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Fifty years of optical fiber photonics development in Poland – OFTA2025

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Abstract—**Fiber Optics celebrates 50th anniversary of development in Poland. The conferences on Optical Fibers and Their Applications, organized in the country for 50 years, have played an important role in the development of the national scientific and technical community of optical fiber technology, or as we call it today, optical fiber photonics. This branch of photonics includes optical fiber telecommunications and instrumental photonics, including optical fiber components and sensors. Each optical fiber system requires an ultra-low-loss, or specialized, transmission medium in the form of a fiber or planar optical waveguides. The medium can be active or passive, sensitive or insensitive to external influences. Optical fiber spatially limits the spread of an optical wave using the refractive method or using a photonic band gap. To build a modern optical fiber system, light sources and detectors are necessary, as well as various optical and photonic components, preferably integrated or optical fiber, and not necessarily volumetric. Volume solutions in photonic systems are being gradually abandoned due to the reduction of costs and workload, and the increase in the reliability of photonic components and systems. The conference has published its materials in the Proc.SPIE publishing series for many years and is known internationally as Optical Fibers and Their Applications OFTA. The XXI OFTA2025 Conference gathered over 60 participants and over 50 papers and posters were presented. The article reviews the proceedings of the OFTA2025 conference. A version of this paper in Polish was published in Elektronika Monthly by SEP.**

Keywords— **photonics, optoelectronics, optical fibers, integrated optics/photonics, optical communications, optical fiber sensors, photonic integrated circuits**

I. Introduction

IT is hard to imagine modern civilization without optical fiber telecommunications and instrumental utility photonics, including optical fiber photonics. Satellite telecommunications operate efficiently thanks to the existence of a very energy and information efficient, transmission-capable and spatially dense backbone optical fiber network underground and undersea, including overhead. We are still quite far from saturation of the transmission and sensing capabilities of optical fibers. Optical fibers combined with photonic integrated circuits and quantum low-photon technologies open up a research and potential application area for many decades into the future.

II. Optical Fiber Technology in Poland – Conceptio et Caesura Anni 1980

Fiber optic technology has been developed in the country since the mid-seventies [1]. In the first half of the seventies, a team of several people for optical telecommunications was formally established at the Institute of Communications in Miedzeszyn. The team and then the Department received stable funding from government sources and around 1975 practically limited its research scope to optical fiber communications. This seemingly insignificant fact, concerning the internal structure of one of the important scientific and technical institutes in the structure of national science, and the opening of the subject of fiber optic telecommunications caused, however, a snowball effect. The centers that began the first theoretical and technological research on fiber optics and fiber optic optoelectronics at that time were the Warsaw University of Technology - Faculty of Electronics, Maria Curie-Skłodowska University - Faculty of Chemistry, NPCME CEMI - Institute of Electronic Materials Technology in Warsaw, Institute of Telecommunications in Miedzeszyn, Institute of Electron Technology, and Białystok University of Technology. From the beginning, the scope of the work included both telecommunication and non-telecommunications optical fibers, sources and detectors, metrology and characterization of optoelectronic components, and applications, i.e. the construction of telecommunication and instrumental modules and systems.

At the end of this first half calendar decade of development 1975-1979 an experimental operational, 2.5 km long telecommunications optical fibre cable was laid in Lublin [2]. At the end of this first decade, i.e. before 1980, valuable optical fibre components for research, scientific and technical, biomedical and industrial applications also appeared in the country. And the most important thing was the existence in the country at the end of this first decade of three strong technological centers for the production of optical fibers in Lublin at UMCS, in Warsaw at ITME and in Białystok at the Białystok University of Technology and in the Białystok Glassworks. These optical fibers produced in the country were made available for research to the increasing number of academic and scientific and technical centers interested in their applications. This meant overcoming a very important stage in the development of the photonics research, technical and application community in Poland. The achievements of the national scientific and technical community of optical fiber technology were summarized periodically, initially every 3 years, and then every 1.5 years, during the national conferences Optical Fibers and Their Applications. In the initial editions of the conferences, in 1976 and 1979 and several subsequent

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editions, numerous invited foreign lecturers from the world's leading technological centers took part. Later, scientific and technical representatives from neighboring countries also took part.

III. Optical Fiber Photonics – Perspectives of Development in Poland

If we were to try to give some conventional date of the beginning of a significant leap in the development of fiber optic technology on a global scale, we could mention, for example, the following: 1966, the date of publication by C.K.Kao and G.A.Hockham, Proc.IEE 113, in which the authors very accurately predict the development of this technology and provide conditions for achieving attenuation below 20 dB/km, next 1967 year, the date of publication of the first extensive monograph by N.S.Kapany entitled Fiber Optics; but also year 1977, when the first test operational transmission fiber optic cable was laid. In Poland, such an optical cable developed in 1978, working for testing in standard canalization, appeared almost immediately, in March 1979, thanks to the extraordinary effort of the team of Professor Andrzej Waksmundzki from UMCS in Lublin. In Poland. The year 1975 could be considered such a starting date, when the subject of fiber optic technology was formally taken up, thanks to the effective initiative of Professor Adam Smoliński, by the departmental Institute of Communications in Miedzeszyn. However, the year 1966 was raised to an absolute first place in the world, because the Nobel Prize for C.Kao is associated with it, also thanks to His subsequent groundbreaking technological works on fiber optics.

