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1. DEPARTMENT OF OPTOELECTRONICS AT THE SILESIAN UNIVERSITY OF TECHNOLOGY – HISTORY AND TODAY

1.1. History of the Department of Optoelectronics

The ordinance of the Ministry of Education and Higher Education No. DT-04-010 / 1/69 of June 13, 1969 established the Faculty of Mathematics and Physics within the structure of the Silesian University of Technology in Gliwice, with effect from June 15, 1969. The Faculty consists of three Departments (in Polish: Katedry):

- Department of Technical Physics,
- Department of Applied Mathematics,
- Department of Descriptive Geometry.

The Organizer-Dean and the first Dean of the Faculty was Prof. Aleksander Opilski, Ass. Prof. (in Polish: Docent) from the Department of Technical Physics.

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Fig. 1. Prof. Aleksander Opilski, first Dean of the Faculty of Mathematics and Physics and first Director of Institute of Physics
Rys. 1. Prof. Aleksander Opilski – pierwszy dziekan Wydziału Matematyczno-Fizycznego oraz pierwszy dyrektor Instytutu Fizyki tego Wydziału

In October 1970, the Faculty of Mathematics and Physics began educating students in two newly established fields of study:

- technical physics, with the specializations: physics and electronics; introduced a new organizational structure of the Faculty, establishing two new units in place of the three existing units:
  - Institute of Physics;
  - Institute of Mathematics.

The first Director of the Institute of Physics was Dr. Aleksander Opilski, Ass. Prof. and his deputies became:

- Prof. Włodzimierz Mościcki, for science;
- Dr. Bogusław Nosowicz, Ass. Prof., for education.

In 1971, six research and teaching Teams (in Polish: Zespoły) and their heads were established at the Institute of Physics:

- Team of Acoustic Methods for Semiconductor Researches - head Dr. Aleksander Opilski, Ass. Prof.;
- Aerosol Dynamics Team - head Dr hab. Bolesław Wysłocki, Ass. Prof.;
- Solid State Physics Group - head of Dr hab. Bolesław Matuła, Ass. Prof.;
- Fluid Structure Team - head Dr. Kazimierz Woźniczak;
- Nuclear Physics Team - head Prof. Włodzimierz Mościcki;
- Semiconductor Material Technology Team - head Dr. Sławomir Konczak.

At that time, the most numerous unit of the Institute of Physics was the Team of Acoustic Methods for Semiconductor Researches, Team, in which a research group in the field of acoustoelectronics carried out particularly intensive research. In 1975, the Acustoelectronics Team was established in the Team of Acoustic Methods for Semiconductor Researches (the

scientific subject was organized by Dr. Aleksander Opilski, Ass. Prof.). Dr. Zenon Cerowski became the manager of this Team.

Simultaneously, the Team of Acoustic Methods for Semiconductor Researches changed its name to Team of Solid State Acoustics. The head of this Team was Dr. Zygmunt Kleszczewski, who headed this Unit until 2003. Additionally, a new unit has also been established at the Institute of Physics - the Team of Nuclear Methods for the Study of Solid States, headed by Dr. Henryk Orwat.

One can be considered that today's Department of Optoelectronics began 50 years ago as the Team of Acoustic Methods for Semiconductor Researches in the structure of Institute of Physics at the Mathematical-Physical Faculty.

In 1979, further organizational changes took place at the Institute of Physics - Teams (Zespoły) received the status of Groupes (in Polish: Zakłady) as independent units in the organization of scientific topics.

The Group of Acoustoelectronics (in Polish: Zakład Akustoelektroniki) has become a very important unit of the Institute of Physics, as a unit with strong human resources and very active in science.

In 1985 the name of the Group of Acoustoelectronics was changed to the Group of Akusto-Optoelectronics, and in 2000 to the Groupe of Optoelectronics (Zakład Optoelektroniki).

By the decision of the Rector of the Silesian University of Technology - Professor Andrzej Karbownik, the Group of Optoelectronics (Zakład Optoelektroniki) was transferred in its entirety to the Faculty of Electrical Engineering in 2009 and it created there an independent organizational unit - the Department of Optoelectronics (Katedra Optoelektroniki). The Department of Optoelectronics is part of the organizational structures of the Faculty of Electrical Engineering until now. As already mentioned, the organizer of the Team of Acoustoelectronics was Dr. Aleksander Opilski, Ass. Prof., and its first head - Dr. Zenon Cerowski. From 1976, the management of the Team was taken over by Dr. hab. Aleksander Opilski, Ass. Prof. In the years 1981-1983 the manager was Dr. Zenon Cerowski.

Fig. 2. The Department of Optoelectronics Staff within the structure of the Institute of Physics of the Faculty of Mathematics and Physics at the end of the nineties years of the 20th century
Rys. 2. Skład osobowy Zakładu Optoelektroniki w strukturze organizacyjnej Instytutu Fizyki Wydziału Matematyczno-Fizycznego pod koniec XX-wieku

After Dr. Cerowski, from 1983 to 2000, the Head of Groupe of Optoelectronics was Prof. Aleksander Opilski. Since 2000, the head of the Group of Optoelectronics (Zakład Optoelektroniki) and then the head of the Department of Optoelectronics (Katedra Optoelektroniki) is Prof. Tadeusz Pustelny.

