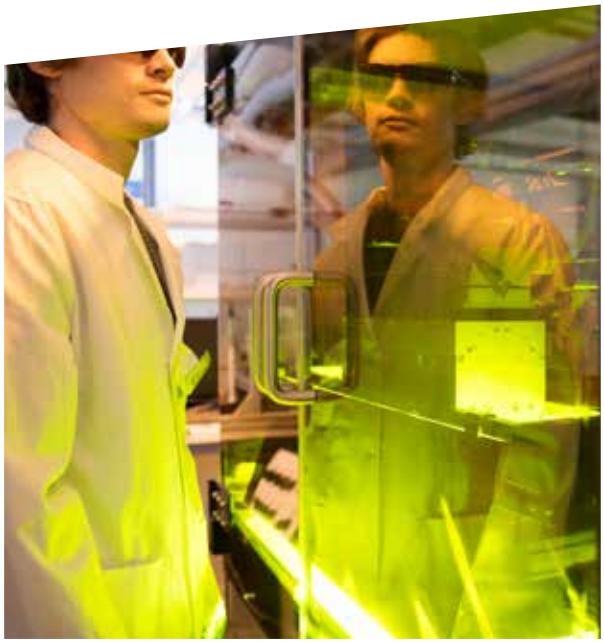
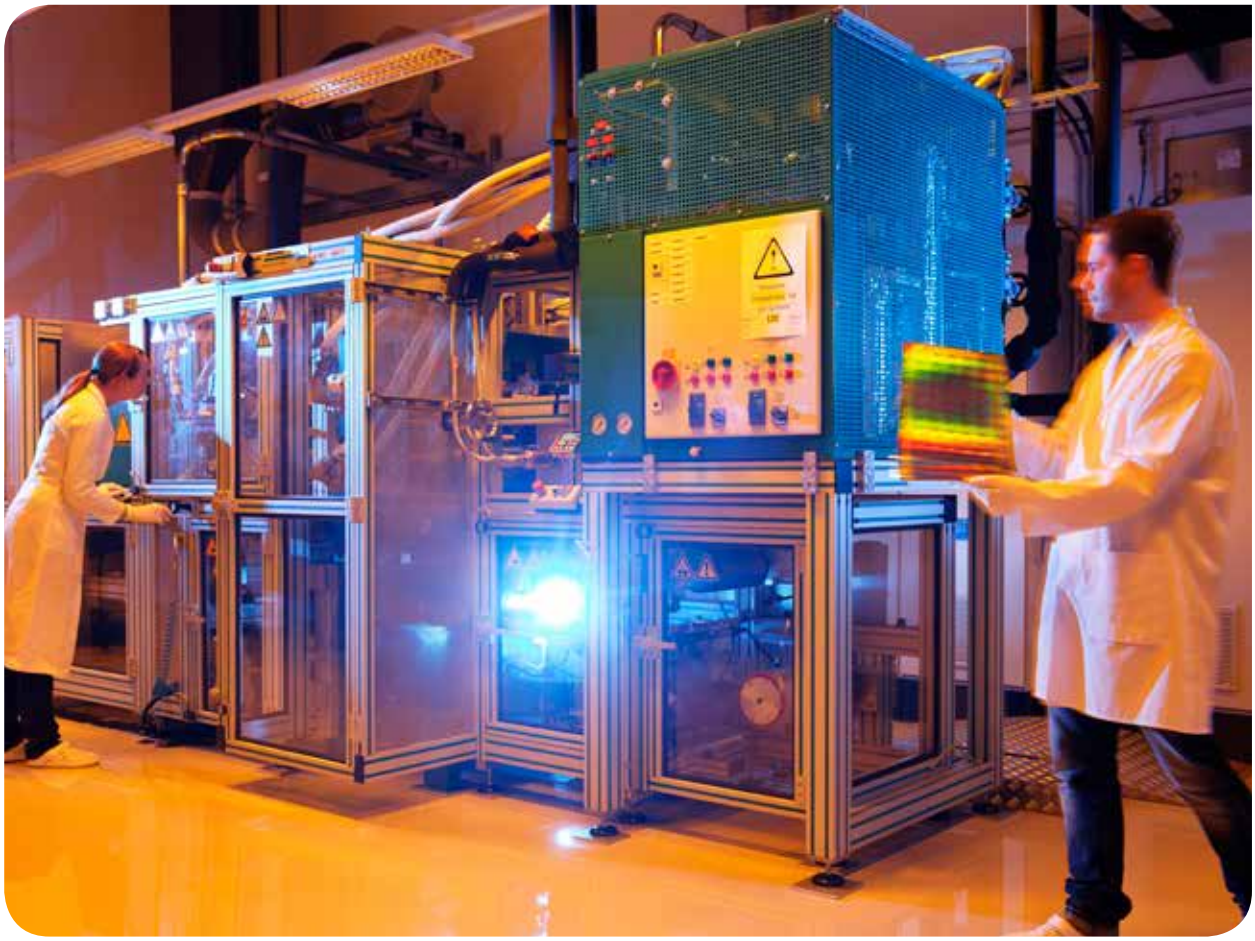
JOANNEUM RESEARCH MATERIALS

