

Laboratory of Optical Fiber Technology, Institute of Chemical Sciences, Faculty of Chemistry, Maria Curie-Skłodowska University in Lublin

About Laboratory of Optical Fiber Technology

Laboratory of Optical Fiber Technology at Maria Curie-Skłodowska University in Lublin has fifty years of experience in manufacturing telecommunication, specialty and microstructured optical fibers made of silica glasses, high silica glasses, and polymers. Currently, it is one of the few university research units in Europe with a complete technological line for manufacturing of optical fibers, apparatus for synthesis of super-pure silica glass, and fiber drawing. The Laboratory is also equipped with instruments for characterization of properties of manufactured optical fibers. The Laboratory consists of:

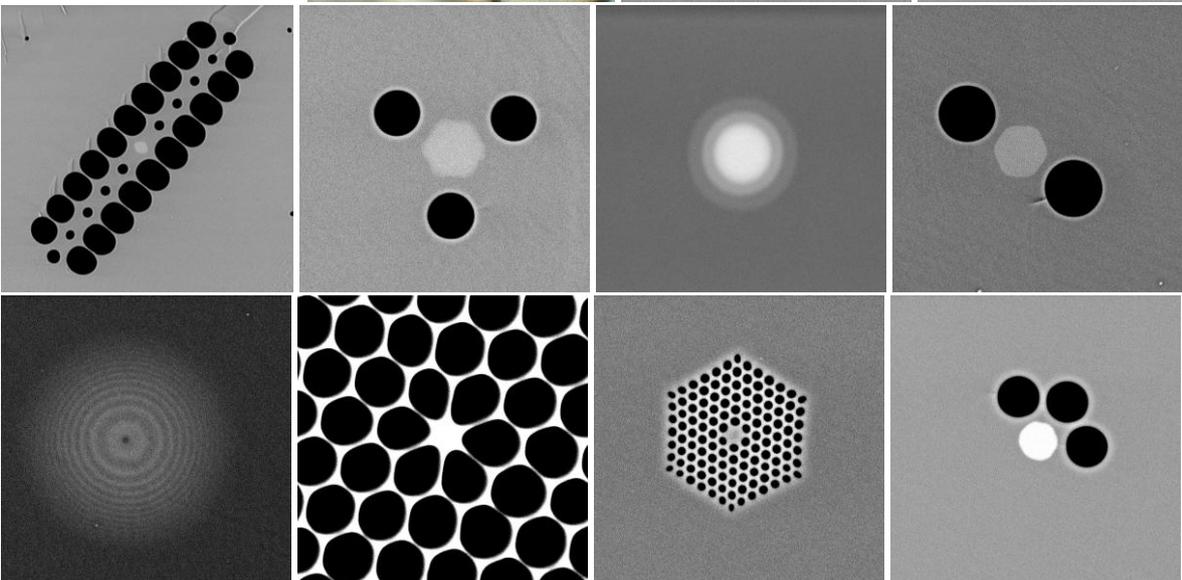
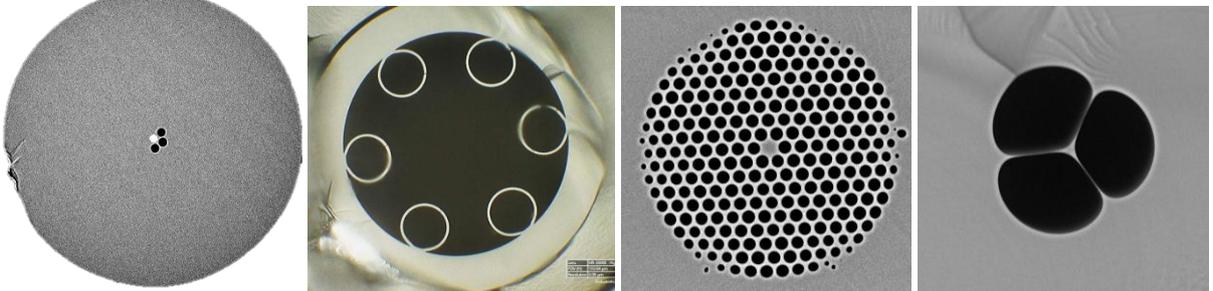
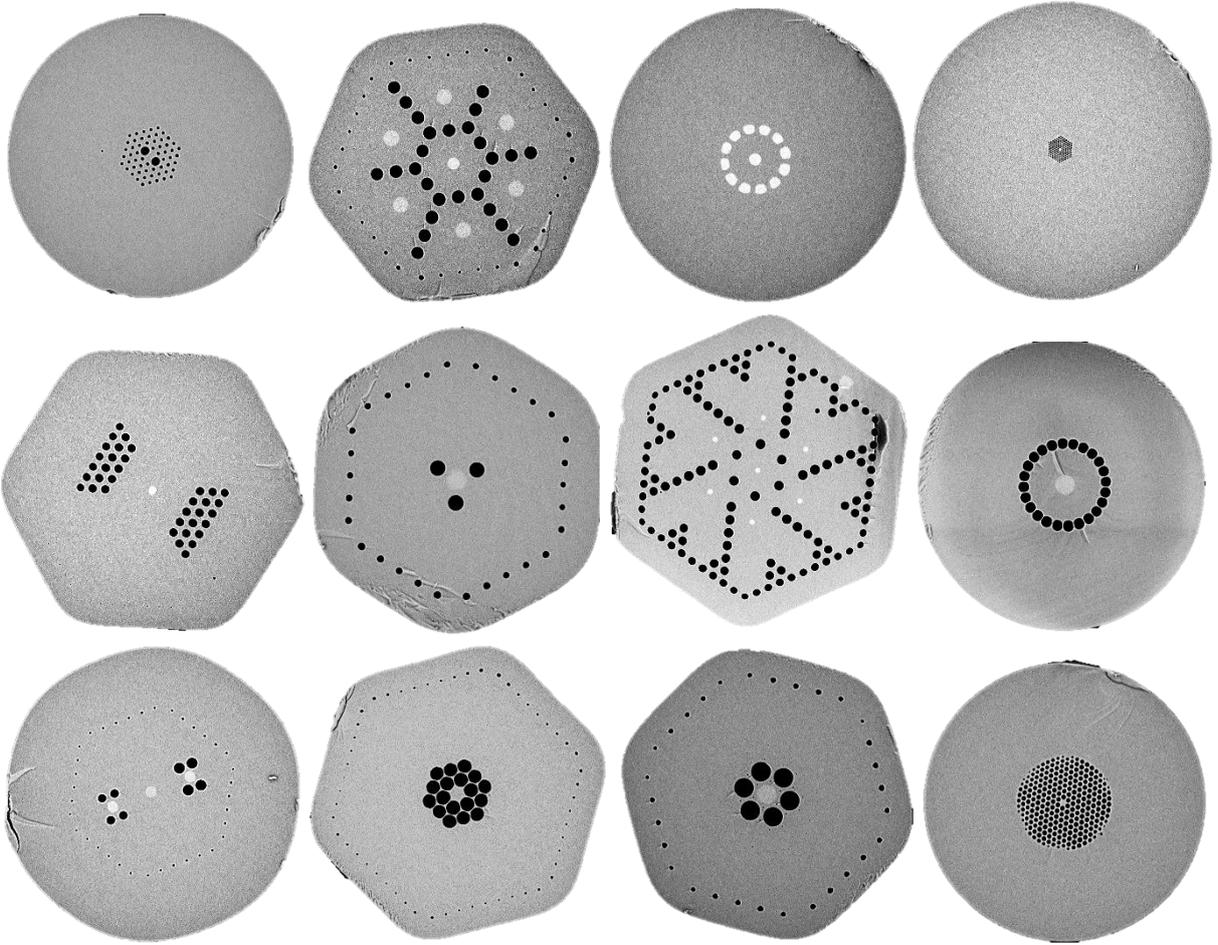
- **glass synthesis laboratory**, where research and technological processes related to the production of glasses and preforms for conventional and microstructured optical fibers are carried out;
- **semi-technical hall**, where optical fibers are manufactured and their quality is controlled;
- **laboratory of technological measurements**, where measurements of optical and mechanical properties of manufactured optical fibers are performed;
- **chemical laboratory**, where synthesis and purification of substrates for the production of glasses and chemicals used in auxiliary works are carried out;
- **design and construction workshop** with a silica glass grinding shop, which allows for construction of specialized equipment necessary for the development of new types of fibers;
- **clean-room** with an area of 10 m² with a controlled air purity class 100, equipped with a laminar chamber in which preforms for microstructured optical fibers are manufactured;
- **optical polymers laboratory** equipped with a dedicated twin-screw extruder for the production of polymer optical fibers and light-weight optical cables, as well as with climate chambers dedicated to testing of optical fibers.