In 2003, the then Group of Optoelectronics, as a result of the European Union competition under the 5th EU Framework Program, obtained the status of *the Center of Excellence - Metrological and Technological Center of Optoelectronics and Acoustoelectronics.*

The Department of Optoelectronics, in all its earlier organizational forms, has always been an academic unit. Its academic activity includes scientific and research activity, teaching activity and organizational activity in the field of promoting science.

1.2. Scientific and research activity of the Department of Optoelectronics

The main research topics of the Department of Optoelectronics (in all its previous administrative forms) are presented below.

In the following presentation an attempt was made to present the main research areas carried out at the Department over the last half-century in terms of research topics, taking into account the chronology of development.

1.2.1. Acoustics of Solid States

In the early 1970s, the Institute of Physics investigated the acoustic properties of solids. To implement this research topic, the Acoustic Methods for Semiconductor Research Team was organized, which later transformed into the Acoustoelectronic Group. The scientific activity of the Acoustic Methods for Semiconductor Research Team was mainly focused on the application of volume and surface acoustic waves in the study of the properties of solids, especially semiconductors. The work was carried out in two research groups.

As a result of the works of the first research group, it was found that the energy gap of semiconductors depends on the crystal structure and on internal mechanical stresses in the semiconductors. Research has confirmed that acoustic methods can provide information about the energy structures of semiconductors. This allowed to determine the width of the semiconductor energy gap based on the measurement of the speed of acoustic waves. Based on the obtained results, a doctoral thesis of Lidia Opilska was prepared (1979). Subsequent work proved the correlation between the width of the energy gap of semiconductors and the velocity of longitudinal and transverse acoustic waves in the three crystallographic directions of single crystals. The developed method was successfully used to determine the activation energy of specific groups of polymers.

The second research group conducted a theoretical analysis of the influence of surface states in semiconductors on the velocity of surface acoustic waves. The results of theoretical analyzes indicated the possibility of determining the electrical and electronic parameters of the subsurface area in semiconductors using acoustic methods, as well as the parameters describing the energy surface states in semiconductors. The result of this theoretical research was Aleksander Opilski's D.Sc. thesis (1977) and the results of analyses obtained by Dr. Zenon Cerowski. In turn, in the doctoral dissertation of Tadeusz Pustelny (1981), both from the theoretical and experimental sides, the issues of surface acoustic wave propagation in the piezoelectric waveguide-semiconductor system were considered. The above research works were carried out as part of the long-term research program PBR3 focused on comprehensive research in the Acoustoelectric Group on the electrical and electronic properties of the space charge area in semiconductors and piezoconductors by means of acoustic and acoustoelectronic methods. The results of theoretical analyzes of longitudinal and transverse acoustoelectric voltage signals showed the possibility of determining many electrical and electronic parameters of the subsurface area in single and complex semiconductors. These parameters include, among others, the surface potential, type of electrical conductivity, concentration of charge carriers, effective Debye path, conductivity relaxation time, rate of major and minority charge uptake by trap states and surface mobility of carriers. It has been shown that the semiconductor type can be determined from the polarity of the acoustoelectric voltage. As part of the so-called of the longitudinal acoustoelectric effect, the Ph.D. theses of Zdzisław Kubik (1984) and Zdzisław Jakubczyk (1984) were

created. M.Sc.Wojciech Wajda also participated in these studies. The final result of the research on acoustoelectric phenomena was the D.Sc.thesis of Tadeusz Pustelny (1996), the subject of which was the development of a new acoustoelectric method for studying the subsurface area of complex semiconductors of groups III-V. The Acoustoelectronics Group also conducted research on the development of acoustoelectronics systems. The result of research on a resonator with an acoustic surface wave was the doctoral thesis by Marian Urbańczyk (1981). As part of this doctoral dissertation, a resonator based on surface acoustic waves at a frequency of approx. 10 MHz was elaborated. At that time, the resonator in this frequency range was an important scientific and technical achievement.

1.2.2. Application of acoustic surface waves for gas detection

The delay line system with a Rayleigh surface acoustic wave (SAW) in a positive feedback loop (the so-called SAW resonator) can be used to detect selected gases in the air environment. This type of sensor is made on a piezoelectric substrate, in which an acoustic track is made, covered with a thin layer of polymer or macromolecular compound (e.g. phthalocyanine) acting as a sensor layer. The effects of sorption and adsorption change the phase velocity of the surface acoustic wave, which results in a change in the operating frequency of the oscillator. To compensate for changes caused by the influence of the environment, for example changes in temperature or pressure, a second identical reference acoustic track is created on the same substrate, not covered with a sensor layer. The Department of Optoelectronics conducted research using thin layers of various metallophthalocyanines (MePc). The layers showed different sensitivity to different gases and vapors. It has been shown that the sensor's response to the presence of gases can be intense. This made it possible to detect the presence of toxic gases on the sensor's surface by measuring the acoustoelectric signal.