The formal undertaking of the subject by a key departmental institute, financed by central sources, changed everything in this area in the country. Universities (or rather heads of research teams) noticed the possibility of opening a front of very interesting research, experimental and theoretical work in a completely new field combining optics, optoelectronics, mechatronics, materials engineering, chemistry, physics, electronics and telecommunications. And that is exactly what happened. Exactly 50 years have passed since that moment. Additional strong evidence of such an extraordinary dynamic of development is the work of the first OFTA1976 conference and immediately afterwards the next OFTA1979. The materials of these first conferences show how many academic centers immediately started research and established appropriate optoelectronic, technological and metrological laboratories. OFTA1976 was organized in February, so in a year it will be exactly 50 years since the beginning of the cycle of these excellent conferences.

Let's hope that these conferences will continue and will present and summarize very good results of research and scientific-technical work in the area of domestic fiber optic photonics. Perhaps they will be continued in a form, slightly or more changed, but adapted to the needs of the contemporary scientific community. We observe these changes, among others, through a decrease in the number of conference participants, as well as the lack of willingness to publish conference materials. These ongoing change processes will require the leaders of the scientific community to significantly re-evaluate and then re-integrate. Many of the leaders still claim that conferences are necessary for the development of scientific communities. At the same time, we notice a strong virtualization of scientific life. Some statutory regulations do not favor conferences. These processes are inert in nature, hence the hope for positive evolutionary changes. The next fiber optic photonics conferences of the OFTA cycle are planned in September 2026 and in January 2028. Perhaps we will be able to return to this text in these years and see how the changes, re-evaluations and re-integration processes in the entire area of photonics have taken place. The research and application potential of photonics is so significant that the domestic community should have no problems with effective functioning and further development.

Where does this hope for further development of fiber optic photonics and the potential interest of young scientists in Poland come from? Without interest in this subject among young scientists, its development in the country is impossible. Arousing such interest is a difficult and responsible task for scientific and technical leaders in this field. In previous years and decades, we probably did it well, even beyond the resources available to the community, because many scientific centers for optoelectronics and fiber optic photonics were established in the country. Their establishment would not have been possible without attracting numerous young scientists to this subject. The development of our domestic photonics is of course a dynamic process. Something has been established, we have built some photonic community, but the further process of maintaining such a state and its development is a constant struggle for resources, for young people, for the interest of the economic and production domains, for building a market. If this is not there with the current stage of photonics development in the country, it means that we are isolated and we deal with matters that are not so much interesting to society as to our own.

In this article, however, we will not go back too much to the past, nor will we flaunt excessive considerations about the future. Exactly ten years ago, in 2015, we described this past, covering the first four decades, in quite detailed summary articles in Elektronika [4,5]. We are interested in the future. We describe this foretaste of the future by presenting not predictions and guesses for the next decade, but works presented at the conference Optical Fibers and Their Applications OFTA2025, showing the current interests and research possibilities of the national scientific community of optical fiber photonics. In other words, we celebrate the fiftieth anniversary of the development of optical fiber photonics in the country by showing a photograph of today. The development potential of combined integrated and optical fiber photonics is significant. We can see it clearly in the world, but in the country? OFTA2025 is by no means a summary of the 50th anniversary of optical fibers in Poland. This is a simple, modest, but very important, working meeting of the community organized periodically to recapitulate current activities and consider what we are planning for tomorrow, the day after tomorrow at the latest. However, such an event has the right to trigger more general reflections on the condition of technical sciences in the country, especially since this national fiber optic anniversary is round and significant.

Photonics is still a very attractive research field with significant discovery potential, especially in the quantum area.

There is also a huge application area of photonics to be developed, so far only partially activated. As is the case in dynamically developing science, photonics and other related disciplines, which were extremely attractive a decade ago, now have strong competitors that attract young people, such as space technologies, artificial intelligence and quantum technologies. The latter field is strongly related to photonics, and in particular with the integrated single-photon or low-photon photonics PIC/QPIC. This is an ideal field of application for optical fibers. Application-oriented optical fiber technologies will continue to be developed, especially in an industrial direction, but research and potential future applications will probably go in a quantum direction. In addition, optical fiber technology, as we have been developing it over the last 50 years, integrates, combines and somehow dissolves in general and in increasingly powerful photonics. Such photonics permeates many layers of our civilization.

We are talking about the future in the form of integrated photonics, with an increasingly large scale of integration. Such photonics creating telecommunication and instrumental systems, combining the functionalities of the Internet of Things, photonic networks, quantum systems already has and will increasingly have fiber optic connections. Such PIC photonic integrated circuits will increasingly often have quantum versions QPIC and they will be used as nodes of photonic quantum networks. This is the probable future of photonics. We have not yet discussed this topic too widely at our conference, although it is being developed in the country. And it is a pity, because more and more centers in the world are working on such a future of photonics. For now, let us move on to our own present day of photonics science and technology.