MATERIALS

Institute for Surface Technologies and Photonics



THE INNOVATION COMPANY



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MATERIALS – Institute for Surface Technologies and Photonics

We are the first point of call for technology and process development in the following areas:

- **Hybrid electronics and patterning**
  - Organic electronics
  - PyzoFlex®
  - R2R printing and mastering
- **Light and optical technologies**
  - Optics: design and production
  - Photovoltaics
  - Lighting
- **Smart connected lighting**
  - Smart electronic systems
  - Human-centric technologies
  - Systems of systems: communication and connectivity
- **Laser and plasma technologies**
  - Laser processing
  - Plasma surface technologies
- **Sensors and functional printing**
  - Additive manufacturing, processing and printing
  - Biosensors and microfluidics

Your benefit

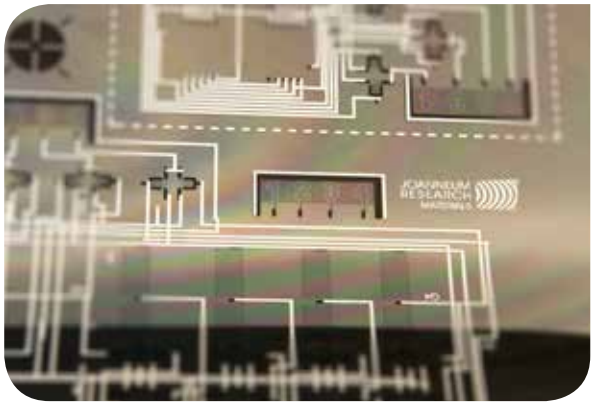
We offer latest technologies for the development of innovative products and services.
We have long-term experience in managing a wide range of research cooperations, thus enabling our clients to successfully participate in nationally and internationally funded research projects.
Our applied research and development complies with the manufacturing industry.

ISO 9001:2015 certified

Our offer

More than 80 researchers work on interdisciplinary solutions across the entire value chain – from the idea to the prototype. Cutting edge technologies and methods based on miniaturisation, integration and materials optimization are used. Combined with state-of-the-art equipment and infrastructure we offer innovative solutions and services tailored to the needs of business and industry.
More than 20 years of close cooperation with leading national and international research institutions enable us to continuously improve and extend our portfolio of expertise.

Our expertize has recently expanded by the establishment of a new research group „Smart Connected Lighting". This research group focuses on the "connected and funcional lighting" and optimizes existing synergies for our customers.



Hybrid electronics and patterning

We apply innovative structuring methods for the development of flexible micro-and nanostructured films on large scale. We research on integrated components for organic electronics, printed physical and biological sensors, large scale opto-electronics and bionic functional foils. These are used in light, medical and packaging technology, consumer electronics, the transport industry, intelligent building services and industrial manufacturing. The combination of complementary patterning processes enables the development of innovative technologies in the field of: interactive surfaces, human-machine interfaces, nano-structered surfaces with special decorative, optical, energy-saving, cleaning, adhesive functionalities, micro-fluidic structures. Furthermore our portfolio includes the development of customized process materials, specifically multifunctional, adaptable UV-curing embossing resins for various application areas.