The technological facilities available at Laboratory of Optical Fiber Technology allow for conducting innovative research, among others in the fields of:

- technology of new types of sensing optical fibers,
- technology of new types of microstructured optical fibers,
- technology of optical fibers doped with rare earth elements for fiber lasers and optical amplifiers,
- chemical fiber-optic sensors,
- new types of protective coatings for optical fibers,
- UV-curable polymers and organic-inorganic hybrid materials.

Portfolio of manufactured optical fibers

Laboratory of Optical Fiber Technology possesses abilities of manufacturing a broad range of standard and specialty optical fibers – from conventional optical fibers with a broad range of possible germanium doping levels (up to 30-some percent), through side-hole and highly birefringent fibers, microstructured optical fibers, to anti-resonant hollow-core fibers. A selection of photographs of cross-sections of optical fibers manufactured by us and close-ups of core regions of some of them should give a good idea of a range of our possibilities:



Key Staff of Laboratory of Optical Fiber Technology

prof. Paweł Mergo, DSc

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Professor Paweł Mergo is a leader of Laboratory of Optical Fiber Technology. He graduated from the Faculty of Chemistry of Maria Curie-Skłodowska University in Lublin and has twenty-five years of experience in metrology and manufacturing technology of conventional and microstructured optical fibers that he has gained during his work at Laboratory of Optical Fiber Technology as well as internships at Université du Québec en Outaouais in Canada and Vrije Universiteit Brussel in Belgium. His main scientific interests include development of technology of novel low- and high-birefringence conventional and microstructured optical fibers made of silica glass and polymers, theoretical optimization of optical fibers, measurement of transmissive and sensor properties of optical fibers, as well as development of new materials for use in fiber-optic technology. Prof. Mergo has authored over 300 scientific papers (H index of 21). Up to now he was manager or contributor for about 20 projects financed by National Science Center, The National Centre for Research and Development, Sixth and Seventh Framework Programmes of the European Community, Horizon 2020.

Małgorzata Gil-Kowalczyk, PhD

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Małgorzata Gil-Kowalczyk is a graduate of the Faculty of Chemistry of Maria Curie-Skłodowska University in Lublin. She has over 14 years of experience in the synthesis and physicochemical characterization of polymeric materials used in photonics. Her scientific interests focus on the optimization of photopolymerization and thermal processes to effectively incorporate substances with unique chemical properties into polymeric materials. These materials are utilized in the fabrication of both optical fibers and their protective coatings. The resulting materials, known as hybrid or active materials, are applied in modern optical sensors, such as those used for hazardous gases detection. It is worth emphasizing that, through her research, she has conclusively demonstrated that polymeric materials used in technology of optical fibers can be effectively modified—with properly optimized processes—by incorporating various active substances already at the polymerization stage. Her professional experience also includes participation in research and development projects focused on innovative polymeric materials for photonic applications.

Krzysztof Poturaj, MSc

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Krzysztof Poturaj is a graduate of the Faculty of Chemistry of Maria Curie-Skłodowska University in Lublin. His scientific experience includes over 35 years of work in the technology team of the Laboratory of Optical Fiber Technology. His scientific interests include the technology of manufacturing silica and high silica glasses using Modified Chemical Vapor Deposition (MCVD) and Furnace Chemical Vapor Deposition (FCVD) methods, as well as the methods of assembling preforms for microstructured optical fibers. Krzysztof Poturaj is responsible for continuous supervision over the MCVD and FCVD technological lines and their modifications for the manufacturing of preforms for optical fibers with properties tailored for specific applications.

Mariusz Makara, MSc

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Mariusz Makara is a graduate of the Faculty of Chemistry of Maria Curie-Skłodowska University in Lublin. His professional experience includes over 25 years of work in the technology team of the Laboratory of Optical Fiber Technology. His research interests include the manufacturing and processing of preforms for microstructured optical fibers and techniques of drawing conventional and microstructured optical fibers. In addition, he deals with the characterization of preforms and optical fibers manufactured at the Laboratory of Optical Fiber Technology.

