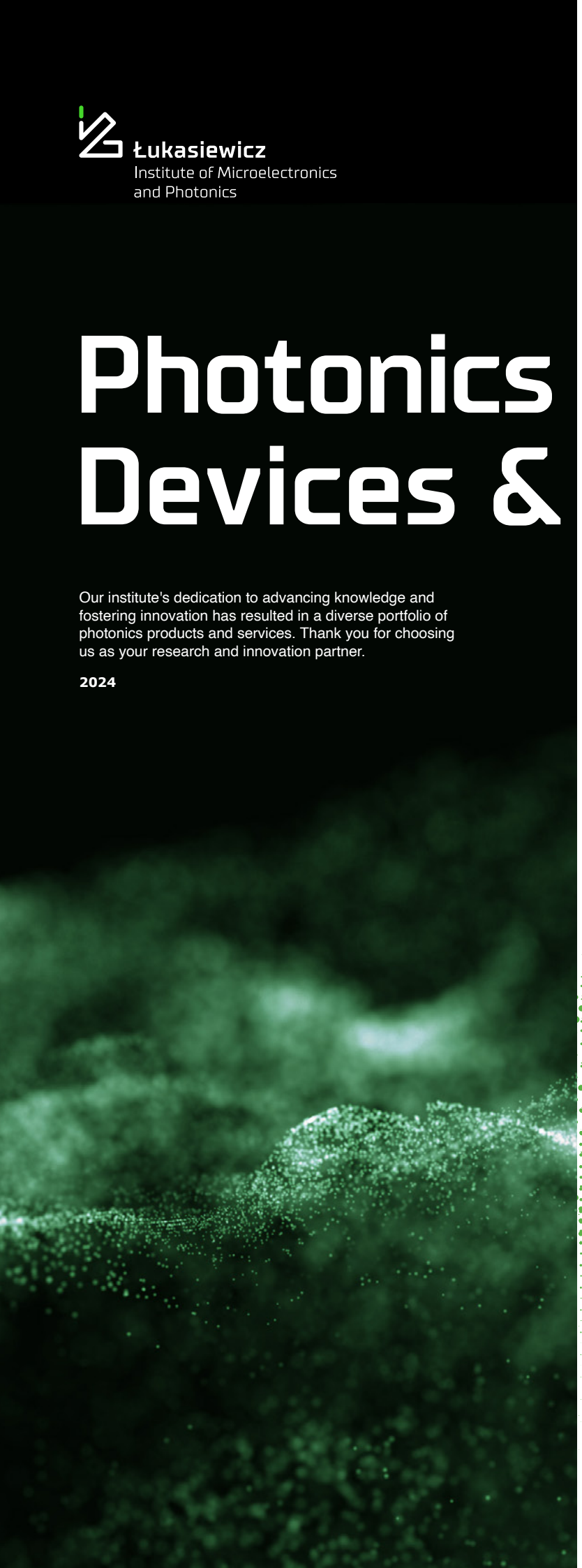
Łukasiewicz
Institute of Microelectronics
and Photonics

Photonics Devices & Services

Our institute's dedication to advancing knowledge and fostering innovation has resulted in a diverse portfolio of photonics products and services. Thank you for choosing us as your research and innovation partner.