Organic electronics

- Cost-effective production of organic-electronic components and circuits on flexible substrates

PyzoFlex®

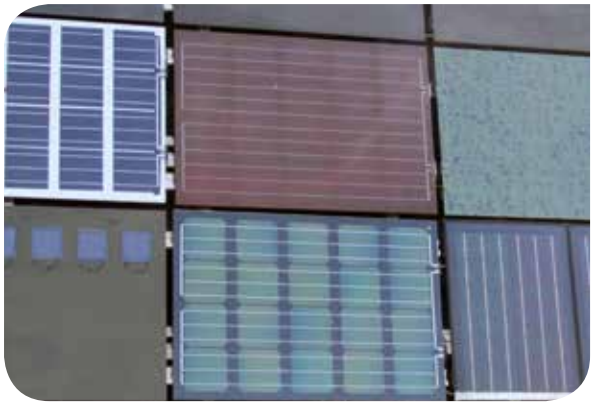
- Piezo and pyroelectric sensor technology and energy harvester
- State-of-the-art assembly and connection technologies for hybrid electronics

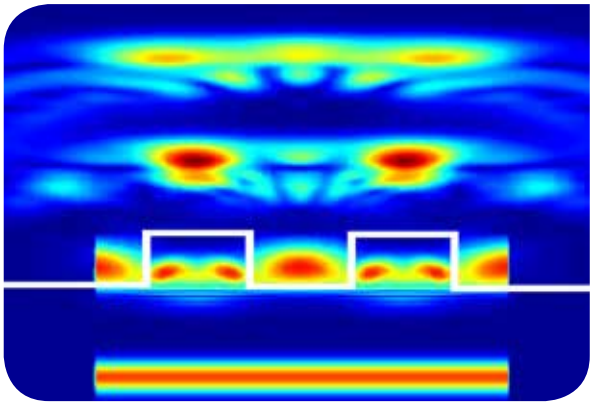
Roll-to-Roll (R2R) Printing and Mastering

- High-precision R2R UV-nanoimprint lithography, R2R hot embossing for micro and nanostructuring of foil-based materials and functional coating systems
- Step & repeat UV-nanoimprint system for seamlessly structured (R2R) embossing stamps
- Maskless grayscale laser lithography for micro and nanostructures (master)
- UV-imprint resins family NILcure

Nanotechnologies on macrosurfaces

With our innovative R2R embossing facilities we can consistently produce structures dimensioned at less than 200 nm on foil substrates with a high throughput rate, which allows us to quickly and precisely realise very fine structures on large surfaces in near-production procedures.





Light and optical technologies

The focus of our work is on the use of the “tool of light”. This involves the design and simulation of complex optical components, their fabrication using precisely targeted material processing and structuring methods in the micro and nanometer range as well as the inspection of the fabricated components. Our portfolio includes the following:

Optics – Design and manufacturing

- Covering the whole process chain of optics fabrication: Design ⟷ Simulation ⟷ Mastering ⟷ Manufacturing
- Design and calculation of foil based optics, freeform microoptics, diffractive and refractive optical elements
- Virtual prototyping by means of optical simulation (ASAP, Zemax, FDTD Solutions, VirtualLab)
- Production of microoptics (mastering and replication)
- Their use in optical and photonic systems such as lighting, photovoltaics and optical sensor technology

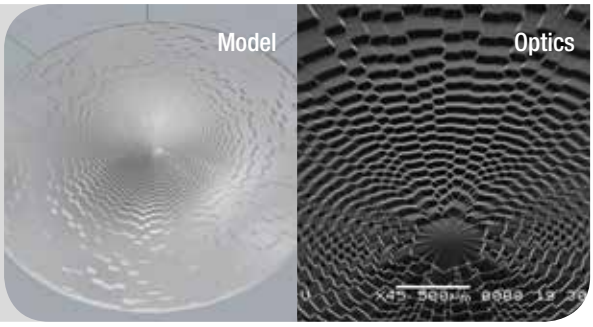
Laser – micro and nanoprocessing

- Laser ablation, drilling, lift-off
- Laser sintering of printed electronic contacts
- Laser structuring for the realisation of optical light control structures in solids (such as metals and glassy materials)
- Laser lithography in polymer resins (including twophoton absorption)
- Functionalization of surfaces (hydrophilicity/hydrophobicity)

