

Department of Optoelectronics at the Faculty of Electronics, Telecommunication and Informatics of the Technical University of Gdańsk

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1. History

The onset of research on the optoelectronics field at the Faculty of Electronics, Telecommunication and Informatics of the Technical University of Gdańsk dates from early seventies. They were conducted by a group of scientists from the Laboratory of Electronical Equipment Technology headed by prof. Henryk J. Wierzba. The very first subject of research were properties of optoelectronic PLZT ceramics, its technology and applications. As a result of this research a high-temperature hot pressing technology has been developed and a laboratory scale manufacturing setup has been built.

The scope of optoelectronics-related research broadened in early eighties when optical fibre technology and optical fibre sensors became of our interest. Shortly afterwards first lectures on fibre optics and on optical fibre sensors were offered to graduate students. An optoelectronics students laboratory has been created to accompany the lectures and to give students a real life experience on the subject. Also, from the early beginning of the research on optoelectronics, related diploma topics were also assigned to students.

As optoelectronic research became a dominant part of the Laboratory activity its name was changed in 1989 to Laboratory of Optoelectronics and Electronic Equipment and subsequently, in 1991, to Laboratory of Optoelectronics. Following the change of the Faculty structure it was changed again, in 1992, to Department of Optoelectronics. In 1993 prof. Bogdan B. Kosmowski took over after prof. Henryk J. Wierzba as the head of the Department.

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2. Present status

The Department of Optoelectronics' staff is currently 18. This includes 3 professors, 6 doctors, 3 assistants, 4 engineers and two technicians. The staff members are involved in research and educational activities. The most important lectures given by them are: Principles of Optoelectronics, Optoelectronic Elements and Devices, Fibre Optic Technique, Electrooptical Displays, Optoelectronic Sensors, Integrated Optics, Lasers and their Applications, Electronic Materials and Components as well as Computer Aided Design of Electronic and Optoelectronic Circuits.

Apart from these lectures the department offers laboratory training for graduate students. This training is tightly connected with the lectures mentioned above and it includes following areas: Principles of Optoelectronics, Optoelectronics Elements and Devices, Electrooptical Displays, Optical Fibre Telecommunications, Electronic Materials and Components as well as Computer Aided Design of Electronics and Optoelectronics Circuits.

The number of lectures continually increases as new ones are continually introduced as a result of the growth of new branches of optics and optoelectronics. One of the most recent additions was a lecture and laboratory on Holography and Diffractive Optics, both developed by Miranda Rogoda-Zawiasa PhD, EE.

3. Research activities

Research activities in the Department are focused on optoelectronics areas such as optical fibre sensors, pyroelectric materials and devices, Liquid Crystal Display optimization and its applications as well as on spectrophotometric and interferometric measurements.

Work is also carried out on some relative areas which include thin and thick film technology and the development of devices for handicapped people.

3.1. Optical fibre sensors

Optical fibre sensors are investigated in our department since early eighties. At the beginning reflective displacement and vibration sensors were developed. This was followed by sensors using modified clad for refractive index, temperature and glucose concentration measurement. Apart from these sensors two measurement systems have been developed for refractive index profile measurement in multimode optical fibres and for numerical aperture measurement. Another group of sensors developed were sensors for biomedical applications, especially those for pH, temperature and blood perfusion measurement.

Along with the development of these sensors a complex research project headed by prof. Henryk J. Wierzba has been launched. The objective of this project was modelling of several types of sensors and sensor networks. Several sensors, among them sensors of colour, blood perfusion, strain and temperature, have been investigated.

As a result of it a program suite, called CADFOS, for numerical simulation of the multimode optical fibre parameters has been developed by Jerzy Pluciński PhD, EE. It simplifies the design process of a broad

range of sensors, allowing it to be completed using only computer simulations in most cases. Example results of power distribution in a bent optical fibre are presented in figure 1. The results of research and the experience gained during construction were subsequently used in optical fibre sensors for process control. Temperature sensors based on thin-film Fabry-Perot etalon and on blackbody radiation were also investigated for measuring temperatures up to 400°C and 1500°C, respectively. The research on temperature sensors has been carried out mainly by Ryszard Hypszer PhD, EE.