Adam Paździor, MEng

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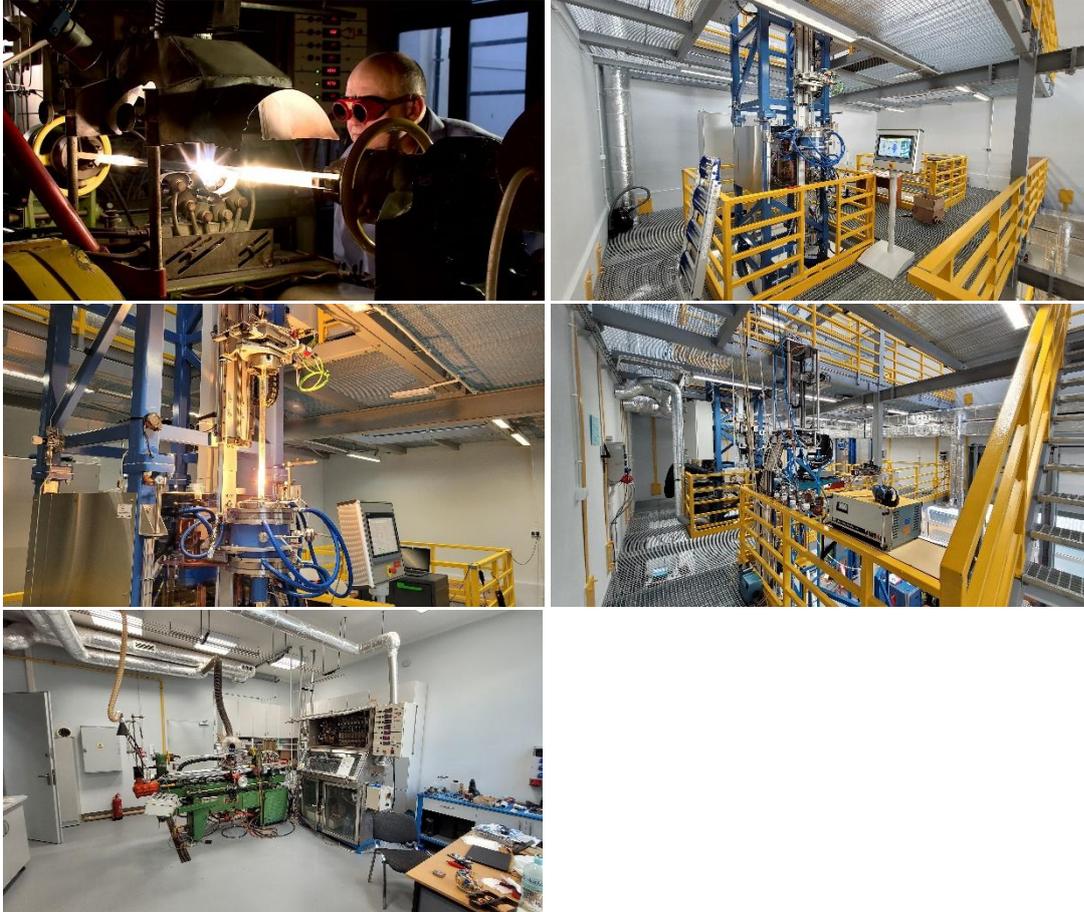
Adam Paździor graduated from the Faculty of Physics of Warsaw University of Technology. He has almost ten years of experience in metrology of optical fibers and development of fiber-optic sensors. At Laboratory of Optical Fiber Technology he is responsible also for supervising the laboratory of technological measurements, including building new setups for measuring properties of optical fibers.

Key equipment

Complete technological line for manufacturing of optical fibers

Complete technological line for manufacturing of optical fibers offers possibility of manufacturing preforms for conventional optical fibers as well as components and preforms for microstructured optical fibers made of silica glasses. Possibilities of doping include germanium, fluorine and rare earth elements.

The silica glass optical fiber drawing tower allows for fabrication of optical fibers with conventional structure and microstructured fibers with external diameters from 60 to 800 micrometers. It is also possible to produce a wide range of silica glass rods and capillaries with a maximum outer diameter of 4 mm. Manufactured optical fibers can be covered with single-layer (hard coating) and two-layer (soft/hard coating) acrylic protective coatings and special single-layer polyimide coatings. The drawing tower is equipped with two easily exchangeable systems for curing the coating: UV lamp and thermal furnace.