Photovoltaics and optoelectronics

- Further development and efficiency increase of established (silicone or CIGS-based) and prospective (e.g. OPV, perovskite) photovoltaic technologies
- Intelligent light control in PV modules or optoelectronic components
- Efficient coloration of solar cells and solar glasses for building-integrated photovoltaics (BIPV)
- LED and LD technology (phosphorus conversion, service life models, reliability analyses, etc.)

Our comprehensive **simulation and rapid prototyping** tools allow us to simulate and create optical structures on a broad range of length scales.



Smart Connected Lighting

We focus on the realisation of comprehensive light and illumination concepts including sensor technology, control and regulation systems, connectivity and communication. This research area reflects the international trend towards connectivity and digitalization, which uses luminaires and the light infrstructure as the core of the whole connected systems. This trend towards “connected and functional lighting” finds its application in the areas of building controls (smart buildings), smart cities, human centric lighting (e.g. circadian rhythms), technical environments (e.g. production lines), automotive and agriculture (smart farming).
Required sensors and communication components are more and more directly integrated in the light infrastructure. Thus, the light infrastructure becomes the artery of connected living and production worlds and the speech centre of the Internet of Everything with a language that interconnects humans, objects and data and enables communication between them. According to the analysis of some futurologists, this language will soon become the most widely “spoken” language in the world.

We perform research for smart connected lighting in the following areas:

- Smart electronic systems
- Human-centric technologies
- Systems of systems: communication and connectivity

Smart Connected Lighting
We develop innovative connected lighting solutions for the living, working and production worlds of today, tomorrow and beyond.

Laser and Plasma Processing

We develop processes for the laser processing of materials and the plasma-assisted treatment and coating of surfaces for industrial applications. The main technologies in this respect are those for which a thorough knowledge of materials science as it relates to materials characteristics is decisive with a view to the development of processes and possible application fields.
Our expertise is based on experience garnered over the last two decades and is related to:

Laser manufacturing technology

- Laser welding
- Laser alloying
- Laser cladding
- Additive Manufacturing of metallic components with 3D printing (LPBF Laser powder bed fusion) and LMD (Laser metal deposition)

Plasma surface technologies

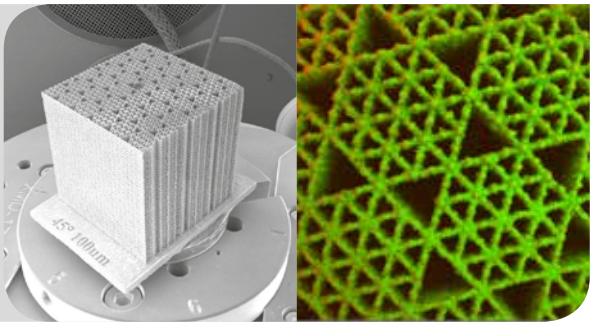
- Laser- and plasma-assisted vapour deposition techniques: Physical Vapour Deposition PVD/Pulsed Laser Deposition PLD, Plasma-Assisted Chemical Vapour Deposition PACVD (e.g. plasma polymerization)
- Low-temperature coating methods
- Plasma activation and plasma cleaning
- Atmospheric-pressure plasma coating