2024

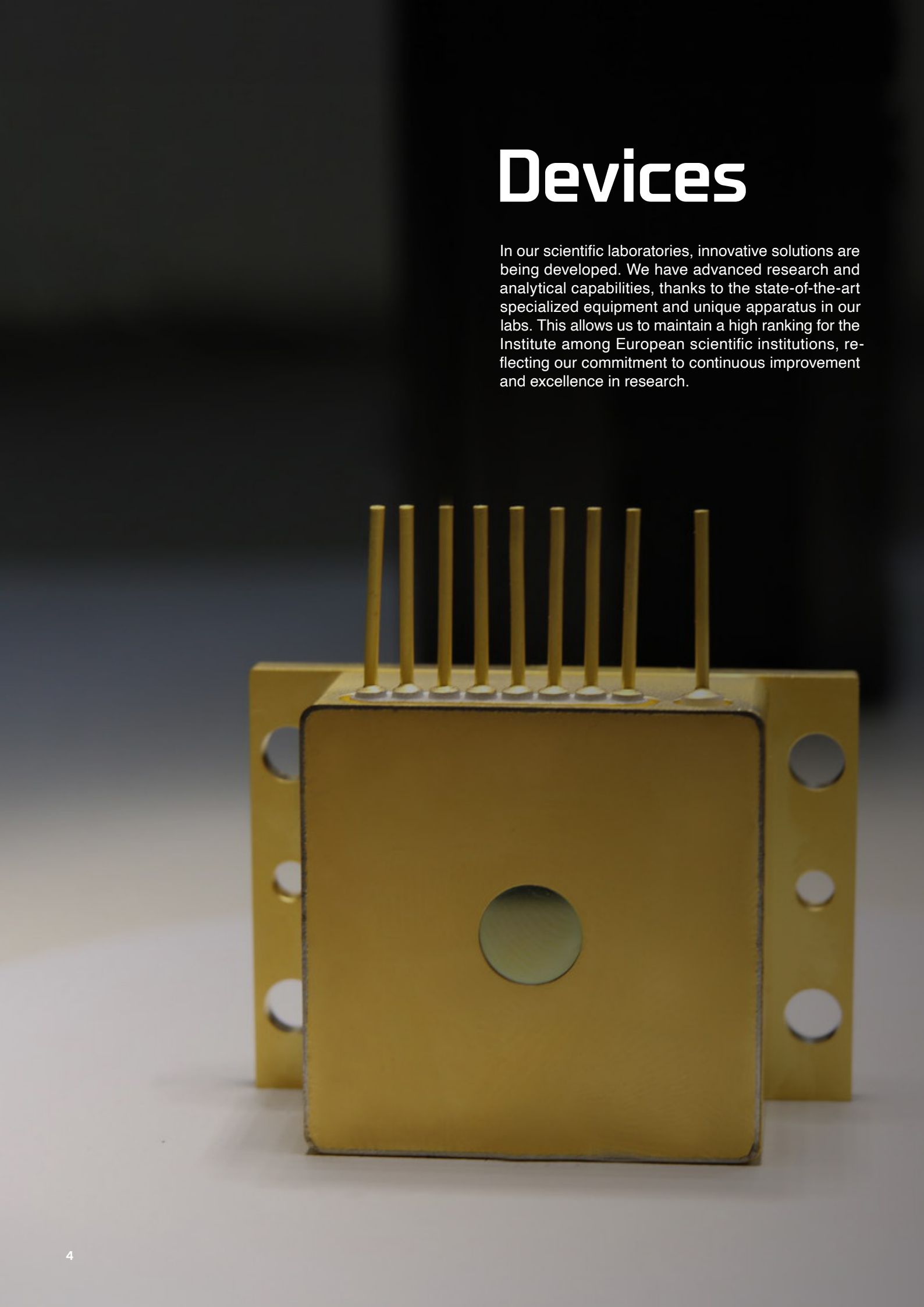


DEVICES

SERVICES

Devices

In our scientific laboratories, innovative solutions are being developed. We have advanced research and analytical capabilities, thanks to the state-of-the-art specialized equipment and unique apparatus in our labs. This allows us to maintain a high ranking for the Institute among European scientific institutions, reflecting our commitment to continuous improvement and excellence in research.



QUANTUM CASCADE LASERS

Imagine having the power to harness the full spectrum of infrared radiation, from 3 to 300μm, at your fingertips. Cascade Quantum Lasers (QCLs) make this vision a reality. These semiconductor marvels work effortlessly in both pulsed and continuous-wave modes, all while maintaining room temperature.

About

Quantum Cascade lasers (QCLs) are semiconductor infrared radiation sources with a broad range of wavelengths, from 3 to 300μm. They operate both in pulsed and continuous-wave modes at room temperature. QCLs are compact, easy to control, and allow for smooth wavelength tuning over a wide range. We produce Quantum cascade lasers in the mid-infrared range: 4.5-14 μm, as well as in the terahertz range.

Application

Defense, environmental monitoring, medicine, communication, and industry. They serve as an excellent source of infrared light for the analysis of moleculara gases and absorption spectroscopy.

MECSEL – OPTICALLY PUMPED LASER

MECSEL (Multi-Emitter Coherent Supercontinuum Sources Emitting in the Near-Infrared) represents a cutting-edge laser technology that leverages optical pumping to produce a laser beam. What sets it apart is its exceptional capability for high-power generation and superior stability when contrasted with conventional infrared light sources. Explore the future of laser innovation with MECSEL.

About

MECSEL (ang. Multi-Emitter Coherent Supercontinuum Sources Emitting in the Near-Infrared) is an advanced type of laser in which optical pumping is used to generate a laser beam. It stands out for its high-power generation and greater stability compared to conventional sources of infrared light.

Application

Medicine: Utilized in laser surgery, light therapy, and dermatology for effective tattoo removal, vascular lesion treatment, wrinkle reduction, and hair removal.

Industry: Ideal for precision cutting, welding, and marking of various materials, including metal, plastic, wood, and ceramics.

Science and Research: Crucial in spectroscopy, distance measurements, surface analysis, and photochemical studies.

Telecommunications: In optical data transmission, optical fiber communication systems, and optical telecommunication solutions.

OPTICAL FIBERS

Materials: silica, silica based or multicomponent glasses, including RE doped glasses

Structure: all-solid or air-hole

Guiding type: TIR (step-index), MTIR (microstructured optical fibers), effective medium (nanostructured optical fibers), anti-resonance AR (negative curvature fibers)

Examples: nanostructured GRIN fiber and PM fiber, ARFiber, dual-band active fiber, high NA optical bundle

PHOTONIC CRYSTAL FIBERS

Enter the world of Photonic Crystal Fibers, where light bends to the will of innovative microstructures. These extraordinary optical fibers feature a core encased in a cladding, but what sets them apart is their cladding's intricate design. Crafted with an array of air holes or capillaries arranged in a precise pattern, they give birth to a mesmerizing photonic crystal structure.

About

These are a type of optical fiber that utilize a unique microstructure in their cladding to control the propagation of light. They consist of a core surrounded by a cladding made of an array of air holes or capillaries arranged in a periodic pattern. This photonic crystal structure creates a photonic bandgap, which can prohibit the transmission of certain wavelengths of light.

