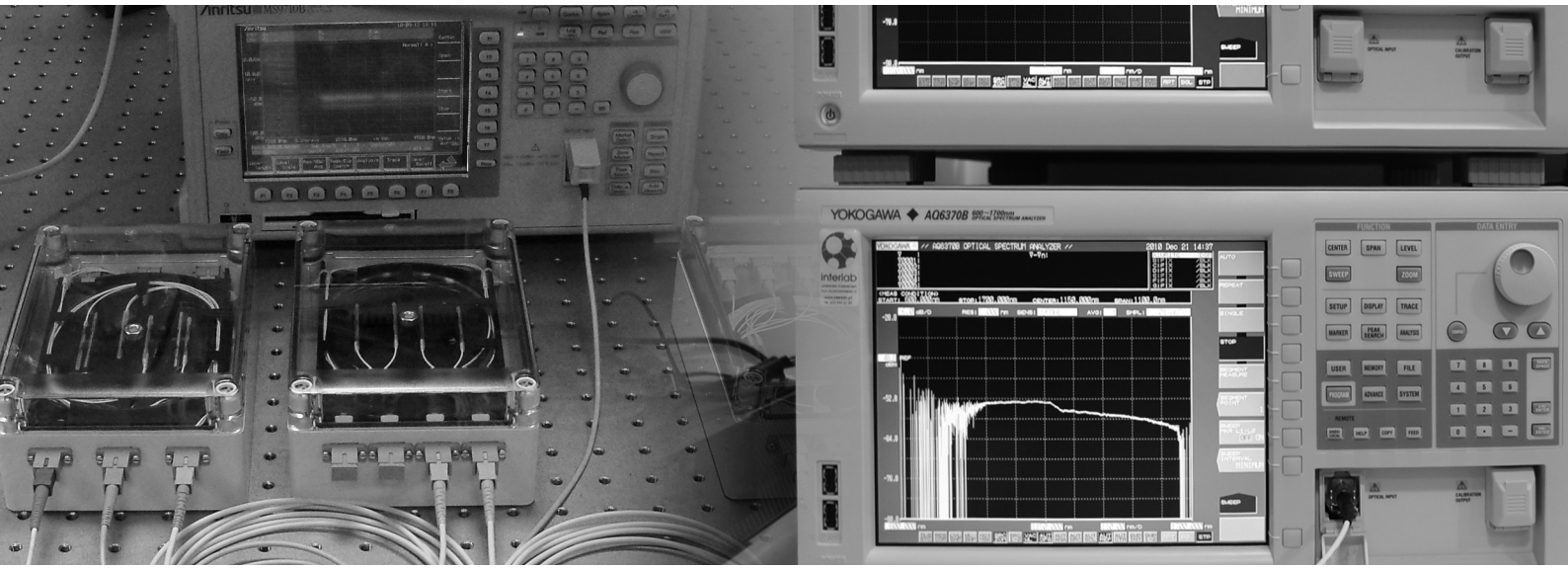
[Rep14]	Madziar K.	Convergence of Electronics and Photonics Techologies for Enabling Terahertz Applications CELTA	**scientific report** from the project granted by the EU Horizon 2020
[Rep15]	Malinowski M.	Tunable hyperbolic metamaterials for photonic devices of novel generation HYPERMAT	**scientific report** from the project granted by the National Centre for Research and Development
[Rep16]	Martychowiec A., Kwietniewski N., Kondracka K., Werbowy A., Sochacki M.	Ti and TiAl-based ohmic contacts to 4H-SiC	**presentation**: SPIE Conference Photonics Applications in Astronomy, Communications, Industry, and High Energy Physics Experiments, 2020
[Rep17]	Michalak B., Sezemsky P., Stranak V., Śmietana M.	Effect of thermal annealing on sensing properties of optical fiber sensors coated with indium tin oxide nano-overlays	**presentation**: 15th Conference Integrated Optics – Sensors, Sensing Structures and Methods 2020
[Rep18]	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
[Rep19]	Mroczyński R.	Research infrastructure for the fabrication and diagnostics of semiconductor structures and devices (SPUB)	**scientific report** from the project granted by the Ministry of Science and Higher Education
[Rep20]	Niewiński M.	Hardware accelerator supporting watermarking of audio files	**scientific report** from the project granted by the University
[Rep21]	Olejnik A., Borecki M., Rychlik A.	A simple detection method of movement of clouds at the sky	**poster**: SPIE Conference Photonics Applications in Astronomy, Communications, Industry, and High Energy Physics Experiments, 2020
[Rep22]	Pacewicz A., Salski B., Krupka J., Kopyt P., Nabiałek A., Chumak O.	Broadband Microwave Characterization of Mono- And Polycrystalline Magnetic Garnet Spheres	**presentation**: 23rd International Microwave and Radar Conference, MIKON 2020
[Rep23]	Pietroń D.	Method development of automatic on-chip calibration (inside an integrated circuit) of a low-noise amplifier parameters in order to obtain a low sensitivity to variation of fabrication parameters	**scientific report** from the project granted by the University
[Rep24]	Piramidowicz R.	Diagnosis of skin cancer in the conditions of limited social mobility	**scientific report** from the project granted by the University
[Rep25]	Piramidowicz R.	Nanostructured photonic crystal fibers for innovative few mode propagation TECHMATSTRATEG	**scientific report** from the project granted by the National Centre for Research and Development
[Rep26]	Piramidowicz R., Stopiński S., Paśnikowska A., Słowikowski M., Kaźmierczak A., Jusza A., Anders K., Pleskacz W., Szczepański P.	Integrated Photonics – yesterday, today and tomorrow	**presentation**: 15th Conference Integrated Optics – Sensors, Sensing Structures and Methods 2020
[Rep27]	Pleskacz W.	Innovative, hardware-software component, based on a dedicated integrated circuit and software to perform various cryptographic application, with the particular attention paid to electronic identification systems with the high level of confidence	**scientific report** from the project granted by the National Centre for Research and Development