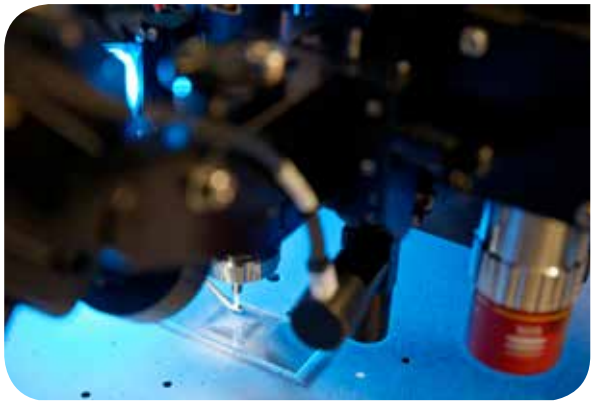
What we offer

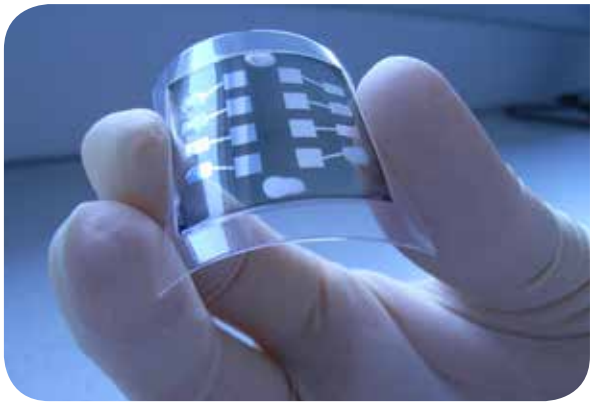
- Process development for industry
- Support during the creation of system concepts and transition from processes to mass production
- Process optimization and quality assurance following successful implementation in mass production
- Advice on questions regarding materials, design and layout

Medical technology

3D printing and subsequent surface coating is an increasingly important topic within medical technology. We develop haemocompatible coatings for a new generation of heart valves, antibacterial and osteoinductive coatings for spine implants and barrier layers for implantable electronic actuators and sensors.







Sensors and Functional Printing

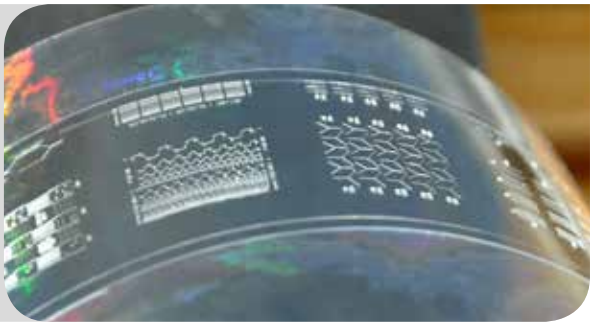
We develop chemical sensors and biosensors as well as new printing techniques. In doing so, we adopt a systematic approach starting from the development of new types of materials for sensory applications, encompassing additive manufacturing processes and concluding with electronics development and instrumentation for measurement systems. The development of new printing methods is centred on process and application development.

- The application fields of chemical sensor and biosensor technology lie above all in process engineering and biotechnological process control, bioanalysis and medical diagnosis, environmental analysis and food technology.
- We develop digital printing methods such as aerosol jet or inkjet printing for printed electronics and optics for the discrete and resource-efficient coating of materials with a wide range of chemical and physical properties at the micrometer level.
- By drawing on different printing technologies and ink systems and in combination with suitable processing methods, our aim is to research and create new applications in fields such as the automotive industry, sensory technology or signage.

Our wide-ranging expertise in the fields of materials development, surface chemistry, micro- and nano-structuring as well as optics and electronics enables the comprehensive development of complex complete systems and tailored manufacturing processes:

- Design and dimensioning
- Development of innovative sensor materials and ink systems
- Development of printing systems and processes suitable for industrial applications such as inkjet, aerosol jet, screen printing or flexography
- Development of prototypes and electronic instrumentation

Microfluidic systems on synthetic foils for bioanalysis
Microfluidic systems form the basis of integrated diagnostic chips and enable the manufacture of extremely compact analysis and sensor components. Our involvement in this respect concerns the creation of large-scale manufacturing methods for microfluidic structures on foils.