Advantages:

high power delivery without the risk of fibre damage
gas sensors almost insensitive to bending

Application

- Incandescent, fluorescent, and LED lamps, which have a very broad spectrum of light and are not spatially coherent.
- Lasers, which have high spatial coherence, very high brightness, and are usually monochromatic.
- Supercontinuum sources, which provide an ultra-broadband white-light spectrum with single-mode beam characteristics and excellent pointing stability.
- Optical coherence tomography,
- Fluorescence lifetime imaging,
- Gas sensing

ANTIRESONANT FIBERS (HOLLOW CORE FIBERS)

About

Have some unique features that make them useful for various applications. One of interesting aspects of these fibers is that the resonances and transmission windows can be adjusted by filling the core with different gases or liquids. This flexibility enables the fibers to be used as gas sensors, where a single fiber can detect multiple gases. This capability opens up possibilities for creating versatile and efficient sensing systems using a single fiber for multiple gas detection.

Application

gas sensing, high-power delivery systems, nonlinear optics, fiber-based sensors, laser bram delivery

- They have large transmission windows, meaning they can transmit light across a wide range of wavelengths.
- These fibers exhibit a small intrinsic nonlinearity, which allows for the transmission of light without significant distortion or loss of signal quality.
- The hollow core of the fiber can be filled with gases or liquids, allowing for tailored properties and functionalities.

LIGHT GUIDE FIBERS

About

flexible and transparent strands or cables that are designed to transmit light signals over long distances. They are made of a core, which carries the light signal, surrounded by a cladding layer that reflects the light back into the core, ensuring efficient transmission. The core and cladding are usually made of high-quality glass.

Light guide fibers offer several advantages over traditional copper wires, such as higher bandwidth capacity, faster data transmission rates, immunity to electromagnetic interference, and longer transmission distances. They are also lightweight, flexible, and can be easily installed in various environments, including underground, underwater, and in space.

Application

Light guide fibers are used extensively in telecommunications, data networking, optical communication systems, endoscope, neurosurgery.

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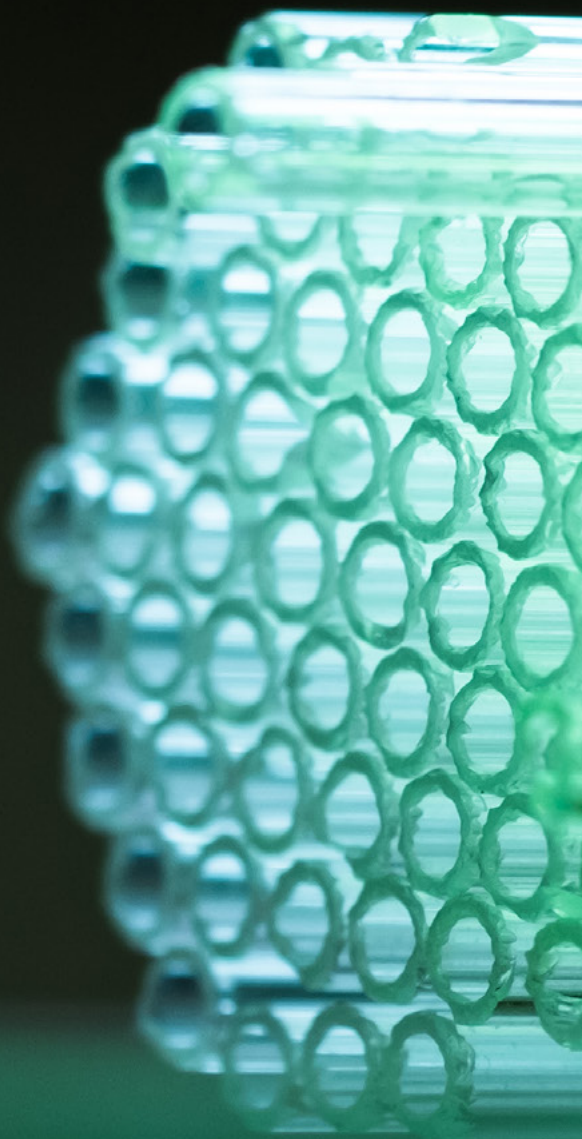
FIBER DRAWING-TOWER HALL

- 7 m high drawing tower with high-temperature
- (~2000 °C) furnace for silica based fibers two 5m high drawing towers with low-temperature
- (~900 °C) furnaces for multicomponent glass based fibers
- spooling system with diameter control and coating section
- high-resolution optical and scaning-electron microscopes



ACTIVE FIBERS

About

These are optical fibers that contain dopant materials, such as rare-earth ions, to introduce optical gain and enable active light amplification. The dopants within the fiber core are excited by an external energy source, typically a pump laser, which causes them to emit light at specific wavelengths. This amplification of light within the fiber allows for the generation of high-power lasers and the amplification of optical signals.