A theoretical, innovative electrical replacement model for the surface wave system in the electronic filter system has been developed. A detailed analysis of the properties of the acoustoelectric effect indicated that it can be used to build a matrix of acoustic gas sensors. Sensor properties of selected polymers layers were tested. Sensitivity has been determined for them, as well as the speed of response and speed of recovery. Methods of increasing the dynamics of these processes have been developed. Based on the obtained results, doctoral theses of Wiesław Jakubik (1998) and Tomasz Hejczyk (2013) were prepared. The D.Sc. theses of Marian Urbańczyk (1999) and Wiesław Jakubik (2013) were carried out on the subject of the detection of selected gases by the method of acoustic surface waves.

1.2.3. Acoustic emission

The method of acoustic emission (AE) gives a unique opportunity to observe deformation processes, locate the sources of these processes and diagnose the state of the tested material, medium, element or device/object.

AE studies in solids were initiated at the Acoustoelectronics Group in 1982. They were AE studies in geological materials (coal, shale and sandstone) during uniaxial loading of samples. The focus was on confirming the occurrence of the Kaiser effect, assigning the tested samples the appropriate type according to Mogi's classification, and determining the rise times of the source function and the size of the sources. In the years 1988–1994, the AE method of coal seams was tested during operation - a prototype measuring apparatus was built and "in situ" tests were performed. The research showed a high agreement between the average values of the wave energies of the recorded AE signals originating in the rock mass and the seismograph records. Thus, a new method was demonstrated to predict rockbursts. In the years 1986-1994, the research material were conveyor belts used in mining. Laboratory tests have shown a large variety of deformation processes in such composite materials and the possibility of diagnosing the condition of the tested tape samples.

In the years 1992-1996, AE researches were carried out in high-temperature Y-Ba-Cu-O superconductor ceramics. The researches on superconducting Y-Ba-Cu-0 ceramics were carried out in an automatic cryostat at temperatures ranging from ambient temperature to the temperature of liquid nitrogen. Research conducted under these conditions have enabled the isolation and differentiation of many thermally stimulated AE events. In particular, the AE signals resulting from the superconducting properties of the tested samples were separated.

Beginning in 1999, the application of the AE method for testing partial discharges (PD) was applied. PD sources in selected elements and devices of the power system (generator coil rods, insulation of low-power electric motors, oil power transformers) were tested. Proprietary EA descriptors with the acronyms ADC, ADP and ADNC were introduced, enabling the analysis of EA signals in the domain of the discrimination threshold. Many studies were carried out in parallel with the electric method in cooperation with the Institute of Electrical Power and System Control at the Faculty of Electrical Engineering headed by Prof. Zbigniew Gacek. Thanks to these investigations, it was possible to scale the results obtained with the AE method and the description of many PD phenomena was built based on the analysis of the results obtained with the combined electrical and AE methods. Currently, oil power transformers are tested using combined methods - the AE method (source location and identification of signals from PD and magnetization processes) and the thermovision method.

In 2015-2016, members of the AE Method Research Team worked at the Office of Technical Inspection (UDT) in Warsaw. During this period, they built a mobile laboratory equipped with the EA AMSY-6 32-channel measurement system, participated in the AT2 - Acoustic Emission Testing (level 2) certified course and obtained AT level 2 certificates

authorizing them to conduct acoustic emission testing of pressure vessels. As a result, in 2015, UDT implemented the acoustic emission method in accordance with the PN-EN 1330-9: 2019 standard. The authors conducted research on over twenty different industrial objects such as pressure equipment (tanks with a vertical axis, tanks with a horizontal axis, reactors, columns, technological pipelines) and storage tanks with a strictly vertical axis. Currently, gas pipelines are tested using the AE method.

The AE DEMA apparatus built at IPPT PAN in Warsaw and the built-in measuring system for recording and analyzing AE signals (built with devices from Bruel & Kjaer, Bell & Howell and Tektronix) were initially used in the AE research. In 2000, DEMA-COMP built a measurement system that combines both of the above-mentioned functions including DEMA apparatus as an element for data acquisition. In 2010, in the Department of Optoelectronics of the year, the proprietary 8-channel measurement system 8EA-WNZ was built, dedicated to the identification of signals from PD and the location of PD sources in oil power transformers using the AE method. The system's gain is fully controlled by its software, with a dynamic range of 65 dB for changes to the input signal. The system bandwidth is from 20 kHz to 1000kHz. The system is equipped with proprietary software written in LabVIEW enabling - signal monitoring, real-time data recording (in the 20-1000 kHz band), basic (in time, frequency and time-frequency domains) and advanced analysis of recorded signals (in the field of discrimination threshold).