JOANNEUM RESEARCH MATERIALS

Pilot lines for Advanced Manufacturing

Consulting → Materials and processes → Prototypes → Pre-production series → Pilot production

We offer pilot lines for

- Roll-to-roll micro- and nano-structuring
- Sensor systems
- Lab-on-a-chip devices
- Functional thin films
- Laser production
- Printed and flexible electronics
- Optical components

Our pilot lines are designed to help our customers implement new innovations and products from idea to prototype and enable them to develop the necessary production methods. Our institute provides state-of-the-art infrastructure along with specialized operators as well as expertise in numerous technical and scientific disciplines.

The utility of a pilot line from the point of view of our customers lies in its ability to bridge the gap during the often difficult transition phase from research to market readiness.

Pilot lines for advanced manufacturing

Roll-to-role (R2R) pilot line for micro- and nanostructuring

The industrial implementation of high precision micro- and nanostructures requires technologies that deliver maximum resolution with optimal quality at medium to high throughput rates. MATERIALS runs a unique R2R pilot line based on UV-nanoimprint lithography and hot embossing processes for the refinement and functionalization of flexible foils, which consists of 4 modules and is continuously being expanded:

- R2R-coating
  - Corona pre-treatment and contactless cleaning of both web sides
  - Web coating of foils with photo-curable and hot embossing resins, conductive or coloring ink by gravure printing, slot-die or two-roller coating
  - Layer thicknesses in the range of 0.2 – 100 µm
  - Resolution for gravure printing, approx. 50 µm

- R2R nanoimprint lithography:
  - Micro/Nanostructuring of UV-curable resin layers with lateral resolution down to 50 nm and structural depths up to 80 µm
  - Hot embossing of thermoplastic layers with lateral structural dimensions between 0.5 – 100 µm
  - Development of multifunctional UV curable resins (NILcure)

- R2R wash and lift-off plant
  - Cleaning/development of foils coated with exposed photo resins
  - Spray nozzle supported lift-off of water-soluble photo and imprint resins

- R2R biofunctionalization
  - Printing of bio- and sensor molecules on pre-treated foil surfaces by means of microarray spotting (optional corona pre-treatment)
  - Biofunctionalization (parallelized print heads for up to 7 different sensor materials)
  - Stop & go operation
  - UV-curing

R2R metallization can be carried out by company partners.

General specifications of the R2R pilot line

- Various foil substrates (PET, PS, PMMA, PVC, adhesive foils)
- Up to 300 mm web width
- 0.5 – 30 m/min web speed or stop & go operation
- ISO 7 cleanroom classification laminar flow box

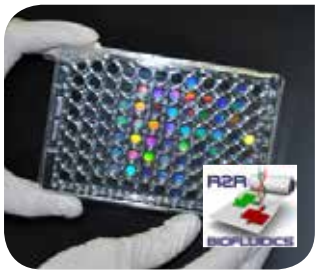
Typical applications of the R2R pilot line

- Foils with biomimetic surfaces with the following exemplary characteristics: liquid-repellent, liquid transporting, drag reducing, anti-reflective, adhesive
- High-resolution metal structures and fine metal grids for transparent flexible electrodes
- Foil-based microfluidics and bio functionalization for various medical diagnostic applications
- Flat optical structures (e.g. grids, lenses, freeform micro optics, scattering foils) for light management in luminaires, sensor technology or photovoltaics

Reference projects

3D-MEOD – 3-dimensionally moulded electro-optical device

A prototype of a modern 3D-human-machine-interface has been developed in the FFG-funded project 3D-MEOD (www.3d-meod.at). Within the project consortium of 14 industrial and scientific partners the whole value chain from conceptional design to prototype was covered. A 3D-seamlessly integrated backlit sensor was realized mainly by means of screen printing, pick and place and high-pressure forming.



R2R Biofluidics – Large-scale manufacturing of bioanalytical components by means of roll-to-roll (R2R) micro and nanoimprints

Two demonstrators are being developed in the H2020 project R2R Biofluidics (www.r2r-biofluidics.eu): an in-vitro diagnostic chip that can directly be used with the patient at the doctor´s place (point-of-care diagnostics) and a demonstrator for easy screening in drug development. The demonstrators feature micro- and nanostructured channels and reservoirs that are interconnected amongst each other with specially functionalized surfaces in order to control and align the growth of neurons and thus improve and accelerate the impact assessment of medications.