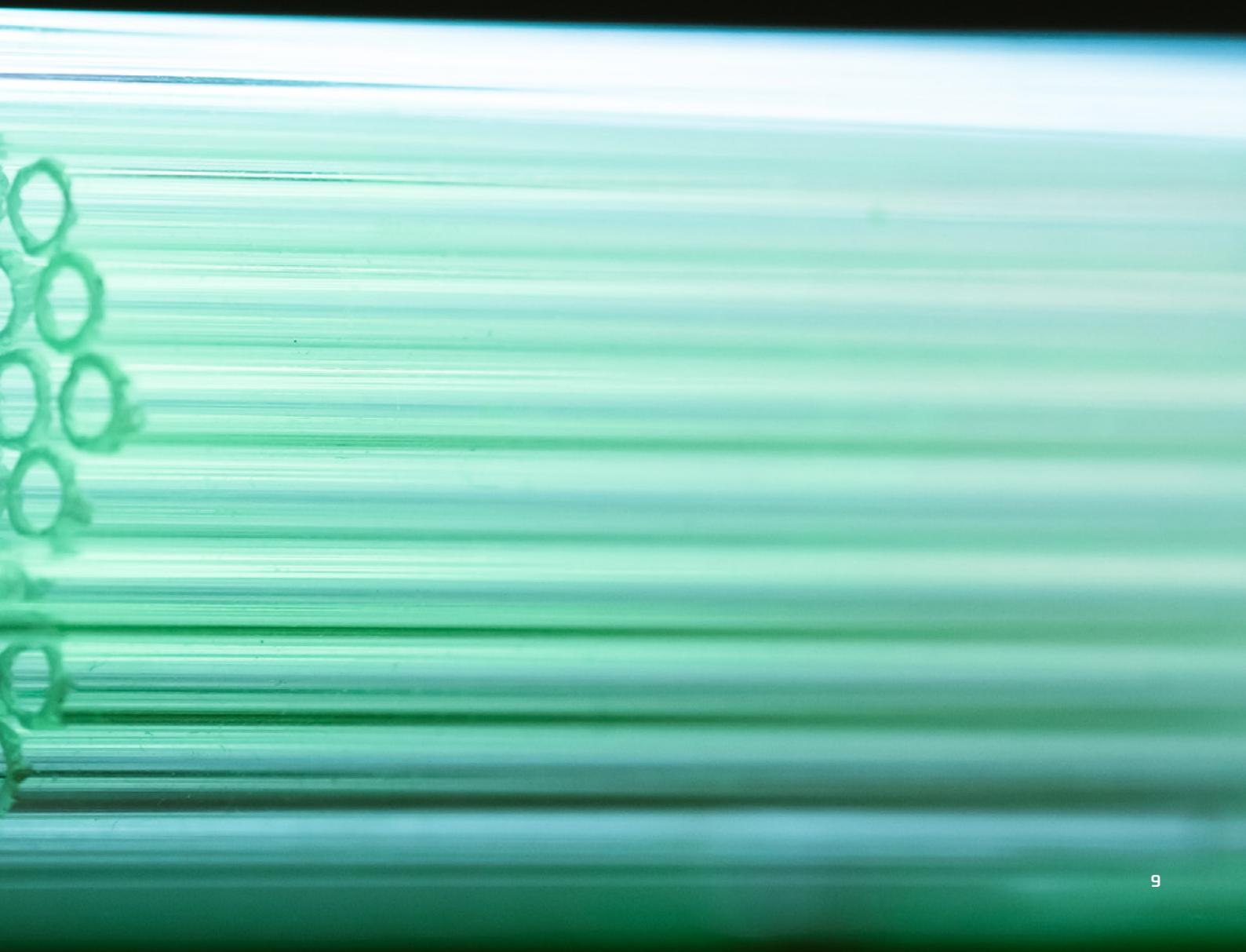
They offer advantages such as high gain, low noise, and efficient signal amplification. The dopant materials used in active fibers, such as ytterbium (Yb) provide different gain characteristics and operating wavelengths, allowing for flexibility in designing fiber-based devices for specific applications.

This fiber concept offers future prospects for arbitrary design of refractive index, gain profile, and photosensitivity. It allows for creating specialty fibers for beam shaping, birefringence, controlled dispersion, and more.

With this fiber, we can effectively manage the refractive index profile, control gain for different modes, incorporate multiple active ions for dual-wavelength lasers, and design large mode area Bragg gratings with enhanced photosensitivity. All these capabilities are combined in a single optical fiber, offering various possibilities for advanced applications.

Application

Telecommunications, laser systems, fiber amplifiers, and optical sensing.



OPTICAL VORTEX MASKS

About

These are optical elements that shape light beams by introducing a helical phase distribution. They create a unique doughnut-shaped beam with no light in the center. However, traditional vortex elements are typically large or have non-parallel surfaces, making it difficult to integrate them into fiber systems. Moreover, their performance is influenced by the refractive index difference between the element and the surrounding medium, resulting in variations when used in different environments like gases or liquids.

To address these challenges, we have developed a fabrication method that allows us to create flat-parallel optical vortex elements. These elements can be easily integrated into optical fiber systems and maintain their performance even in liquids, including water. Unlike traditional vortex elements, our nanostructured fabrication technique involves changing the refractive index within the material itself, achieving the same desired results.

Application

These twisted light beams have found applications in optical trapping and manipulation of microscopic particles, high-capacity optical communications, optical microscopy, and quantum optics. They offer unique properties for studying light-matter interactions and have the potential to enable new technologies in optical communication, imaging, and sensing.

GRIN LENSES

About

These lenses work by changing the refractive index inside the lens, creating a refractive index profile similar to a traditional lens. By cutting the lens to different lengths, we can achieve lenses with varying properties.