The current composition of the Acoustic Emission Research Group for Objects: Prof. Franciszek Witos, Prof. Zbigniew Opilski, Dr. Aneta Olszewska, M.Sc. Maciej Setkiewicz. Major achievements: the D.Sc. monograph by Franciszek Witos (2008) and Ph.D. dissertations by Aneta Olszewska (2014) and Grzegorz Szerszeń (2016); 11 papers in 4 monographs, over 20 articles in journals from the JCR List, 3 patents and 3 KBN/NCN grants. Ph.D. dissertation by Teresa Buchacz (2011) on the diagnosis of electrical power equipment insulation was prepared.

1.2.4. Acoustooptics

At the beginning of the 1970s, the members of the Acoustic Methods for Semiconductor Research Group also joined research in the field of acoustooptics. The topic was taken up as a result of the creation of new light sources - lasers. The initiators of the research topics were Dr. Aleksander Opilski, Ass. Prof. and Mr. Zygmunt Kleszczewski M.Sc.. Research focused both on the use of deflection of the light wave by means of an ultrasound beam to study the properties of liquids having very high viscosities, and on the acousto-optical properties of single crystals, which are particularly useful in acoustoelectronics. Acousto-optical methods for testing the propagation of surface acoustic waves have been developed. The result of this research were doctoral dissertations by Zygmunt Kleszczewski (1971) and Janusz Berdowski (1975). As a result of the rapid development of solid state research with the use of acousto-

optic and acoustoelectronic methods, the Team of Acoustic Methods for Semiconductors Research was in 1975 divided into two groups: the Team of Solid State Acoustics and the Team of Akustoelectronics.

Mr. Zygmunt Kleszczewski (Ph.D. at the time) became the head of the first group. He continued his acoustooptical research for many years and was awarded the title of professor in 1997. The head of the second team (the Team of Acoustoelectronics) was Dr. Aleksander Opilski, Ass. Prof., who obtained the title of professor in 1979.

The work of the second team focused on the study of the interaction of ultrasonic waves with electrons in semiconductors using surface and volume acoustic waves. Research on the interaction of ultrasonic volume waves with electrons has become an important factor in the development of thin-film piezoelectric transducer technology made of CdS and ZnO. Based on this research, Ph.D. theses of Józef Finak (1978) and Hubert Jeronimek (1985) were created.

The interaction of the electromagnetic field with the acoustic field was the subject of Marek Błahut's Ph.D. dissertation defended (1984) at the Faculty of Physics of the University of Gdańsk.

1.2.5. Biomedical engineering

For many years, biomedical engineering has been present in the scientific and research field of today's Department of Optoelectronics.

This subject was present in the form of cooperation between the Department of Optoelectronics and the Foundation for the Development of Cardiac Surgery in Zabrze. This cooperation was established with the late Professor Zbigniew Religa. The Department has developed a system unique in the world for determining the current blood volume in the ventricle of an artificial heart. Two systems for determining the volume of the blood part of the chamber have been developed based on the acoustic idea and also with the use of a system of optical sensors. The research was led by: Prof. Tadeusz Pustelny, Mr. Grzegorz Konieczny, M.Eng. and Dr. Zbigniew Opilski. Research on the system of monitoring the work of an artificial heart ventricle was presented in the Ph.D. dissertation by Grzegorz Konieczny (2013).

In the field of biomedical engineering, model studies of the metrological parameters of the circulatory system for the needs of hemodynamic diagnostics of the heart were carried out in Professor Pustelny's group. The research allowed to propose a low-invasive method of determining the parameters of the circulatory system from the area of the heart. The research ended with Maciej Gawlikowski's doctorate (2011).

The Department of Optoelectronics, in cooperation with the Institute of Medical Technology and Apparatus and the Medical University of Silesia (ITAM), conducted very intensive research on the development of a system for early detection of dysplastic and

neoplastic skin changes in patients. The result of several years of investigations was an original in the world scale the optical system of skin cancer diagnostics. On the part of the Department of Optoelectronics, the participants of that time were: Prof. Tadeusz Pustelny, Dr. Marian Urbańczyk, D.Sc.. Dr. Zbigniew Opilski, Dr. Erwin Maciak. Research on the development of a skin cancer diagnostics system has been very successful. The system was exhibited in Brussels at the world exhibition EURKA Innova in 2007 and received the highest distinction at the exhibition: Gold Medal with Mention and Grand Prix du Jury EUREKA Innova 2007.

In the field of biomedical engineering, Dr. Przemysław Struk is very active. For years, Dr. Struk has been developing cooperation with the University of Besancon with the group led by Professor Christopher Gorecki. The result of joint research is the development of a diagnostic endoscopic system for detecting neoplasms in body cavities. The developed diagnostic system presents a high level of technological and metrological advancement. It is an achievement on a global scale. Dr. Struk summed up his research in the field of biomedical engineering with his S.Sc. thesis in 2019.