During the project a complete analysis of an optical fibre sensor of colour has been developed by prof. Bogdan B. Kosmowski followed by a prototype for a selected application. This kind of sensor has a broad range of potential applications ranging from automotive to food industry and health care.

Also a new approach to the sensors analysis has been developed for this project by prof. Walerian Gruszczyński, who used a well-known SPICE circuit analyser for component, and system properties modelling.

At present a new stage of work was started. Its aim is development of distributed and quasi-distributed sensors of temperature and strain using Optical Time Domain Reflectometry. This technique seems to become more and more promising, especially because of the latest developments in OTDR equipment which now allows measurements to be made with centimetre

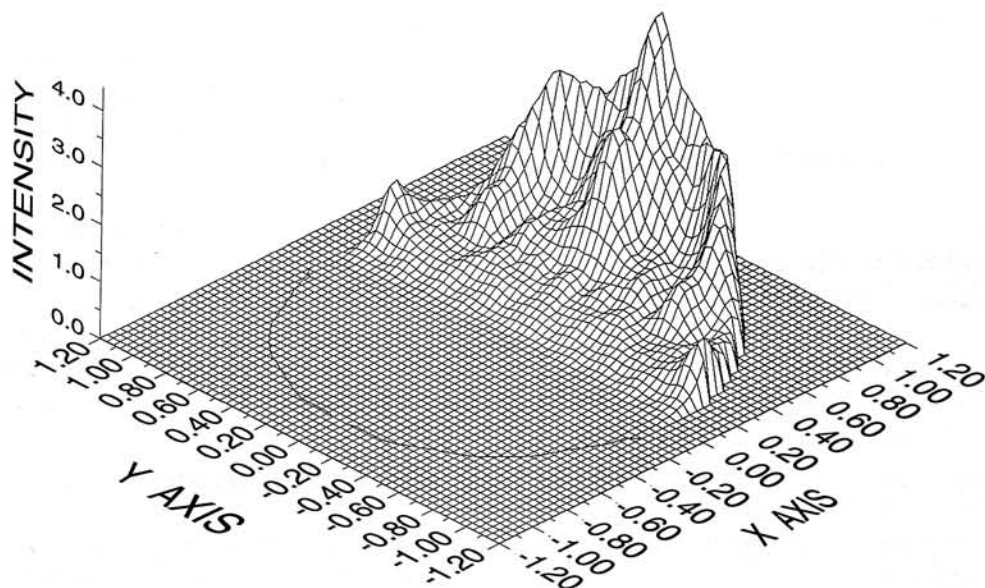


Fig. 1. Optical power distribution in a bent multimode optical fibre.

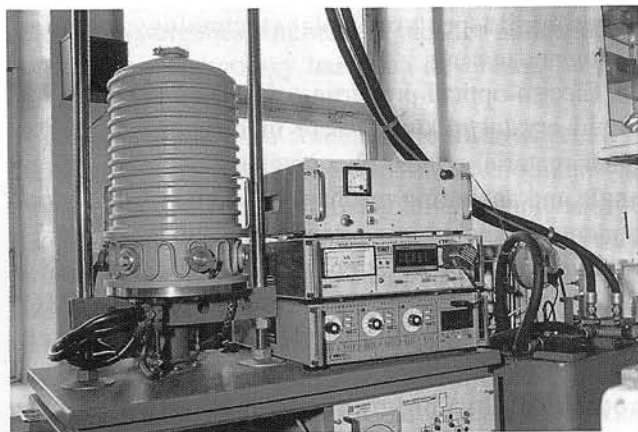


Fig. 2. Optical Time Domain Reflectometer system TDR 30 (left), and an optical fibre splicer (right).

resolution and with substantially reduced deadzone. The OTDR being used for these research, namely TDR 30 made by Opto-Electronics Inc., is presented in figure 2. It can detect a Fresnel reflection with centimetre resolution over distances of a few kilometres having at the same time the dynamic range of 90dB.