GRIN lenses composed of low and high refractive index glass rods can have different optical properties depending on the materials used. They can be designed with a flat and parallel shape, similar in diameter to optical fibers. For example, we have created 469 GRIN microlenses with a diameter of 20 µm and a fill factor of 100%. Multiple lenses or other optical elements can be stacked together and drawn in a fiber drawing tower to create lens matrices easily.

Application

Adaptive optics technology – they are used in astronomy to measure telescopes and in medicine to characterize eyes for treating complex refractive errors in the cornea. Adaptive optics involves real-time measurement, reconstruction, and reshaping of the wavefront phase to correct for aberrations.

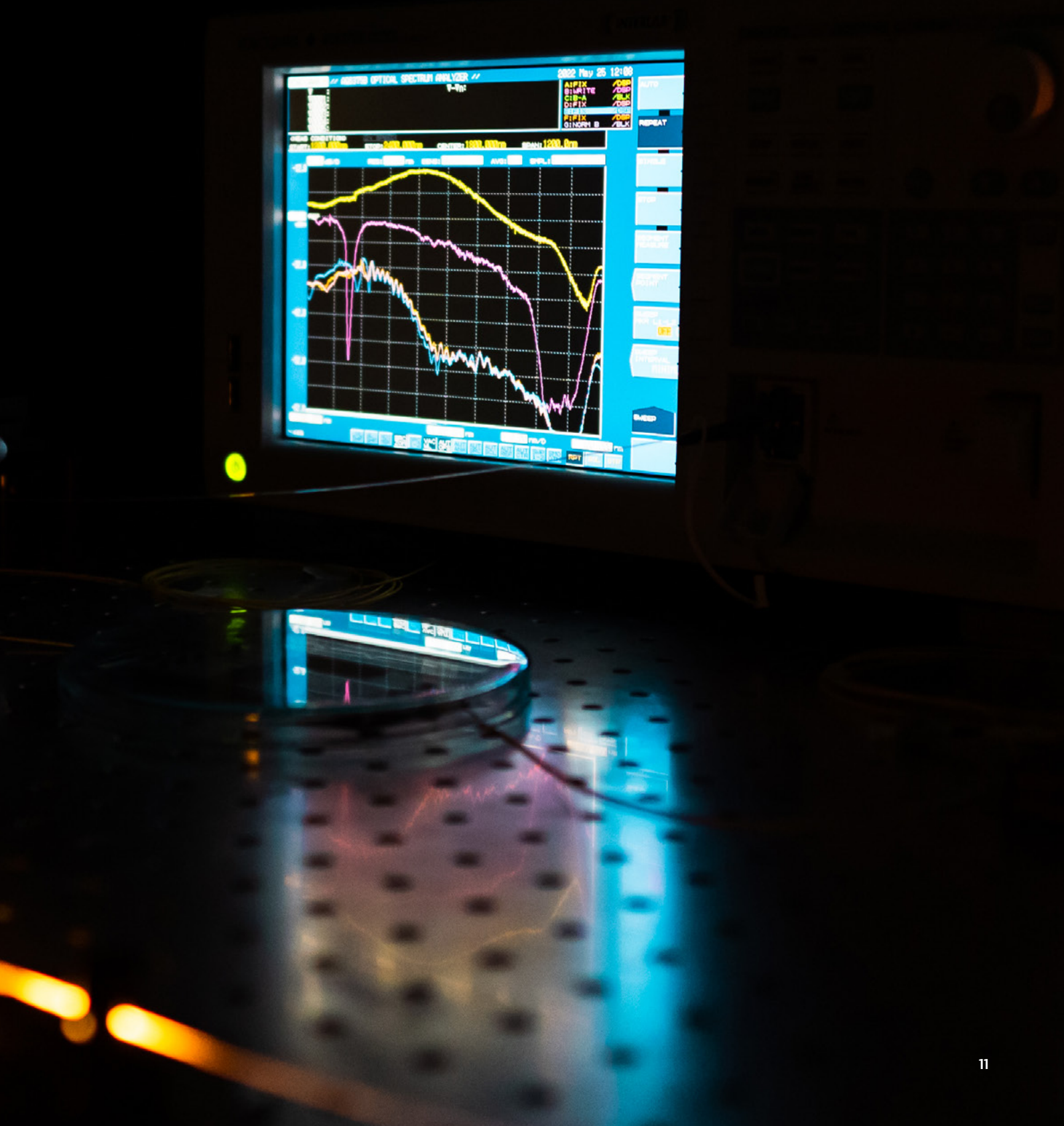
OPTICAL MICROCOMPONENTS

Technology

Nanostructuring or hot-embossing

Examples

Microlens and microlens array, phase microcomponent (OAM), diffractive optics, MidIR lens



Services

The strength of our Institute lies in our staff - accomplished researchers who excel in various scientific disciplines. Their achievements include hundreds of publications in top global scientific journals, dozens of patents, including international ones, and participation in prestigious scientific projects.