The Department of Optoelectronics has developed a system for imaging subcutaneous blood vessels in human tissues with the use of optical radiation in the infrared range. Diagnostics with the use of the developed system allows the detection of dysplastic and neoplastic changes in the soft tissue (including the detection of breast tumors in women). Diagnostics is non-invasive and completely safe for patients. It enables multiple tests to be carried out in any repeating series. The research was carried out in cooperation between the Department of Optoelectronics of the Silesian University of Technology and the company WASKO S.A. The participants of the research were: Dr. hab. Zbigniew Opilski, Ass. Prof., eng. Maciej Setkiewicz, Prof. Tadeusz Pustelny, and on the part of WASKO S.A.: Dr. Mirosław Pach and Dr. Tomasz Hejczyk.

1.2.6. Optoelectronics

In the early 1980s, the Acoustic Methods for Semiconductor Research Group became very active in the field of optoelectronics research. For this reason, in 1985, the Group of Acustoelectronics (in Polish: Zakład Akustoelektroniki) changed its name to the Group of Akusto-Optoelectronics. The research topics focused on the technology of planar and stripe optical fibers and the use of these optical fibers to build sensors of various physical quantities. In terms of sensor applications, fiber optics were also tested on the basis of which reflective displacement and vibration sensors were constructed, as well as temperature sensors using: optical fiber deformation (microbending sensor), shift of the absorption edge of temperature changes in semiconductors, as well as the phenomenon of luminescence. Based on the modified optical fiber system, a model of the displacement sensor was created. The system consisted of a pair of optical fibers forming the measurement path and a separate pair of

optical fibers forming the reference path. The system was powered by a LED diode. In a Y-type splitter, the light was distributed between two paths. After passing the measurement path, light was transmitted through a gradient lens which formed the measurement beam (it changed the beam divergence). After reflection from the surface capable of movement, the light signal returned to the lens and illuminated the optical fiber, at the end of which was a detector (photodiode or phototransistor). The purpose of the reference beam was to compensate for changes in the signal resulting from fluctuations in the intensity of the light emitted by the LED diode and losses resulting from microbending of the optical fiber. These studies were carried out and presented in the Ph.D. dissertation by Paweł Karasiński (1998). An electronic system designed for this purpose was used to analyze bending losses. The optical fiber system was adapted to work with a programmable microprocessor, which was used to process data from many such systems (linearization, averaging and presentation). The sensor of the presented design worked as a pressure sensor. It was also used to control the temperature of the head of a mining shearer. Research on the use of special type D optical fibers in the aspect of developing a magnetic field sensor with a relatively high intensity based on the so-called the Faraday effect was developed by Kamil Barczak. The research was summed up with a Ph.D. dissertation (2003), the effect of which was the development of original magnetic field sensors with very good insulating properties. The research on the possibility of using fiber optics and special optical fibers for the measurement of high intensity electric currents (hundreds of amperes and more) and for the measurement of magnetic field induction was summarized by Kamil Barczak with his D.Sc. thesis (2020). The problem of magnetic field detection based on the influence of this field on planar structures with magnetic liquid crystal layers was investigated and analyzed in the Ph.D. dissertation of Cuma Tyszkiewicz (2006).

Ion exchange technology in glasses was used to produce planar and strip optical fibers. The designed optical fibers were used for the construction of planar lenses, single and multimode passive elements of integrated optics and in the technology of planar sensors in systems with amplitude modulation and for the production of monolithic interference sensors in a glass substrate. The theory of ion exchange without the presence of an external electric field and in the presence of this field was developed for modeling the technology of the production process of optical fibers with given parameters and for burying optical fibers.

The developed technology for the production of stripe optical fibers allows for the construction of planar Y-type splitters, planar NxM interferometers in the Mach-Zehnder configuration, multi-mode planar refractometers and multi-mode MMI interference structures. As a result of research in the field of optoelectronics and planar optics technology, Ph.D. theses of Roman Rogoziński (1996) and Kazimierz Gut (1999) were created.

Research on the analysis of surface plasmon propagation in planar structures of integrated optics as well as in optical structures based on optical waveguides was developed very intensively at the Group. These studies resulted in Ph.D. dissertations of the then Masters of

Physics - Zbigniew Opilski (2002) and Erwin Maciak (2005). Research on this subject was continued in the Ph.D. dissertation of Jolanta Ignac-Nowicka (2004).

Research on physical phenomena occurring in planar and fibrous optical fiber elements, research on the technology of their production and construction of optical sensors of various physical quantities are constantly being intensively developed in the Department of Optoelectronics. They are mainly focused on:

- modeling of the electrodiffusion process for ion exchange in glasses,
- analysis of the influence of the refractive profile of the fiber on the sensitivity of the differential interferometer,
- fringe field analysis in the study of planar optical fibers,
- applications of optical fibers in sensor technology,
- electroluminescent effects and their practical use, testing and examination of a fibrous luminescent sensor.