Optical spectrum analysers & supercontinuum sources

Two NKT Photonics supercontinuum sources offer light of a broad spectral range from 410 to 2400 nm with single-mode emission, high spatial coherence and high optical power density (one of the sources has total power of 5.5 W, total power in visible range of 1.5 W).

The set of two Yokogawa optical spectrum analyzers of high sensitivity and high dynamic range include one for wavelength range from 350 to 1200 nm (model AQ6373B) and one for wavelength range from 1200 to 2400 nm (model AQ6375B). Both devices have advanced functions for spectral analysis, including color analysis (AQ6373B) and WDM analysis for characterization of wavelength division multiplexed telecommunication signals (AQ6375B).

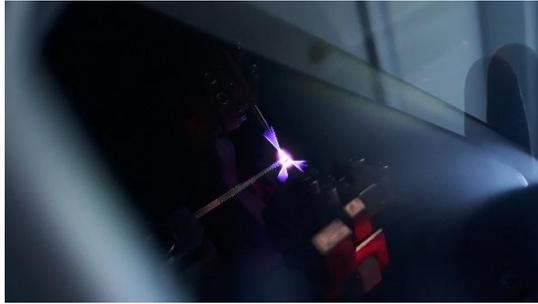
Supercontinuum sources together with set of wavelength selectors and optical spectrum analyzers enable spectral characterization (for example spectral attenuation measurement, chromatic dispersion measurement) of optical fibers, sensors and components in broad wavelength range.



Glass processing stations for splicing optical fibers and component manufacturing

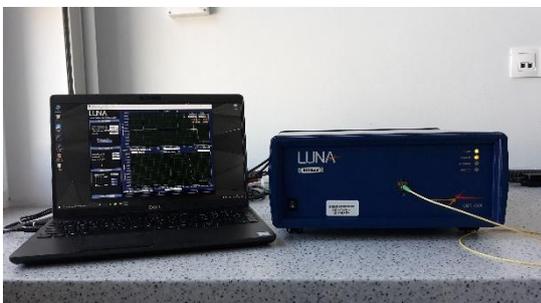
The 3SAE CMS (combiner manufacturing station) enables splicing of optical fibers (max. diameter: 2 mm), manufacturing fiber-optic tapers, bundling optical fibers and manufacturing optical power combiners by cleaving a bundle with built-in cleaver and splicing it to an optical fiber. The station is equipped with high resolution vision system which enables real-time control of performed processes, precise selection of cleaving location, as well as measurement of diameter along length of an optical fiber. For heat source the station utilizes thermally stabilized plasma which – together with built-in vacuum system – ensures operational temperatures ranging from below 300 up to over 3000°C. The station ensures flexibility in adjusting dimensional properties of heat zone thanks to exchangeable two- or three-electrode heat source.

The Vytran FFS2000WS workstation enables preparation, splicing, recoating and proof testing wide range of optical fibers, including polarization-maintaining optical fibers.



Fiber-optic distributed sensing system

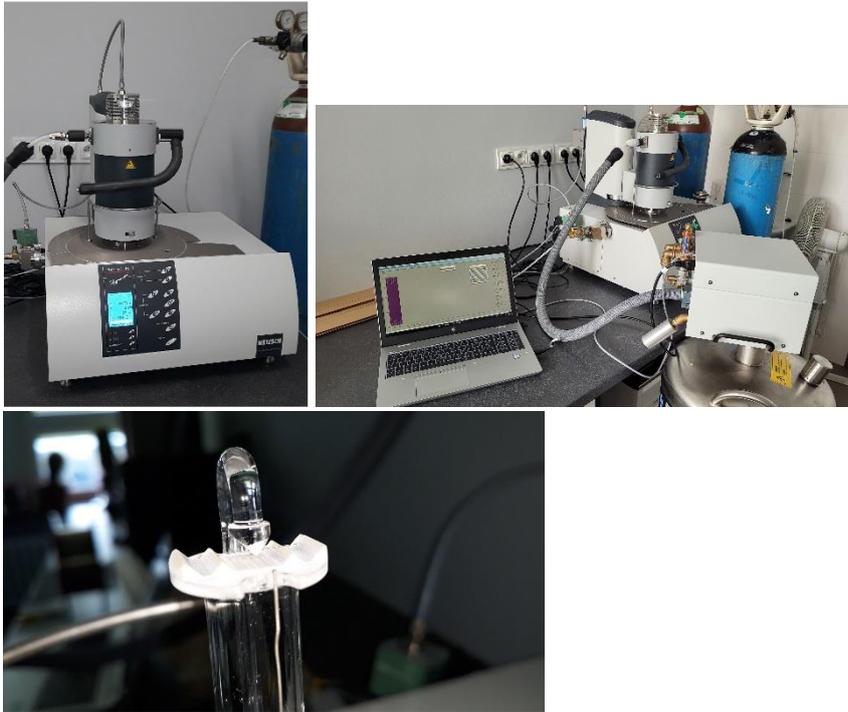
The LUNA OBR4600 system is based on optical frequency-domain reflectometry and Rayleigh scattering and enables performing measurements in optical fibers in both time and frequency domain in the range of third telecommunication window (1525 - 1610 nm). The device is characterized by high dynamic range (80 dB), no dead zone and high spatial resolution: 10 μm with measurement range of up to 30 m, and 20 μm with range of up to 70 m. The device enables measurements of return loss, insertion loss, distributed loss, length, polarization state, phase derivative and group delay. The device is equipped with distributed sensing mode and extended measurement range mode (up to 2 km).