PRECISION SOLDERING OF OPTOELECTRONIC CHIPS

About

FINEPLACER PICO is an advanced device for the precise positioning of electronic components with small spacings, such as BGA, CSP, Flip Chips, and "Flip Chip" sets, optoelectronic components, microelectronic systems (MEMS), sensors, micro-optics, TAB, and other SMD components. The device offers positioning accuracy at the level of 5µm. Additionally, FINEPLACER PICO enables the precise assembly of electronic components and their soldering in air and/or nitrogen atmosphere according to a specified temperature profile.

Application

Due to its versatility, it finds applications in various fields where precise positioning and assembly of electronic components are required.

OPTICAL ELEMENT COUPLING (PIGTAILING)

About

The pigtailing mounting station is a precise tool that enables the accurate and stable connection of optical fibers to these components, ensuring efficient light transmission and optimal performance.

Application

Used in the process of connecting optical fibers to optical components such as laser diodes, cascade lasers, or laser chips.

RTA/RTP ANNEALING

About

The AccuThermo AW-610 rapid thermal processing system allows for precise annealing of samples at temperatures up to 900°C with precise temperature control (+/-1°C). Various gas environments with adjustable nitrogen flow are available. The maximum temperature ramp rate is 100°C/s, and the maximum substrate diameter is 4 inches. Annealing temperature stability is maintained at 1°C.

Annealing processes are crucial for preparing various electronic and optoelectronic structures, where they can modify the properties of individual elements through dopant diffusion or recrystallization.

Application

For creating electrical contacts in semiconductor structures and preparing substrates before various crystal growth, layering, and nanostructure processes.

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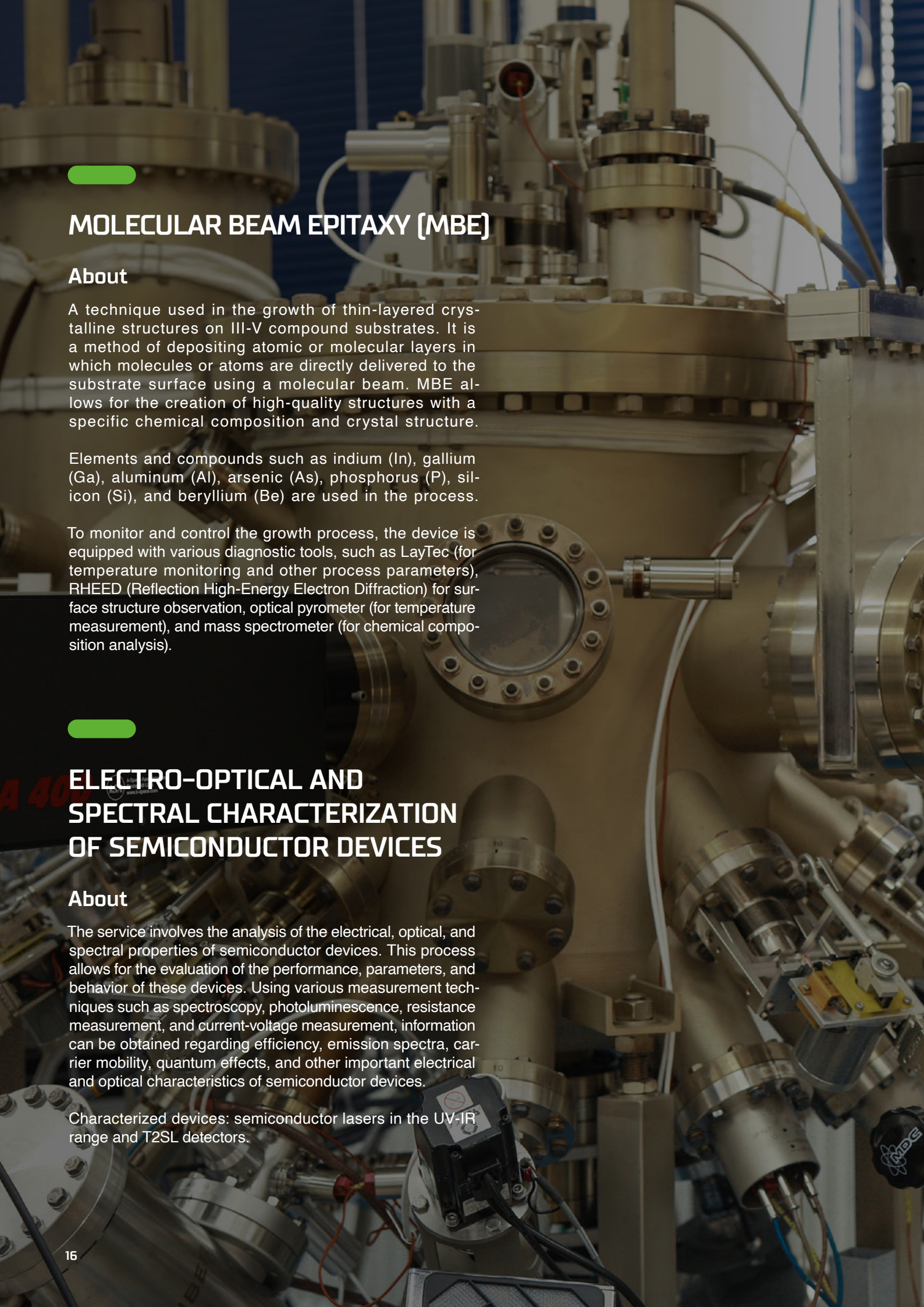


MOLECULAR BEAM EPITAXY (MBE)

About

A technique used in the growth of thin-layered crystalline structures on III-V compound substrates. It is a method of depositing atomic or molecular layers in which molecules or atoms are directly delivered to the substrate surface using a molecular beam. MBE allows for the creation of high-quality structures with a specific chemical composition and crystal structure.