IV. OFTA Conference Series on Fiber Optics and Their Applications – Importance, Economics, Logistics, Publications

The conference "Fiber Optics and Their Applications" is a traditional scientific and technical event organized for almost 50 years. Our research community Fiber Optics conference, known under the name and acronym OFTA, Optical Fibers and Their Applications, is almost the same age as the ECOC conference (European Conference on Optical Communications), the first edition of which was held in London in 1975. The goal of OFTA has been to periodically summarize the progress in the field of fiber optic technology and their applications in Poland, but also in our region and the world. The conference most often gathers experts from various fields and academic communities, departmental institutes, industry, telecommunications operators, hardware and software manufacturers and suppliers. The first conference "Fiber Optics and their Applications" was held in February 1976, and the next ones in 1979 and 1982/83, 1986 and 1989. Initially, it was organized every three years until 1989. In 1981 and 1982, the national fiber optic community additionally organized the conference "Fiber Optics Metrology" [5] by the Lublin research centre and the conference "Non-Telecommunication Fiber Optics" by the Białystok research centre [6]. In 1996, the organizational rules of the fiber optic conference were changed. The organizer of the first conferences was the Committee of Electronics and Telecommunications of the Polish Academy of Sciences in cooperation with departmental institutes. Later, such organizations as the Polish Committee of Optoelectronics of the Association of Polish Electrical Engineers and the Polish Section of SPIE, from which the Polish Photonics Association was established, have joined.

In 1996, it was decided to formally divide the fiber optic conference into two cycles - Technologies and Applications, organized every 18 months and organized alternately by two technological centres in Lublin and Białystok. Historically, the first conferences were held in Jabłonna near Warsaw, in the conference facilities of the Polish Academy of Sciences, and then in the Palace of Culture and Science in Warsaw. The next editions were organized in Krasnobród, Nałęczów and in Lublin by Maria Curie-Skłodowska University and Lublin University of Technology (technological cycle) and in Białowieża, Supraśl and Białystok by Białystok University of Technology (application cycle). From this series of conferences, several volumes were published in the years 1986-2023 in the international publishing series Proceedings of SPIE [7,8], containing several hundred national and international papers in total. It is a great pity that this practice of showing national achievements on the international publication market, which is beneficial for our scientific and technical community, has been abandoned. Proc.SPIE is a very important global conference publication, indexed in Scopus and WoS, and despite this, it has a small number of categorization points awarded in the country. The reasons for this state of affairs are known in the community and are the result of complex evolutionary processes currently taking place in science.

SPIE Volumes published by our scientific community and indexed globally are a permanent testimony to valuable work in the field of photonics conducted in the country. This valuable path of archival records on a global scale was interrupted for many reasons. Firstly, preparing a valuable Proc. SPIE volume from a conference is very laborious. It requires significant effort on the part of the organizers and good mobilization of the authors, preferably before the conference. Secondly, Proc. SPIE volumes are undervalued in the national system for assessing the value of publications. Thirdly, young scientists currently have a completely different view of publications and bibliometrics, hence the lack of followers for such a hard-working publishing campaign. This view is strongly determined and reinforced by statutory requirements regarding the evaluation of individual persons and scientific institutions in Poland. There are no people willing to publish in conference series. In any case, it is amazing that the name of our fiber optic conference has remained completely unchanged for half a century. It is interesting that in the Empik online bookstore you can still buy a book by prof. A. Smoliński published in 1980 under this title [9]. Numerous reports from the OFTA conference series were published in the professional national press [10].

The 20th Conference on Optical Fibers and Their Applications OFTA/TAL2023 was organized in Lublin on September 11-14, 2023, by the Lublin fiber optic research center, i.e. the Optical Fiber Technology Laboratory at the Institute of Chemical Sciences of the Maria Curie-Skłodowska University in cooperation with the Department of Electronics and Information Technology of the Lublin University of Technology [11]. The 21st conference on Optical Fibers and Their Applications OFTA2025 [12], which we write about in this article, was organized by the Department of Photonics, Electronics and Lighting Technology, Faculty of Electrical Engineering of the Białystok University of Technology. The honorary patronage over OFTA2025 was declared by JMR of the Białystok University of Technology. The scientific and environmental patronage was declared by the Polish Photonics Association, PTETiS and the Polish Technological Platform of Photonics. The Honorary Chairman of the Scientific Committee of OFTA2025 was prof. Wiesław Woliński. The members of the Scientific Committee represented the Universities of Technology - AGH, Białystok (PB), Lublin (PL), Poznań (PP), Silesia (PS), Warsaw (PW), WAT, Wrocław (PWr), Universities - Silesia (US), Warsaw (UW), UMCS, and Łukasiewicz Institute of Microelectronics and Photonics (IMF).

The conference was held at the Ibis Styles Hotel in the center of Białystok on January 20-23 2025. The conference was attended by over 60 people from almost all photonics research centres in the country. During the conference, over 50 lectures and posters were presented in total. The lectures of invited guests and plenary lectures, session papers and the poster session covered the current development of fiber optic technologies and their applications in the country. The conference focused in particular on the following directions and applications: materials for photonics, fiber optic technology, optoelectronic components and systems, metrology of fiber optics, optoelectronic components and systems, fiber optic applications, luminescent fiber optics, and lighting technology. The conference program was divided into the following sessions: Fiber Optics and Measurements, Fiber Optics Applications, Luminescent Fiber Optics, Fiber Optics and Special Waveguides, Discussion Panel Photonics - Present and Future in Poland, and Poster Session. During the thematic plenary sessions, 23 papers were presented. During the poster session, 17 papers were presented. The discussion panel was related to the community submission of photonic technological equipment investments to the road map for the development of research infrastructure in the country. Necessary organizational changes to scientific conference meetings of the national photonics community were discussed.