Research on the sensing properties of thin layers of macromolecular compounds and organic semiconductors by means of acoustic surface waves is focused on:

- determination of low concentrations of gas mixtures with acoustic methods,
- electrical properties of phthalocyanine layers in the SAW gas sensor system,
- analysis of the cross-flow filter system replacing the system using acoustic surface waves,
- production and characterization of fluorophore-absorber pairs for an ammonia sensor based on the phenomenon of luminescence.

Ion exchange technology is in the Optoelectronic Department most often used for the production of gradient fiber structures and inter-mode interferometers (MMI). By appropriate selection of technological conditions - the type of admixture, the chemical structure of the glass as well as the size of the window through which the ion exchange process takes place, time and temperature of the process, single- and multi-mode optical fiber structures can be produced, the geometry and numerical aperture of which can be changed in a wide range.

In addition to the ion exchange technology, extensive research is carried out on the production of optoelectronic waveguide structures using the sol-gel technology.

Theoretical and numerical analyses of the structures of planar optics and integrated optics are the subject of scientific interests of Dr. hab. Marek Błahut, Ass. Prof.. This subject was undertaken by him in the D.Sc.thesis (2003). Professor Błahut continues this subject and successfully develops it, especially in terms of the application of the phenomenon of intermodal interference in sensors of selected gases.

The technology of ion exchange in glasses for the production of elements and systems of planar optics was undertake in the D.Sc.thesis of Dr. Roman Rogoziński (2008).

In addition to the ion exchange technology, research on the production of photonic waveguide structures with the sol-gel technology is carried out in the Department of Optoelectronics. This research was the basis of the D.Sc. thesis of Dr. Paweł Karasiński (2013). The subject of theoretical and numerical analyzes of planar and strip systems made in

the sol-gel technology was also the main subject of the D.Sc. thesis of Dr. Cumy Tyszkiewicz (2019).

Today, the research on planar and strip structures is continued and developed by Professors of the Silesian University of Technology, Paweł Karasiński and Cuma Tyszkiewicz.

Research on the phenomenon of plasmon resonance is also intensively developed in the Department. Based on this phenomenon, several types of sensors of various physical quantities have been developed. This field is developed by professors of the Silesian University of Technology: Dr. hab.Zbigniew Opilsk, Ass. Prof. and Dr. hab. Erwin Maciak, Ass. Prof.

The research on optoelectronic structures was led by e.g. Dr. Iwona Zielonka, Dr. Damian Kasprzak, Dr. Jolanta Ignac-Nowicka, Dr. Artur Szewczyk.

1.2.7. Highly advanced metrology of nano layers and nanostructures

In the 21st century, the staff of the Optoelectronics Department continue to conducts intensive research in the field of nanolayer and nanostructure technology and their physicochemical characterization. Technological researches are carried out in cooperation with the Department of Physical Chemistry of the Silesian University of Technology, but also in cooperation with the Institute for Chemical Processing of Coal in Zabrze, as well as with the Institute of Electron Technology and the Institute of Electronic Materials Technology in Warsaw. The aim of cooperation with the Department of Physical Chemistry is to develop nanostructures of oxide semiconductors with a highly developed surface in the form of nanometer-thick layers, as well as in forms of nanotubes and the so-called nanoflowers. The research aims to use nanostructures of oxide semiconductors in sensors of selected gases in the process of monitoring the natural environment as well as control and monitoring of working environments in closed facilities. The result of the research is the development of sensors of nitrogen oxides, carbon oxides, hydrogen, ammonia, methane as well as volatile organic compounds.

The result of cooperation with the Institute for Chemical Processing of Coal in Zabrze is the development of original technologies of graphene oxide and graphite oxide nanostructures for applications in hydrogen sensors, as well as carbon oxides and nitrogen oxides. The cooperation with the Institute of Electronic Materials Technology, where graphene layers were developed for the needs of sensor technologies were of a similar nature. On the side of the Department of Optoelectronics, the following scientists took part in technological research: Dr. Marcin Procek, Dr. Sabina Drewniak, Dr. hab. Erwin Maciak, Ass. Prof., Prof. Tadeusz Pustelny, Dr. hab. Zbigniew Opilskidr, Ass. Prof., Dr. Przemysław Struk, D.Sc., Mr. Piotr Kałużyński, M. Eng., Mr. Maciej Setkiewicz, M. Eng.

The Department of Optoelectronics has a very rich and modern metrological base in the field of micro- and nanostructure characterization. The metrological base of the Department consists of: SEM Scanning Electron Microscopy, AFM Atomic Force Microscopy, Optical Microscopy (including polarization) as well as Near Field Microscopy, Spectral Optical Spectroscopy, Surface Plasmon Spectroscopy.