[Rep28]	Pleskacz W.	Miniature, dual-frequency, system-on-a-chip for precise satellite navigation GPS/Galileo integrated with application processor dedicated to IoT devices with low power consumption	**scientific report** from the project granted by the National Centre for Research and Development
[Rep29]	Reszewicz S., Siwiec K., Pleskacz W.	CMOS Differential Amplifier as a Physically Unclonable Function	**presentation**: IEEE 23rd International Symposium on Design and Diagnostics of Electronic Circuits and Systems 2020
[Rep30]	Sai P., Słowikowski M., Filipiak M., Wiśniewski P., Cywiński G., Sakowicz M., Prystawko P., Rumyantsev S., Knap W.	Combination of Laser and e-Beam Lithography for Large Area Submicron Grating-Gate AlGaN/GaN THz Devices	**presentation**: 33rd International Microprocesses and Nanotechnology Conference 2020
[Rep31]	Salski B., Karpisz T., Kopyt P., Krupka J.	Characterization of dielectric materials for 5G telecommunications with a Fabry-Perot open resonator	**presentation**: Electronic Materials and Applications 2020, EMA 2020
[Rep32]	Salski B., Karpisz T., Kopyt P., Krupka J.	Plane-wave Expansion Method for Calculating Modes in a Fabry-Perot Open Resonator	**presentation**: 23rd International Microwave and Radar Conference, MIKON 2020
[Rep33]	Siemion A., Melaniuk A., Zagrajek P., Komorowski P., Walczakowski M., Surma M., Sobotka P., Ducin I., Czerwińska E.	THz diffractive lens manufactured using 3D printer working for 0.6 THz	**presentation**: 23rd International Microwave and Radar Conference, MIKON 2020
[Rep34]	Siemion A., Surma M., Komorowski P., Ducin I., Sobotka P.	Terahertz diffractive optics: Different way of thinking	**presentation**: SPIE Conference Optical Engineering + Applications: Terahertz Emitters, Receivers, and Applications XI, 2020
[Rep35]	Słowikowski M., Kaźmierczak A., Bieniek M., Szostak S., Osuch T., Krej M., Dziuda Ł., Stopiński S., Piramidowicz R.	ASPIC-based photonic system for monitoringbreath/respiratory rateof patient under MRI diagnosis	**presentation**: 15th Conference Integrated Optics – Sensors, Sensing Structures and Methods 2020
[Rep36]	Słowikowski M., Lelit M., Juchniewicz M., Stonio B., Michalak B., Filipiak M., Pavłov K., Wiśniewski P., Stopiński S., Piramidowicz R., Beck R.	Fabrication aspects of silicon nitride photonics integrated circuits	**poster**: 15th Conference Integrated Optics – Sensors, Sensing Structures and Methods 2020
[Rep37]	Śmietana M.	DIAMSEC – ultrasensitive sensing platform for rapid detection of epidemiological and pandemic threats	**scientific report** from the project granted by the National Centre for Research and Development
[Rep38]	Śmietana M.	Optical analysis of electrochemical reaction products in picoliter volumes	**scientific report** from the project granted by the National Science Centre
[Rep39]	Śmietana M.	Optical fibre based biosensor of Lyme borreliosis spirochetes	**scientific report** from the project granted by the Polish National Agency for Academic Exchange
[Rep40]	Śmietana M.	Opto-electrochemical effects in thin conductive oxides for sensing applications	**scientific report** from the project granted by the University
[Rep41]	Śmietana M.	S^2EC – integration of optical and electrochemical techniques towards biochemical sensing with high sensitivity and selectivity	**scientific report** from the project granted by the University