The second area of current research is the application of optical fibre sensors for civil engineering purposes, being at the same time a topic of a PhD thesis of Paweł Wierzba MSc, EE.

We also plan to conduct some research on the vibration and deformation measurement in large steel or concrete constructions, like bridges, roads and dams using a laser measurement system produced by a Finnish company NOPTEL OY.

3.2. Pyroelectric materials and devices

Investigation of pyroelectric material properties has been the area of continuous research at the De-

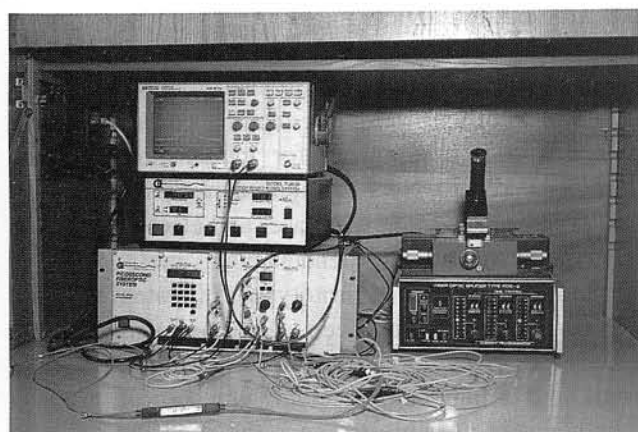


Fig. 3. Hot pressing equipment for PLZT ceramics production.



Fig. 4. Electron Cyclotron Resonance Plasma Assisted CVD system.

partment of Optoelectronics for over two decades and it has been mainly focused on PLZT optoelectronic ceramics. During the research which was mainly conducted by Andrzej Łoziński PhD, EE, manufacturing methods, optical, electrical and pyroelectric properties as well as possible applications have been thoroughly investigated. One of these setups, for hot pressing manufacture of PLZT ceramics is presented in figure 3.

Devices based on PLZT ceramics have been fabricated using hot pressing, thick film and sol-gel technology. These devices are mainly optical switches, electrooptical modulators and infrared detectors. At the current stage of research PLZT-based detectors for mid- and far-infrared are investigated with work underway to build an array of such detectors. Moreover, several methods of measuring several electrical, optical and pyroelectric properties of these materials have been developed and measurement setups have been built.

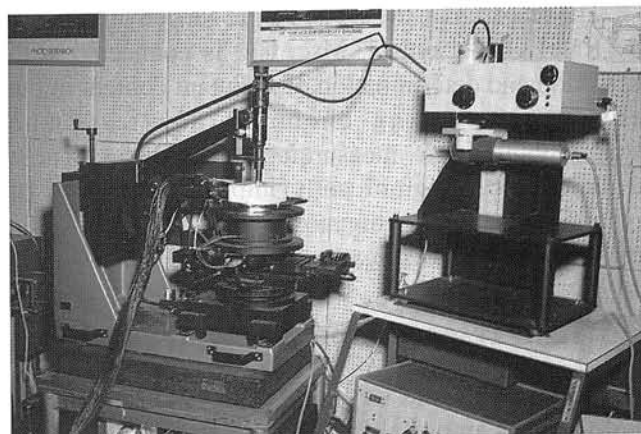


Figure 5. Display Measurement System.

3.3. Thin film technology

Research on thin film technology has been primarily focused on problems related with microelectronic and hybrid technology. For these purposes several new processes were invented, tested and used in equipment built in the faculty. This equipment used different types of Chemical Vapour Deposition (CVD) as well as Physical Vapour Deposition (PVD)

Recently the focus of the research, carried out by Piotr Wroczyński, PhD, EE., has shifted to diamond film deposition. A microwave Electron Cyclotron Resonance Plasma Assisted CVD system has been developed to gain a better knowledge of processes taking place during diamond synthesis. The system is presented in figure 4.