It is worth paying attention again to the trends in the organization of scientific conferences in the country. They concern not only our Optical Fibres and Their Applications but also other conferences in the field of electronics and telecommunications, and probably in other disciplines. A decade ago, or even before Covid, our conference gathered two or even three times more participants. The reasons for this state of affairs are complicated and multi-layered. One can mention, for example, high participation costs, less interest of young scientists in the subject, low rank of compact conference publications in the form of so-called proceedings, significant conference competition in the field of electronics and telecommunications in the country, resulting from the desire to keep such meetings alive, etc. This is not a trivial trend, especially since in the normal life of the scientific community, conferences play a very important scientific and didactic role. Neglecting community conferences means significant damage to everyone - scientists and research topics.

The scientific proceedings of the last two conferences mentioned above, organized in 2023 and 2025, were published only modestly in the form of programs and one-page abstracts saved on flash drives. In the documentary sense, this can be described as a step back from previous methods of recording and publishing. If someone is not satisfied with publications in Proc. SPIE, they can publish our conference materials in the IEEE eXplore or Optica conference series, as well as Springer. It is very difficult to accuse these conference publishing series of lacking international reputation. Despite this, it will probably be very difficult to change this tendency of conference documentation. All of these series are undervalued due to the strange national slot scoring system.

OFTA2025 decided to publish several articles, depending on the authors' free decision, in the quarterly of the Polish Photonics Association's Photonics Letters of Poland. PLP publishes however only about 10 articles quarterly. This limitation to a very small number of 10 articles results from the interest of the PSP Association in maintaining a high level of publications, maintaining indexing in Scopus and WoS and is basically imposed by the requirements of the act and competition on the publication market. The Organizing Committee additionally recommends the publication of OFTA2025 conference papers in the very active Electronics journal of the MDPI publishing house in a special thematic issue Fiber-Optic Communication System: Current Status and Future Prospects. These publications have open access status, which means they require a fee on the part of the authors. It is doubtful whether the potential publications mentioned above would replace properly prepared conference materials published by us in a good, world-class publishing house.

Some national conferences, similar to our OFTA, recommend a whole range of arranged national journals for their proceedings. For example, the well-known and very good National Electronics Conference recommends the publication of distinguished papers by the Scientific Committee of the conference in the following national journals (some of them also publish papers from the area of photonics): Archives of Electrical Engineering, Bulletin of the Polish Academy of Sciences – Technical Sciences, Electronics – constructions, technologies, applications, International Journal of Electronics and Telecommunications, Metrology and Measurement Systems, Opto-Electronics Review, Przegląd Elektrotechniczny, Przegląd Telekomunikacyjny, Zeszyty Naukowe Uczelni UMG. This is a very useful action strengthening our domestic scientific and publishing market.

A workable option is to publish your own volume of materials in the best possible publishing house, for obvious reasons international and in English. Some good publications of the series of conference materials were mentioned above. If we do not publish such a volume, and no other materials, what happens? Nothing special?!. After the conference, there is absolutely no publication trace left, the meeting is only a scientific community event, maybe only of significant social and interpersonal research value. This is of course an important aspect for the development of the community, but it transforms from soft value to hard value sometimes with a significant delay. We often want to have hard effects immediately, but somehow we forget about them here. As mentioned previously, science is largely virtualized. Source materials, not derivatives but purely source materials, have a special value on the Internet. Such a conference without a trace did not generate source materials immediately. It only creates a promise of potential generation of such materials. Practice shows that a conference is forgotten quite quickly and no one wants to look back too long and produce sources for a conference that took place a long time ago.

Another option is a solidly prepared permanent and unchanging address internet portal for the conference series. There you can archive materials and link the portal to reliable international databases. Our OFTA and its Lublin version TAL have not developed such a portal. There are only some links prepared and maintained by people who are careful in archiving their achievements and international linking. There are many such permanent addresses of leading well-known conference series. International organizations take great care of such matters because they are related to pure economy. In our discipline, these are EOS, OSA - Optica, SPIE, IEEE and IEEE Photonics Society, EPS, Springer, etc. Our cyclical photonics conferences have not developed such influential and significant portals rich in source materials, neither OFTA, nor laser technology, nor others.

There are modest exceptions related to the activities of associations, e.g. the Polish Photonics Association. There is a certain amount of information collected on the psp.pl portal, but there is not and will not be a database of conference materials there. It is similar with the very modest portal of the Polish Optoelectronics Committee of the SEP. These are not those places, although they could be a library of permanent conference addresses, if such addresses existed and some effective traffic was registered on them. It can be clearly said that the domestic scientific community, not only in the field of photonics, completely underestimates the power of the Internet, and one could even say that it ignores it. The source materials of the Polish scientific Internet are generally modest, relative to the development of this area in the world. To put it very simply, as a result of the operation of our Constitution for Science Act, only publications for 200 points count. Is this what the development of science is about? It is rather underdevelopment. Perhaps this will be changed? Science is not about gaining points at all. We check the impact and find not many citations of these 200-point publications. Let's ask the question, how many 200-point publications were created from the twentieth OFTA2023 conference, how many will be created from the twenty-first OFTA2025 conference? Probably none, because no one writes in the publications that they were presented at excellent research community national conferences that do not even have a permanent Internet address, and therefore basically do not exist.