RSA Green Photonics – for a sustainable use of light

In the Research Studio Austria project "Green Photonics" we are working on innovative solutions for customized microoptical structures for targeted light control in the application areas of lighting, optical sensor technology and light-energy conversion. For these areas algorithms for the design and optimization of diffractive, refractive and freeform microoptics are being developed for targeted light control. By using commercially available simulation tools (ray tracing and finite difference time domain) as well as in-house developed simulation platforms (such as multiscale simulation), we virtually check and optimize systems by using optical simulation. Additionally we create CAD data for production.

3D print & coat – 3D-printed plastic surfaces with wear protection coating

In this project, laser sintering facilities for additive plastics manufacturing are being improved by our partner Laser Sinter Service LSS, and 3D-printing processes (laser sintering) for fibre-reinforced plastics are being developed by our partner RPD for optimally reproducible fatigue behaviour and coatability (high rigidity and smooth surface topography). Our research activities are focused on this production chain, which is becoming increasingly important in the industry with respect to the development of tough, error-tolerant, low-friction wear-protection coatings (based on a bionic material concept with nacre as a model). The required higher coating rates are achieved through regulation via RFID temperature sensors in vacuum sputter processes in order to avoid thermal damage to polymers (at maximum process temperatures <70°C).

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JOANNEUM RESEARCH MATERIALS

Infrastructure and methods

Clean room
- Class 6 clean room certified according to ISO 14644

Nano imprint lithography
- Roll-to-roll plant with hot embossing
- Roll-to-roll plant with UV nanoimprint lithography
- Nanoimprint lithography in a batch process (up to 4 x 4 inch²) under clean room conditions
- Step & Repeat UV nanoimprint system for the manufacture of flexible, large-scale (300 x 600 mm) and seamlessly structured embossing stamps
- R2R wash and lift-off plant

Lithography and mastering
- High-resolution 3D structuring by two-photon absorption
- Electron beam lithography
- Maskless grey-scale lithography
- 3D plotter
- Photo lithography
- Reactive ion etching (anisotropic etching)

Optical and multiphysics simulation
- Ray-Tracing (ASAP, Zemax)
- Multilayer analysis
- Wave propagation methods (FDTD Solutions, Virtual Lab)
- Method development for the combination of beam and wave optics
- Freeform optics
- Fluiddynamics (COMSOL)

Vacuum deposition methods
- Industrial vacuum deposition facilities for hybrid PLD process (magnetron cathode sputtering and ion beam deposition), max. vacuum chamber diameter 500 mm, coating height 400 mm
- Plasma-assisted fluorination
- Plasma-assisted polymerisation
- Low temperature sputtering system (max 50 °C substrate temperature)
- 2 chamber high-vacuum deposition unit with sample and mask transfer for combined organic and inorganic coatings
- Parylene deposition (surface polymerisation)
- Surface modification using O_2 / N_2 / H_2O / NH plasma, UV / ozone treatment or primer coating
- Modular pilot plant incl. glovebox cluster

Additive printing and coating methods
- Roll-to-roll facility for gravure printing
- Roll-to-roll bio functionalization (microarray spotter)
- Screen printing with automatic screen alignment

Infrastructure and methods

- Aerosol jet printing
- Inkjet printing
- Polymer 3D Printing Stratasys Object 30 Pro
- Pad printing
- Doctor blading
- Spin coating
- Spray coating
- Electrospinning
- Flexography
- Thermal and photonic curing (UV, IR laser)
- Piezoelectric microspotter for microarray and lab-on-a-chip
- Atmospheric-pressure plasma coating (APP coating)