Currently, the technological base, but above all the metrological base in the field of physico-chemical characterization of layers, including micro and nonostructures, presents a high international level. This database allows for the implementation of scientific research in the field of technology and metrology at a high, global level. These studies are successfully conducted by: Dr hab. Erwin Maciak, Ass. Prof., Dr hab. Zbigniew Opilski, Ass. Prof., Prof. Tadeusz Pustelnego, Dr. hab. Paweł Karasiński, Ass. Prof., Dr. hab. Cuma Tyszkiewicz, Ass. Prof., Dr hab. Kamil Barczak, Dr hab. Roman Rogoziński, Ass. Prof., Dr. Marcin Prock, Dr. Sabina Drewniak, Dr. Kazimierz Gut, Mr. Piotr Kałużyński, M. Eng., Mr. Maciej Setkiewicz, M. Eng.

The Department of Optoelectronics cooperates with: MOEMS Group Institut FEMTO-ST at Université de Franche-Comté, Besançon, France, Institute of Microelectronics in Barcelona, Spain, University of Goteborg in Sweden, University of Oulu in Finland, with Optoelectronics Group of University of Twente in the Netherlands, University of Stuttgart in Germany and in many others.

1.2.8. Summary of the research activities of the Department of Optoelectronics

The tangible scientific and research achievements of the employees of the Department of Optoelectronics are scientific publications in journals of recognized and high international position. During the fifty-year history of the Department of Optoelectronics, its employees have published over 500 articles which were indexed in the global Web of Science and SCOPUS databases. They obtained nearly 30 international and national patents. They have carried out several dozen research projects. They took an active part in the Government Projects PR, the Research and Development Projects PBR and the Research and Science Projects PBN. Department staff participated in many projects of the National Research Centre NCN and the National Centre for Research and Development NCBR. They participated and are participating in the projects of the Foundation for Polish Science FNP.

In the Department of Optoelectronics and in the earlier organizational structures of this unit, four people obtained the academic title of professor: Prof. Aleksander Opilski, Prof. Zygmunt Kleszczewski, Prof. Tadeusz Pustelny, Prof. Marian Urbańczyk.

From the group of employees of the Department of Optoelectronics, 10 people are or have been employed as associate professors of the Silesian University of Technology, including: Tadeusz Pustelny, Marian Urbańczyk, Marek Błahut, Franciszek Witos, Roman Rogoziński, Paweł Karasiński, Zbigniew Opilski, Cuma Tyszkiewicz, Erwin Maciak. Procedures for the

employment as Associate Professors at the Silesian University of Technology habilitated: doctors: Przemysław Struk and Kamil Barczak are actually in progress.

In the near future, the procedures for conferring the degree of D.Sc. should begin: Dr. Sabina Drewniak, Dr. Aneta Olszewska, Dr. Kazimierz Gut and Dr. Marcin Procek. Katarzyna Witkowska and Kazimierz Adamski participate in the activities of our Department. 35 persons associated with the Department of Optoelectronics obtained the Ph.D. degree in physical or technical sciences.

Two Professors from the Department of Optoelectronics were elected members of the scientific committees of the Polish Academy of Sciences: the Acoustics Committee and the Electronics and Telecommunications Committee.

For their scientific activities, the Department's employees received several dozen Awards from the Rector of the Silesian University of Technology. They have been awarded several times with the Awards of the Minister of Science and Higher Education.

The Department of Optoelectronics conducts extensive scientific cooperation with national units. The Department cooperates in the field of research and teaching with various universities and research institutions belonging to the European Community as well as with research centers from around the world.

1.3. Educational activities

During the 50 years of its activity in the organizational structures of the Silesian University of Technology, the Department of Optoelectronics was very active in teaching. The Department was very active in the didactic process organized at the newly established Faculty of Mathematics and Physics. The employees of the Department participated in the organization of lectures, seminars and exercises as well as in the organization of many teaching laboratories, both in basic courses as well as in specialized subjects.

The employees of the Department participated in classes in the field of widely understood physics at all departments of the Silesian University of Technology. Many subjects and laboratories were original and innovative on a national scale. Research workers of the Department of Optoelectronics promoted many (several dozen) Masters of Engineers (mgr) and Engineers (inż) in the field of Technical Physics as well as in the field of Electronics and Telecommunications and in the field of Electrical Engineering. Numerous Scientific Student Groups operate at the Department of Optoelectronics. The Department of Optoelectronics was the main organizer of the Electronics and Telecommunications major and the main organizer of the Power Engineering major, specializing in Prosumer Power Engineering at the Faculty of Electrical Engineering.

For their teaching activities, the employees of the Department of Optoelectronics were repeatedly awarded with the Award for the Educational Activity of the Rector of the Silesian University of Technology.

1.4. Organizational activity in the area of popularizing science

Professor Aleksander Opilski, the organizer and the first Dean of the Faculty of Mathematics and Physics in 1969, was a founding member of the Polish Acoustic Society PTA (1963).

The Department of Optoelectronics, in all the organizational forms discussed above, has been the initiator and main organizer of scientific conferences in the field of broadly understood acoustics from the very beginning.