Such national conferences as our OFTA, but similar ones like Laser Technology and others, especially technological ones, are of invaluable importance for the national scientific and technical community and we are unable, unwilling, unable, neglecting to transform their achievements into a lasting product. This is a very serious neglect. We do not generate a lasting product from the significant additional value collected at the conference. We do not diligently build a national knowledge base every day, which contributes to the global base. We are wasteful, maybe lazy, or maybe it is simply stupidity. Or maybe publications in modest conference materials, like in low-scoring journals, are embarrassing? Quartiles count. Only the first quartile really matters. The magic sign Q1` on the title page of some scientific journals is of key importance. And here a large part of the Quarterly Journals of the Polish Academy of Sciences are in the third and fourth quartiles. Apparently, publication in such journals can ruin the scientific career of young scientists? You published in the fourth (third quartile), but shame on you. Some of us have probably encountered such opinions.

V. Optical Fibers and Their Applications OFTA2025 – Topics and Review of Some Research Papers

Splitting of topics between the two technological and application editions of the OFTA conferences, organized every year and a half, is only conventional. Both conferences usually have rich technological and application sessions. Technology includes materials engineering, glass synthesis, optical polymers, optical fiber drawing, and the production of optical fiber photonic components. Applications include the construction of optical fiber systems and photonic systems, laboratory tests, and application tests.

A. OFTA2025 – glasses, optical/photonic materials, technologies

The search for new functional luminescent hybrid materials is related to the expanding field of applications of optoelectronics and fiber photonics. Optical active polymers are created by joint doping with rare earth ions and quantum dots. Co-doping with various optically active components enables research and practical tests on FRET energy transfer from the lanthanide ion donor to the quantum dot acceptor. Development of stable conditions for such transfer with high energy efficiency in the hybrid co-doped optical polymer PMMA opens up possibilities for the construction of new fiber optic components. The advantages of doping with quantum dots include a narrow emission band, quantum efficiency, photostability, and a wide absorption band. It is advantageous to combine these features of quantum dots with a long lanthanide luminescence decay time. The technology of the hybrid material system requires uniform dispersion of dopants. Technological tests were carried out for Tb and CdSe/ZnS dopants. The parameters of the system were: PMMA matrix, quantum dot emission 606 nm, Tb excitation 345 nm, Tb emission 547 nm, energy transfer efficiency about 20%, lanthanide luminescence decay time shortened with increasing quantum dot concentration (PB).

Different types of glasses are tested and subject to different heat treatment methods to obtain optimal luminescence properties. Tellurium-germanate mixed oxide-fluoride glass TeGeGaBaZnNaEr doped with ErF3 was treated with CO2 laser and standard heat treatment. This glass belongs to the group of low-loss transparent glass-ceramic materials activated by rare earth ions RE. Thermal treatment of such glass leads to nanocrystalline glass-ceramic material with BaErF nanocrystallites which causes significant increase in up-conversion emission. Crystallization was obtained by local interaction with CO2 laser beam. Oxides with different degree of oxidation were TeO_4, TeO_3, GeO_4, GeO_6, Ga_2O_3, Na_2O, and fluorides BaF_2, ZnF_2, and active dopant ErF_3. The synthesized material subjected to thermal treatment was characterized structurally, chemically and optically (AGH, UJ, PB).

The tests were carried out with bioactive glass 13-93. Bioactive glass fibers are doped with Samarium of different concentrations in order to enable measurement of their degradation in the tested simulated liquid biological environment. Applications of such fibers are related to techniques of accelerating the healing and regeneration processes of tissues. Laboratory techniques require long-term degradation measurements covering periods of tens of hours. After the process of exposure of the fiber, it is examined structurally by SEM/EDS methods. The degree of degradation of the fiber surface and the formation of the HCA layer are revealed (PB).

Research on low-phonon fluorozirconium glasses ZBLAN (ZrBaLaAlNa) is conducted due to the possibility of their use for drawing specialized optical fibers and building photonic systems in the UV, VIS and mid-IR region, beyond the transparency range of pure silica. The low-phonon matrix is a good medium for doping with lanthanides, including multi-ionic doping. ZBLAN fiber lasers have many advantageous features typical for fiber lasers, such as the possibility of cooling, ease of integration with integrated circuits, etc. The generated light beam has good spatial and spectral parameters, and high power. ZBLAN glasses doped jointly and separately with multivalent thulium ions and ytterbium ions were synthesized. Such an arrangement of optically active ions enabled obtaining radiation emission in a wide spectral range. Co-doping with ytterbium ions sensitizes the combined ionic system, increasing the excitation efficiency of thulium ions via energy conversion (PW).