Elements and compounds such as indium (In), gallium (Ga), aluminum (Al), arsenic (As), phosphorus (P), silicon (Si), and beryllium (Be) are used in the process.

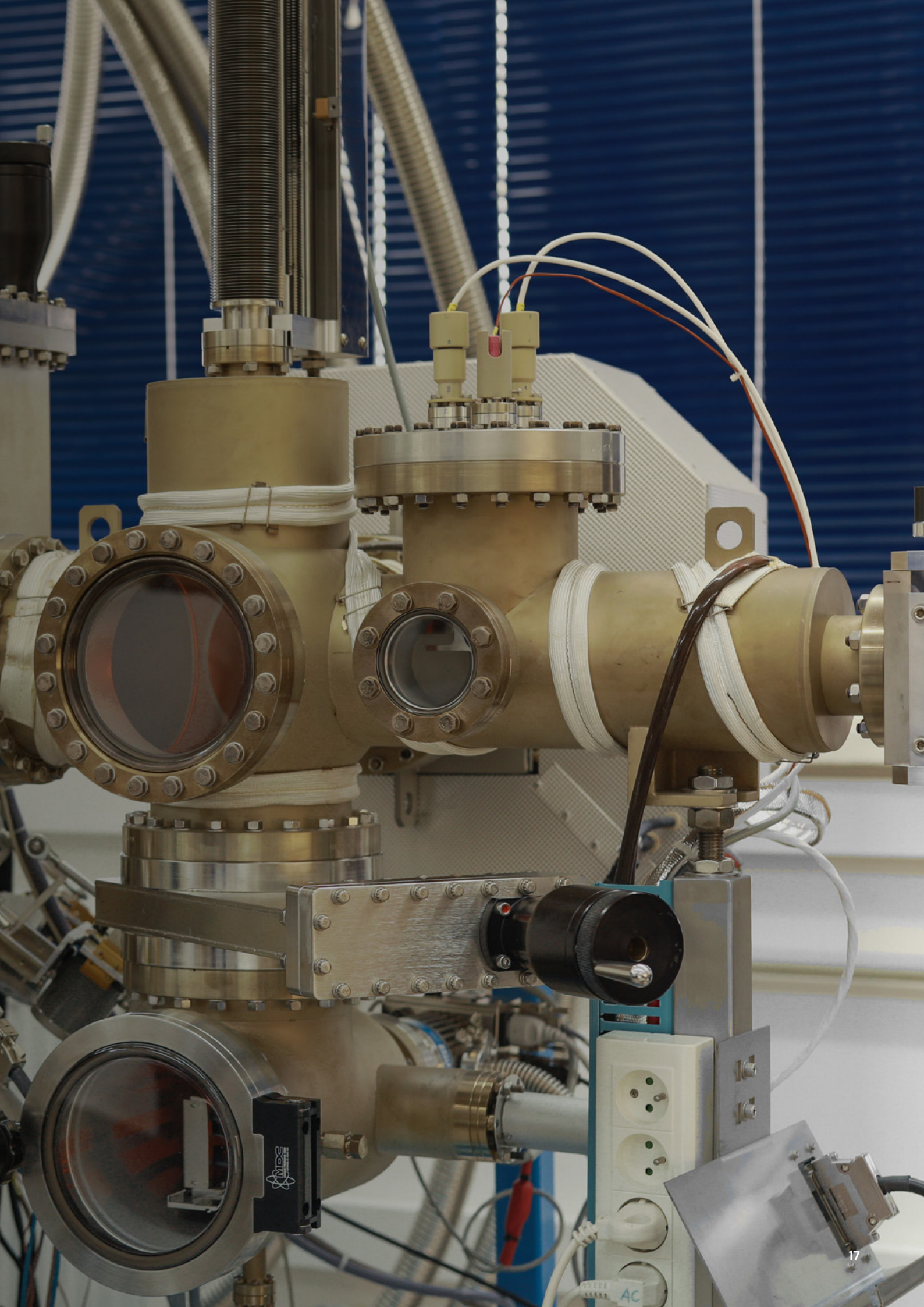
To monitor and control the growth process, the device is equipped with various diagnostic tools, such as LayTec (for temperature monitoring and other process parameters), RHEED (Reflection High-Energy Electron Diffraction) for surface structure observation, optical pyrometer (for temperature measurement), and mass spectrometer (for chemical composition analysis).

ELECTRO-OPTICAL AND SPECTRAL CHARACTERIZATION OF SEMICONDUCTOR DEVICES

About

The service involves the analysis of the electrical, optical, and spectral properties of semiconductor devices. This process allows for the evaluation of the performance, parameters, and behavior of these devices. Using various measurement techniques such as spectroscopy, photoluminescence, resistance measurement, and current-voltage measurement, information can be obtained regarding efficiency, emission spectra, carrier mobility, quantum effects, and other important electrical and optical characteristics of semiconductor devices.