[Rep42]	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
[Rep43]	Stopiński S.	Photonic integrated circuit for interrogation of fiber Bragg gratings	**scientific report** from the project granted by the University
[Rep44]	Stopiński S.	Photonic integrated circuits for new generation of optical gyroscope systems	**scientific report** from the project granted by the University
[Rep45]	Stopiński S.	Photonic integrated multi-channel transmitter for quantum key distribution	**scientific report** from the project granted by the University
[Rep46]	Szczepański P.	Shaping optical properties of planar metamaterials for photonic structures of novel functionalities	**scientific report** from the project granted by the University
[Rep47]	Szmidt J.	Methods and means of protection and defense against high power microwave pulses	**scientific report** from the project granted by the National Centre for Research and Development
[Rep48]	Szmidt J.	Technologies of semiconductor materials for high power and high frequency electronics – WidePOWER	**scientific report** from the project granted by the National Centre for Research and Development
[Rep49]	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 Axis III Higher Education for the Economy and Development of the Operational Programme Science Education Development 2014–2020
[Rep50]	Wiśniewski P., Majkusiak B., Stonio B.	Tunneling and Resonant Tunneling Effects in the Metal-Ultrathin Oxide-(n+)Silicon Structures	**presentation**: Joint International EUROSOI Workshop and International Conference on Ultimate Integration on Silicon 2020

10. CONFERENCES, SEMINARS AND MEETINGS

NUMBER	CONFERENCE, SEMINARS AND MEETINGS	PARTICIPANTS
[Con1]	Electronic Materials and Applications EMA 2020, Orlando, USA, January 22–24, 2020	Krupka J.
[Con2]	IEEE 23rd International Symposium on Design and Diagnostics of Electronic Circuits and Systems DDECS 2020, Novi Sad, Serbia, April 22–24, 2020	Pleskacz W., Reszewicz S., Siwiec K.
[Con3]	Joint International EUROSOI Workshop and International Conference on Ultimate Integration on Silicon 2020, Caen, France, Online Only, September 1–30, 2020	Majkusiak B., Stonio B., Wiśniewski P.
[Con4]	SPIE Conference Optical Engineering + Applications: Terahertz Emitters, Receivers, and Applications XI, San Diego, USA, Online Only, August 24–September 4, 2020	Komorowski P.
[Con5]	SPIE Conference Photonics Europe: Integrated Photonics Platforms: Fundamental Research, Manufacturing and Applications, Strasburg, France, March 29–April 2, 2020	Kaźmierczak A., Piramidowicz R.
[Con6]	The Summer XLVI th IEEE-SPIE Joint Symposium on Photonics, Web Engineering, Electronics for Astronomy and High Energy Physics Experiments, Wilga, Poland, August 31–September 6, 2020	Borecki M., Kondracka K., Kwietniewski N., Martychowiec A., Sochacki M., Werbowy A.
[Con7]	XIX Krajowa Konferencja Elektroniki, Darłówko Wschodnie, Poland, August 30–September 3, 2020	Kamiński M., Kwietniewski N.
[Con8]	15th Conference Integrated Optics – Sensors, Sensing Structures and Methods, IOS'2020, Szczyrk, Poland February 24–28, 2020	Anders K., Beck R., Bieniek M., Jusza A., Kaźmierczak A., Paśnikowska A., Piramidowicz R., Pleskacz W., Słowikowski M., Stonio B., Stopiński S., Szczepański P., Szostak S., Śmietana M., Wiśniewski P.
[Con9]	22nd European Conference on Integrated Optics, ECIO20, Paris, France, June 23–24, 2020	Anders K., Beck R., Kaźmierczak A., Piramidowicz R. Słowikowski M., Stopiński S., Stonio B., Wiśniewski P.
[Con10]	23rd International Microwave and Radar Conference, MIKON 2020, Warsaw, Poland, October 5–8, 2020	Komorowski P., Krupka J.
[Con11]	33rd International Microprocesses and Nanotechnology Conference MNC 2020, Osaka, Japan, Web Conference, November 9–12, 2020	Słowikowski M., Wiśniewski P.



Optoelectronics Division

11. AWARDS

[Award1] Piramidowicz Ryszard, Szostak Sławomir, **WUT Rector's Collective Award for Organizing Achievements (2nd stage)** (Nagroda Zespołowa II stopnia JM Rektora Politechniki Warszawskiej za osiągnięcia Organizacyjne), 2020

[Award2] Piwowarska Elżbieta, **WUT Rector's Individual Award for Organizing Achievements (3rd stage)** (Nagroda indywidualna III stopnia JM Rektora PW za osiągnięcia Organizacyjne), 2020

[Award3] Pleskacz Witold, **President's of the Republic of Poland Silver Cross of Merit** (Srebrny Krzyż Zasługi), 2020

[Award4] Szmidt Jan, **Diamond Engineer 2019 selected in the XXVI Golden Engineer 2019 Readers' Plebiscite of „Przegląd Techniczny"** (Diamentowy Inżynier 2019 roku wyłoniony w XXVI Plebiscycie Czytelników Przeglądu Technicznego Złoty Inżynier 2019), 2020

[Award5] Szmidt Jan, **Officer's Cross of the Order of Polonia Restituta** (Krzyż Oficerski Orderu Odrodzenia Polski za wybitne zasługi w pracy naukowo-badawczej i dydaktycznej, za popularyzowanie polskiej myśli naukowej na świecie), 2020