Optical fibers made of ZBLAN glass were produced experimentally. ZBLAN glasses were synthesized in inert gas-insulated conditions. The fragility and susceptibility to crystallization of ZBLAN glass require appropriate technological conditions for bulk glass processing and further processes for obtaining the fiber. Optical fiber preforms with a step-refractive profile were obtained by extrusion. The obtained optical fibers were characterized in terms of numerical aperture and spectral properties (IMF).

Nonlinear photonic optical fibers exhibiting the photonic band gap effect were produced from preforms prepared by 3D printing. The printer enables printing of preforms replacing the standard method of assembling preforms from glass rods and capillaries and pulling such an arrangement into an optical fiber. The preforms are printed directly from bulk glass extruded from a crucible. The extrusion process is controlled classically by temperature and pulling speed. The 3D printing head, containing an XYZ shift, is coupled to the crucible in a thermal chamber. Nonlinear SiBPbZnCd lead-boron glass fibers intended for supercontinuum generation were produced. The fiber contained a full core and three rings of air holes in the cladding arranged in a hexagonal lattice. An octave-wide supercontinuum was obtained after exciting the fiber with a femtosecond laser beam (UW, IMF).

The glass matrix of the active optical fiber is doped with active ions. Active ion carriers can have different forms. These are, for example, nanoparticles, nanocrystallites or quantum dots. In the case of nanocrystallites, it can be a glass powder with a suitably small grain size of around 100 nm. Technological parameters include the concentration of the dopant in the fiber core, the uniformity of its dispersion in the glass matrix, and the absence of induced crystallization of the matrix around the nanocrystallites. Doping of various matrices using various nanocrystallites, including $YPO_4:Yb^{3+}$ (AGH), was studied.

Titanium-germanate glasses were doped with RE ions for IR emission applications. The glasses were doped with Nd, Er, Ho and Tm ions. Spectroscopic studies showed the beneficial effect of titanium dioxide on the IR emission properties of synthesized titanium-germanate glasses (US, AGH, PB).

In MIR-active optical fibers exhibiting broadband emission, optical power profiling is an important issue. Optical fibers with a double cladding of low-phonon germanate glass have been produced. An emission bandwidth of nearly 800 nm was obtained at 796 nm pumping. The optical fibers are optimized to obtain ASE sources (PB, PS, AGH).

To build ASE sources, multi-ring optical fibers doped with active ions 3+ Tm/Ho are being developed. The aim of such shaping of refraction in the fiber is to obtain a large mode field. The exchanged ions enable emission in the spectral region safe for the eye 1.7-2.1 micrometers. Optical fiber preforms and the shaped refractive profile were manufactured and characterized. Variable numerical aperture values were obtained in the range of 0.05 - 0.12. The luminescence profile depended on the length of the optical fiber, which was related to the reabsorption and emission of ASE (PB, AGH, US).

The produced active multi-ring fiber doped with Tm^{3+} ions was used to build a pulsed fiber laser generating radiation with a wavelength of about 2 micrometers. The laser emitted in the 793 nm band. The laser, in combination with an acousto-optic cell, generated pulses with a duration of several hundred nanoseconds, peak powers of the order of hundreds of watts at frequencies of the order of several kilohertz (PWr, WAT, PB, AGH).

Physic-chemically active nanoparticles subject to changes under the influence of external interactions are commonly used in biophotonics. Interactions can be electrical, optical, thermal, mechanical, including ultrasound. They are used as an activator in sonodynamic and photodynamic therapy. Nanoparticles with an activation dopant of lanthanides and modified with transition metals convert NIR light into UV or VIS. Photostable biophotonic nanoparticles Ln-UCNP were synthesized and hybridized in a microwave reactor with nonpolar solvents (AGH).

Luminescent properties of SiLiZn glass-ceramics doped with chromium ions of different oxidation 3+ and 4+ were studied. The Cr dopant exhibits long lifetime and high luminescence efficiency. Emission was observed in the range of 700-1000 nm and 1000-1700 nm depending on the Cr oxidation. The material was characterized for biomedical applications (PB).

There are many technological methods for creating functional optical fiber ends. In some applications, such ends are referred to by the general name of a fiber head. Fiber surface modifications include such functionalities as microlenses, collimators, cones, diffusers, deflectors, diffractors, and sensors. Three-dimensional two-photon polymerization was used to create functional structures on the front surface of the fiber. The method allows for the creation of any microstructures with a resolution of around 100 nm. For example, several-millimeter sections of microstructured optical fibers of any geometry were produced. Microstructures were used in fiber microinterferometers and ring resonators. Microstructures facilitate the generation of complex light beams, optical vortices, Bessel beams, Laguerre-Gauss beams, and photonic beacons (PW).

High-quality optical composite SiOx:TiOy layers for the VIS-NIR spectral range were made for the construction of integrated photonics systems. The layers were produced by the optimized sol-gel and dip-coating method. Planar layers and optical fibers with different refractive contrast were created. Stripe optical waveguides, directional couplers and Mach-Zehnder interferometers were produced on the developed high-quality low-loss optical layers (PS).

The influence of europium doping on the properties of SiOx:TiOy waveguide layers was studied. High-quality composite optical layers with a refractive index of about 1.65 were produced. The produced layers were characterized by ellipsometry, spectroscopy, m-line methods. Surface morphology was studied by AFM, optical profilometry and SEM/TEM. The material structure of waveguide layers was studied by HRTEM (PS).