3.4. Spectrophotometric measurements

Spectrophotometric measurements are of our interest since mid-eighties. The first works which were carried out in early eighties were focused on automating and computerizing the measurement process. Current research on this field concentrate on blood perfusion measurement and chemical dry tests.

The first project, which has been conducted by prof. Henryk J. Wierzba, on measurement of blood perfusion resulted in the development of an integrated spectrophotometric system for blood perfusion measurement. This system, developed with significant contribution from Adam Mazikowski MSc, EE, and Witold Gołński MSc, EE., consists of a sensing head and processing electronics connected to a PC computer with dedicated software. It allows for reliable measurements to be made under software control facilitating the measurement process and data management.

The research on the second area, carried out mainly by Rafał Gruszczyński, MSc, EE, is connected with detection and determination of pollutant content in the environment using chemical dry tests and spectrophotometric measurement techniques. These techniques can significantly improve resolution of measurement eliminating most of readout errors, when compared with visual readout.

3.5. LCD research and development

Work on Liquid Crystal Displays (LCDs) technology was undertaken by prof Bogdan B. Kosmowski at the Technical University in Karlsruhe, Germany in 1980, and it is continued till now

covering all aspects of displays technology, manufacturing and testing.

Electro-optical properties of twisted nematic (TN) liquid crystal mixtures were investigated as well as other material related phenomena, like bistability, tilt angle and anchoring mechanisms. Other display components like polarisers, retarders and colour filters also received appropriate attention. This work resulted in development of a computer program called DIMOS (from Display Modelling System) for accurate simulation and optimization of liquid crystal displays. Several copies of this program were sold in European countries.

The second area of research was display measurement and quality control with special stress laid on automobile dashboard display applications. Because several types of measurements were needed, including colorimetric and transient ones for different observation angle and for different optical modes, a computerized measurement system called Display Measurement System (DMS), presented in figure 5, was built. Its capabilities extend well beyond the full characterization of liquid crystal displays, but it also can be used for measuring other types of displays and for a range of colorimetric and spectrophotometric measurements.

3.6. Blind aids

Another important area of research in the department concerned for facilitating the life of handicapped people, especially blind ones. Devices for them have been built since late seventies. The first design was a device which allowed to check a text being typed on an electric typewriter prior to printing it onto paper. As speech synthesis technology was not available that time, the check was performed using a Braille output device.

Extensive research was carried out on stimulation of tactile organs by electrical pulses creating the so-called tactile phantom sensation for reading purposes. Along with this work a stimulator for acupuncture has been designed and built. Now the equipment, which enhances traditional acupuncture with laser and electrical stimuli, is produced by three independent companies.

Shortly afterwards a prototype of a system facilitating road crossing has been developed. This system consists of transmitters placed on top of traffic light posts and a handheld receiver which informs about whether it is possible to cross the road but helps to maintain a right direction at the zebra crossing.

As the speech synthesis technology became avail-

able in early eighties a number of aids for blinds incorporating this technology has been developed for different applications.

In early nineties, a research program targeted at the obstacle detection resulted in development of a prototype of such system using an ultrasonic source and multiple receivers. Now, the work is underway on another such system based upon laser triangulation with further plans of including machine vision technology to improve detection capabilities. All of the research described above has been conducted by Ryszard Kowalik PhD, EE., and Irena Postawka

MSc, EE., with significant contributions of other department staff.

4. International Cooperation

Department of Optoelectronics actively cooperates with Universities in Karlsruhe, Berlin, Ilmenau, Dresden, Stuttgart, in Germany as well as with Finnish Universities in Helsinki and Oulu. Research programs are also conducted with Universities in Strassburg, France and in Senday, Japan.