Characterized devices: semiconductor lasers in the UV-IR range and T2SL detectors.



PHOTONIC DEVICE PROCESSING TECHNOLOGY

About

Services related to the production of photonic structures include photolithography, etching, sputtering, deposition of metal and dielectric layers, die bonding, wire bonding, and encapsulation of structures.

The available technological infrastructure enables comprehensive support from the concept and design stage through prototyping to small-scale production. The services are primarily aimed at small and medium-sized enterprises that require the development of specialized devices for specific applications.

Lithography: Various lithographic techniques such as UV lithography, X-ray lithography, or electron beam lithography (EBL) are used to create structural patterns on semiconductor materials.

Surface cleaning and preparation: Before the deposition of material layers, substrate surfaces are cleaned and prepared to ensure optimal adhesion conditions and interface quality.

Layer deposition: Various layer deposition methods such as molecular beam epitaxy (MBE), chemical vapor deposition (CVD), electron beam deposition (EB), plasma-enhanced chemical vapor deposition (PECVD), etc., are used to create layers with specific chemical compositions and structures.

Lithography and microstructural techniques: Using lithographic techniques and chemical or reactive etching, microstructures such as trenches, slots, masking layers, light windows, and other structures necessary for the operation of photonic devices can be created.

Metallization and contacting: This involves the deposition of metallic layers such as gold, copper, or aluminum to create electrodes, contacts, and electrical connections with photonic elements

LUMINESCENT POWDERS (PHOSPHORS)

About

Luminescent powders based on matrices such as YAG, YAP, YAM, NAP, Y2O3, Nd2O3, Al2O3 doped with rare earth ions (e.g., Nd, Er, Eu, Yb, Pr, Sm, Ho, Tm, Tb) can be used as phosphors or as the active phase in polymer composites. For example, YAG:Er generates a wavelength that is safe for the eye and can be used in many applications where human vision is exposed to damage, whereas Y2O3 doped with rare earth ions can be used as a phosphor in optical light-emitting displays.

They are based on matrices such as Y3Al5O12 (YAG), YAlO3 (YAP), Y4Al2O9 (YAM), NdAlO3 (NAP), Y2O3, Nd2O3, Al2O3. They are doped with rare earth ions such as Nd, Er, Eu, Yb, Pr, Sm, Ho, Tm, Tb. They can serve as phosphors or active phases in polymer composites. Or as luminescent markers.

Application

YAG:Er generates eye-safe wavelengths and can be used where human vision is at risk of damage (telemetry, security systems, and motion detectors). On the other hand, Y2O3 doped with rare earth ions can be used as a phosphor in optical displays.

ANTIMONIDE STRUCTURES

About

Discover our expertise in cutting-edge epitaxial structures and advanced infrared detection technologies. Our focus is on heterostructures and devices based on III-V compounds containing antimony, particularly type II superlattices, and their characterization, as well as flip-chip bonding using indium bump interconnections. With our profound knowledge in epitaxial growth, characterization (HRXRD, PL, Hall, I-V, C-V, RI), and bonding, we are poised to provide tailor-made solutions that cater to your specific research and business needs within the realm of infrared detection and its related applications.

Application

Phosphor, high-power white light source, or nonlinear absorber.

FLUORIDE GLASSES

About

The technology allows for the production of oxygen-free ZBLAN fluoride glasses, whose name is derived from the first letters of the used fluorides: ZrF4, BaF2, LaF3, AlF3, and NaF. To ensure high-quality glasses, the melting process takes place at a controlled temperature and in a protective atmosphere within special glove-box chambers.

ZBLAN glasses are characterized by high transmittance in the range from ultraviolet to mid-infrared, as well as a low refractive index, both linear and nonlinear. It is possible to customize the shape of the glasses according to the individual requirements of the customer.

Oxygen-free glass with broadband transmission from UV to NIR optical range. This glass type has low linear and nonlinear refractive index value.

OPTICAL GLASSES

About

Reach for glass tailored to your application. The parameters that we optimize include: glass transition temperature, melting point, thermal expansion coefficient, transmission range, linear and non-linear refractive index, glass doping level, e.g. with rare earth ions, and glass absorption coefficient (for glasses intended for optical filters).

The produced glasses can be mechanically processed, including cutting, rounding, grinding and polishing, to obtain the required shapes and dimensions of the material, depending on the application.

YAG TRANSPARENT CERAMICS

About

YAG ceramics, based on yttrium aluminum garnet, doped or co-doped with rare earth ions and transition metals, can be utilized as optically active materials. It is possible to introduce various rare earth elements, such as Nd, Yb, Ce, Tm, Er, Ho, Eu, Dy, Pr, Sm, Tb, as dopants.

Key characteristics include high chemical and thermal resistance (melting temperature of 1970°C), low porosity (density of 4.55 g/cm^3), high hardness (8.5 on the Mohs scale), thermal conductivity (11 W/mK), and a coefficient of thermal expansion of 7.8 x 10^-6/°C.

Samples with diameters up to 15 mm are readily available - marked with a circle, indicating special recognition.

Application

As a laser material

HMO GLASS & TELLURITE GLASS

About

High thermal stability glasses dedicated to NIR and MIR optical range. Perfect for multiple heat treatment of hot-embossing process. Glasses have high linear and nonlinear refractive index value.

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