Thermomechanical analyzer

The thermomechanical analyzer (TMA) enables characterization of phase changes, coefficient of thermal expansion, glass transition temperature and softening points under static or dynamic load conditions with the imposed temperature regime. TMA provides information on the values of the main mechanical quantities, e.g. Young's modulus and the mechanical properties of materials

necessary for the correct design of the optical sensor system, in particular when new materials are used in it. Mechanical tests can be carried out in the temperature range from -150 to 400°C at a constant temperature or in a fixed constant temperature increase (max. rate 3°C/min).

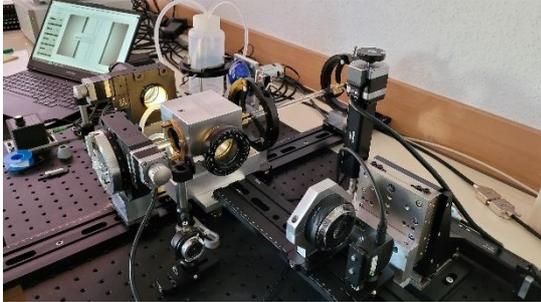
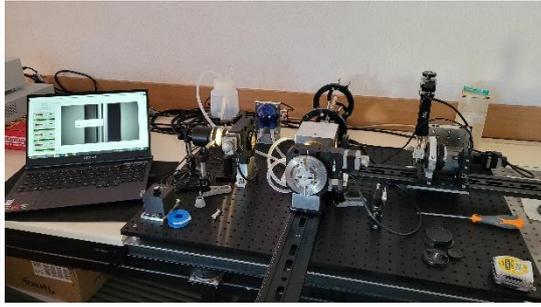


Laboratory of Thermal and Spectroscopic Analysis

Laboratory of Thermal and Spectroscopic Analysis is equipped with Netzsch STA 449 Jupiter F1 system, which enables the simultaneous acquisition of data from four analytical techniques in a single measurement. The applied instrumentation allows for coupled analysis using TG/DSC/FT-IR/MS, ensuring a comprehensive characterization of the studied materials. The laboratory specializes in the analysis of novel polymeric materials, which are evaluated for their potential application in polymer (or glass) optical fiber technology. Additionally, research is conducted on polymers doped with substances exhibiting unique properties, which can be utilized in sensor technologies. Beyond polymeric materials, the laboratory also analyzes hybrid materials, Metal-Organic Frameworks (MOFs), Zeolitic Imidazolate Frameworks (ZIFs), composite materials, and carbon-based materials. All studied substances are assessed for their potential application as broadly understood photonic materials. The laboratory is also equipped with an ATR-FT-IR module, enabling rapid analysis of both solid and liquid materials. Additionally, infrared transmission analysis is also available for more detailed characterization.

Equipment for preform characterization

York P102 Preform Analyzer permits refractive index profile measurement in the cross-section of the preform while a custom setup enables measurement of core ellipticity and internal stresses in the preform.



Tensile testing machine

The tensile testing machine has an exchangeable force sensor (one up to 100 N and one up to 2000 N) and set of sample mounts, including pneumatic jaws. The machine enables static and dynamic tests of mechanical strength and reliability of optical fibers and cables.