Erbium-doped thin glass films were produced by the RF sputtering method. The glass matrix was germanium-gallium-barium. The doped glass was synthesized by the melting method. The glass surface was polished to the optical quality. The glass sample was placed on a copper substrate. The glass surface was prepared for RF sputtering by plasma pretreatment in a protective atmosphere. Optical quality thin films were obtained (PB).

The optical fiber for transmission to be put in cable must be suitably protected by external coatings. Coating techniques are very well developed on a mass scale. Despite this, further research is being conducted on the potential optimization of structures. Optical fibers are susceptible to moisture and other chemical factors. Depending on the application, they must be suitably protected. The thermal resistance of hard acrylic varnish coatings in the form of a protective coating is being tested. Thermal resistance includes thermal stability under normal operating conditions of the optical fiber or under slightly increased or decreased temperature conditions. Thermal resistance also includes the behavior of the coating in high temperature conditions above 200°C, but also in conditions below 0°C. The behavior of coatings in high temperature conditions was tested by spectroscopic analysis. The temperature-changed varnish was examined using the ATR-FT-IR method and microscopically. The use of new types of coatings for optical fibers operating at high temperatures above 300°C was also tested. For such solutions, metal coatings are used that increase the attenuation of the optical fiber. Different types of UV-cured TMPTA polymer were used to coat the fibers. The polymer was analyzed using thermogravimetric and TG/DTG spectroscopic methods (UMCS).

Optofluidic microcircuits are used in biophotonics. A self-organized one-dimensional photonic crystal formed in a mixture of gold nanoparticles suspended in a nematic liquid crystal was used to build the components of the optofluidic system. The system is spectrally tuned in a wide spectral range. The tuning process is reversible by modifying the capillary diameter. The period of the periodic structure is variable in the range of several dozen micrometers. The high refractive contrast results from a step change in the refractive index between the nematic and isotropic phases of the liquid crystal (LC).

The stress properties of a nanostructured optical fiber with a large mode area were studied. The tested optical fiber operated in a single mode in the long-wave window of the telecommunications band. The aim of the research is to determine the possibilities and scope of applications of short sections of such optical fibers for sensing purposes (ZUT, UW).

B. OFTA2025 – sensors and components, measurements, tests and applications

Fiber optic sensors are used in industrial conditions in difficult operating environments. The fiber optic sensor with a Bragg grating allows measuring, in a limited range of absolute deformations of the order of 1 mm, the longitudinal deformation of mechanical structures. Such fiber optic sensor networks built into mechanical structures have long been used for monitoring, e.g. bridges, aircraft wings, etc. The fiber optic Bragg sensor was built into a measurement system for monitoring the degree of elongation of compensators in a gas transmission pipeline. The measurement of deformation of the order of several dozen or several hundred mm is possible thanks to a mechanical transducer that converts the required deformation of the mechanical structure into the permissible deformation of the sensor of the order of 1 mm. The test measurement and monitoring system with a fiber optic sensor was placed on a real compensator of a gas transmission pipeline (PS).

Data from fiber optic sensors must be efficiently periodically read and recorded and processed. In the case of many individual or networked fiber Bragg sensors, integrated photonic interrogators are used in the most efficient, structurally and energetically, solutions. Interrogators are built in the form of PIC systems containing AWG waveguide matrix demultiplexers and asymmetric Mach-Zehnder interferometers. Sensor systems with integrated interrogators are used in tests for monitoring large mechanical objects, as well as in the biomedical environment (PW).

Fiber Bragg gratings are quite commonly used in practice as sensors of physical and chemical quantities, and in particular mechanical, thermal, optical and other. Standard solutions use short sections of optical fiber with a single or multiple Bragg gratings recorded. The most common parameters measured by such sensors are individually or in multi-parameter combinations: temperature, refractive index of the liquid, longitudinal stress, rotation angle and bend radius. Bragg gratings are divided into construction classes such as classical, modulated, long period, oblique and others. They differ in spectral characteristics and sensitivity to external interactions, including differential characteristics between various simultaneous interactions. This allows the construction of advanced multi-parameter sensor systems built on a single fiber optic network. Fiber optic oblique Bragg gratings have a spectrum consisting of the Bragg mode, the Ghost mode and a wide spectrum of cladding modes. The significant spectral width of cladding modes covering the range of 10 - 50 nm, and the changes of this spectrum under the influence of external influence are used for measurements. For measurement purposes, selected single cladding modes are analyzed, as well as their envelope. The cut-off wavelength for individual modes is determined from these measurements. Considerable accuracy of refraction measurements of the order of 10exp-5 can be achieved (PB).

Oblique fiber Bragg gratings are cascaded with different angle arrangement to obtain appropriate wavelength shift sensitivity of cladding resonance. The resonance shift is independent of source power fluctuations in the fiber and fiber bending. Such sensor structure can also be immunized for measurements of refraction from polarized light (PL).