The Institute of Physics, operating within the structures of the Silesian University of Technology, was an active organizer of the annual scientific conferences held since 1953 - Open Seminars on Acoustics OSA. The Department of Optoelectronics is the main organizer of OSA conferences organized every 7 years by the Upper Silesian Branch of the PTA.

These seminars (under the current name of the Open Seminary on Acoustics), organized by the national PTA Departments, are the most important annual scientific event of the Polish acoustic community, with numerous participants from around the world.

In 1971, during the Open Seminar on Acoustics at the Kolejarz Hotel in Zakopane, there was an initiative to establish periodivc conferences on the subject of intensively developing quantum acoustics, molecular acoustics and sonochemistry. The initiative was undertaken by a group of physicists from the Silesian University of Technology. The winter period was chosen as the time of the conference (already then the Open Acoustics Seminars were held in September). The initiative group was composed of: Prof. Franciszek Kuczera, Prof. Aleksander Opilski and Dr. Stanisław Szyma - all from the newly established Institute of Physics of the Faculty of Mathematics and Physics of the Silesian University of Technology in Gliwice. The group established an annual conference - the Winter School on Molecular, Quantum Acoustics and Sonochemistry.

50 years have passed since this historic meeting. The first Winter School of Molecular, Quantum Acoustics and Sonochemistry was held in 1972 at DW Relaks in Ustroń-Jaszowiec. The first chairman of the Organizing Committee was Dr. Aleksander Opilski, Ass. Prof. and in the following years Dr. Stanisław Szyma, Ass. Prof. The next chairmen of the Organizing Committee were: Dr. Joachim Gmyrek, Prof. Tadeusz Pustelny, Dr Roman Bukowski, Prof. Marian Urbanczyk. Since 2013, the conference has been chaired by Dr. hab. Franciszek Witos, Ass. Prof. This conference later, in the 90s of the XX-th century, took an international character as the Winter School on Molecular and Quantum Acoustics, transformed a few years ago into the Winter School on Wave and Quantum Acoustics. The scientific patronage

over the conference has been held by the Acoustics Committee of the Polish Academy of Sciences for several decades. The annual Winter School on Wave and Quantum Acoustics conference in 2021 will celebrate the magnificent Golden Jubilee of the 50th Conference.

The Winter School of Environmental Acoustics and Vibroacoustics has been held annually since 1973. The initiator and organizer of this conference was also the Institute of Physics of the Silesian University of Technology. For the first several years, the main organizer on the part of the Institute of Physics was Dr. Bogusław Nosowicz, Ass. Prof. Then the organization was taken over with great dedication by Dr. Mieczysław Roczniak. Currently, Dr. Roman Bukowski is managing organizational activities with great commitment.

The Department of Optoelectronics from the Faculty of Electrical Engineering of the Silesian University of Technology has been the organizer since 2004 of the annual international scientific conference Integrated Optics - Sensors, Sensing Structures and Methods IOS. The conference is held annually at the turn of February and March in the Silesian Beskids. Its co-organizer is the Electronics and Telecommunications Committee of the Polish Academy of Sciences and the Photonics Society of Poland. The aim of the IOS Conference is to exchange knowledge in the field of analysis and design of optoelectronic and sensor systems and systems, as well as to exchange experiences in the field of technology and practical applications of opto- and nanoelectronics and metrology. The conference unites the national and international photonic and optoelectronic community. Every year, a large group of scientists from abroad participate in the IOS conference. IOS has become the very important annual conference on widely understood photonics.

The activity of the staff of the Department of Optoelectronics in the field of organization and promotion of acoustics, as well as photonics and optoelectronics in the Polish and international scientific community is highly appreciated.

1.5. Summary

In 2021, the Department of Optoelectronics celebrates the 50th anniversary of its activity in the structures of the Silesian University of Technology.

This is an important and beautiful reason to reflect on the past time. This is the important reason to recall the successes and achievements, but also the problems that were the subject of the past half century. This is the reason to reflect on the history of the past years, even if we were not able to participate in everything in this history personally.

But history - it's first of all people. Those who are absent forever, but also those - everyday colleagues, colleagues and friends, acquaintances.

And this historical study is an expression of great respect and sincere gratitude to all those who had and have their personal participation in this Golden Jubilee. It is an expression of

respect for those who had the chance to leave a part of themselves in the Department of Optoelectronics.

May this Golden Jubilee also be an opportunity to look with hope into the future of the Department of Optoelectronics.

Fig. 3. The Staff of the Optoelectronics Department, Faculty of Electrical Engineering, 2017
Rys. 3. Pracownicy Katedry Optoelektroniki w strukturze Wydziału Elektrycznego w 2017 r.

Reference sources

This story of ***Department of Optoelectronics at the Silesian University of Technology - history and today*** has been prepared on the basis of the Author's own knowledge and experiences, resulting from his 48 years of work in the Department of Optoelectronics and in all its previous organizational forms in the Silesian University of Technology.

In the study of the History of the Optoelectronics Department, the Author also used existing own documents.