Electronics

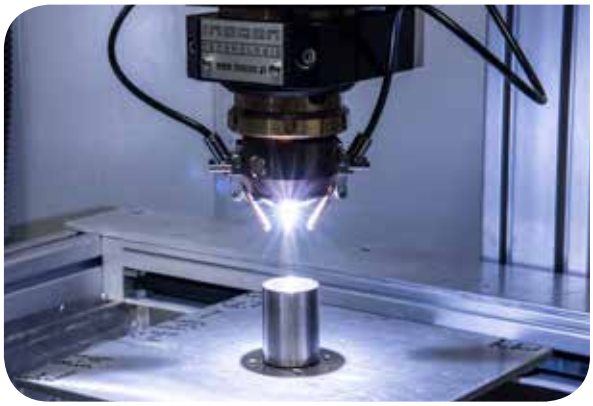
- Optoelectronics and electronics development
- Circuit board plotter for rapid prototyping
- Analog and digital technology
- Development of testing and calibration methods
- Circuit simulation and design (Altium Designer)

Industry standard lasers and NC-controlled machining systems

- Yb:YAG laser, Nd:YAG laser and CO_2 laser with 100 W to 6 kW beam power and 100 µm to 6 mm beam diameter
- CNC-controlled machining centres (up to 6 axes) and articulated robot (6 axes + external rotation and tilt axis)
- Combined laser and milling centre
- Special laser optics (PFO scanner optics, bifocal optics, dynamic focussing optics, …)
- 3D-printing powder bed facilities (LPBF Lasser powder bed fusion) EOSINT M 280, FARSOON FS 121 M

Surface, film and material characterisation methods

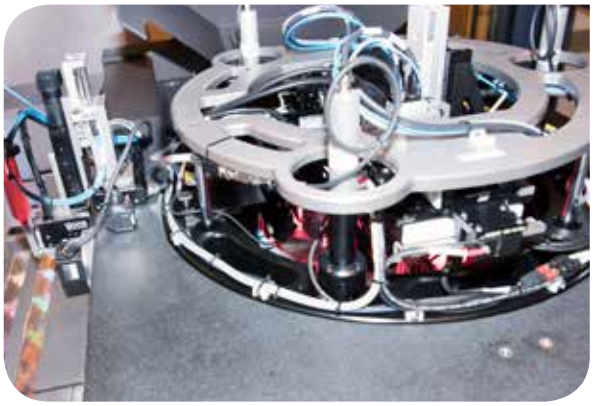
- Analysis of permeation processes: high-performance barrier or O2 permeation (detection limit in the range of 10^{-5} to 10^{-6} cm^3 / m^2 day bar)
- Surface chemical analysis by x-ray photoelectron spectroscopy (XPS / ESCA, depth profiling)
- Spectroscopic ellipsometry
- Scanning tunnelling microscopy (STM)
- Surface morphology by scanning electron microscopy SEM) or atomic force microscopy (AFM) including EFM, KPFM and MFM systems engineering
- Profilometry (stylus profilometer)
- Film thickness measurement in the micrometer range using the spherical cap grinding method (calotest)
- Measurement of residual film stress using the bending beam method
- Microtribology
- Coating adhesion test by micro-scratch test



JOANNEUM RESEARCH MATERIALS

Infrastructure and methods

- Determination of hardness and Young's modulus by microindentation
- Tension testing machine
- Contact angle measurement
- Viscosimetry
- Impedance spectroscopy (layer and corrosion testing)
- Zeta potential
- Electrical characterization of components using a parameter analyzer under an inert atmosphere
- Optical characterization of optoelectronic components
- UV-VIS-NIR spectroscopy
- Luminescence spectroscopy
- Fluorescence spectroscopy
- Polarisation spectroscopy
- Picosecond photophysics
- Multiphoton spectroscopy and lithography
- Light microscopic analysis
- Colorimetry
- Photogoniometry
- Cyclovoltametry
- Quartz crystal microbalance with dissipation monitoring (QCM-D)
- Thermal analysis (thermogravimetric analysis / differential scanning calorimetry – TGA / DSC)
- Infrared spectroscopy
- Metallography
- X-ray fluorescence analysis
- Stability measuring station for investigating the short- and long-term behaviour of components under the influence of different gases and environmental conditions
- Gas measuring station for investigating the sensory behaviour of coatings and components up to 500ºC
- Solar simulator



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