The interest in optical vortex beams results from the possibility of their use in the construction of optical fiber sensors. Vortex beams carry not only the spiral angular momentum of SAM but also the quantized orbital angular momentum of OAM. The topological number defines the region of phase singularity in the center of the beam. The OAM beam can be propagated in an antiresonant optical fiber. The annular shape of the beam enables its use in photochemical flow microreactors. The photonic system of the microreactor consists of an OAM mode generator on a nanostructured optical fiber transforming the fundamental mode into a vortex beam. Such a beam is coupled to the annular core of the capillary optical fiber and should be propagated without distortions over a considerable distance. This length determines the path of interaction of light with matter and plasmonic nanoparticles in the reactor undergoing a photochemical reaction (UW, IMF).

Fiber optic cones are components used for mode transformation, optical power concentration, coupler construction, etc. In high-power fiber lasers, spectral and phase beam combining is necessary so that the required effect and good beam quality are obtained at the output of the multicore structure. In systems with incoherent light beam combining, the beam quality is much worse, but the solution is technologically simpler. An important fiber laser component was built on a constricted seven-core fiber from 350 to 150 μm. A significant improvement in the beam quality was achieved at a high power level (UW, IMF).

Connections between different types of optical fibers are one of the basic components in optical fiber photonics. Connections can be permanent, glued, welded or detachable. In connections, it is important to match the modal fields between the connected fibers in order to avoid power losses. Very often used in sensing techniques, optical fibers with a hollow core transmitting a beam of light, using the effect of antiresonant reflection from a thin capillary wall, must be connected to a standard optical fiber. The splice of both optical fibers must maintain the capillary geometry perfectly. Methods have been developed to connect such optical fibers for different types of optical fibers with a hollow core (UMCS).

The application of transmission spectroscopy and FTIR-ATR-HATR methods for determining the concentrations of biogenic compounds, nitrates, nitrites, phosphates and ammonium ions was tested with potential use in metrology of municipal and industrial sewage. A compact fiber optic system for transmission and absorption spectroscopy was built, suitable for work in laboratory conditions with the above-mentioned compounds intensifying the eutrophication process in the aqueous environment (PW, VIGO).

A fiber optic sensor was tested to determine the surface condition of machined mechanical components. During surface processing, the measurement conditions change. A fiber optic interferometer in a compact set was used for measurements. Measurements were made of steel surfaces in the range of 10-550 micrometers. The sensor was made using 3D printing methods. Changes in the sensor signal were used to assess the progress of processing the tested component (PG).

The properties of a photonic sensor with a germanium-on-silicon integrated structure and a germanium suspended waveguide designed for carbon dioxide measurements in the 4.23 micrometer band were analyzed and simulated. A numerical model of the sensor system was created. The sensor geometry was optimized to obtain maximum measurement sensitivity and sensor integration in a photonic integrated circuit (PW, VIGO, PWr).

Open optical communication systems include dedicated transmission lines but also, for example, the Li-Fi broadcasting method. For the purposes of open optical communication, an integrated transceiver based on InP material was developed. The system has an FSOC architecture of a multi-channel integrated photonic transceiver. The signal properties of the system were tested for transmission up to 10 Gb/s and the transmission quality and the BER parameter value were assessed by measurements (PW, VIGO).

A fiber optic method for detecting viral RNA was proposed. A spherically terminated fiber tip was used as a sensor. The fiber optic head was coated with multilayers of gold, HNS and DNA layers. Adding viral RNA to such a structure causes changes in the measured spectral spectra (PG).

A capillary fiber-optic nanoparticle magneto-optical biosensor is tested. The technique is based on magnetic biolabeling using biotin and streptavidin coated magnetic nanoparticles (UW). The work is performed in collaboration with Huanzhong University.

The spontaneous Raman emission was analyzed in a telecommunications fiber transmitting a classical and quantum signal. The Raman phenomenon plays an important role when a quantum signal is transmitted simultaneously with a classical signal through a telecommunications fiber. The classical signal is a source of broadband spontaneous Raman emission. Raman emission photons are difficult to filter out and interfere with the quantum signal. The analysis was performed for a classical single-mode telecommunications fiber (PWr, WAT, UMK).

Photonic metrology is proposed and tested for selective detection of threats to aquatic ecosystems and contamination of bottom sediments. Bottom sediments collected over a long period of time in water areas exploited industrially contain many hazardous and toxic substances. UV-VIS spectroscopy is used to determine color, nitrate content, organic content, total oxygen content, spectral absorption coefficient, chemical oxygen demand. Fluorescence spectroscopy shows the content of algae. Raman scattering spectroscopy and FTIR detect and analyze microplastics. The research is conducted in the Kłodnica/Gliwicki Canal aquatic ecosystem (PS).

Photonic metrology systems use distributed fiber optic sensors. The sensors are assembled in the form of measurement networks. The sensors additionally measure several parameters simultaneously, such as temperature and stress, temperature and humidity, pressure, etc. In addition to the construction of the photonic part of such a complex network, software processing of the measurement results is important. The distributed sensors are, for example, multi-point in the form of Bragg gratings distributed along the fiber. The measurement system used a fiber optic reflectometer measuring Brillouin and Rayleigh scattering. Machine learning and linear regression methods were used to process the measurements. Multiple measurements created a training database. The parameters were the number of measurement points and the length of the measurement section (PWr).

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