Łukasiewicz
Krakow
Institute
of Technology

Research & Development Strategy

Łukasiewicz Research Network
– Krakow Institute of Technology

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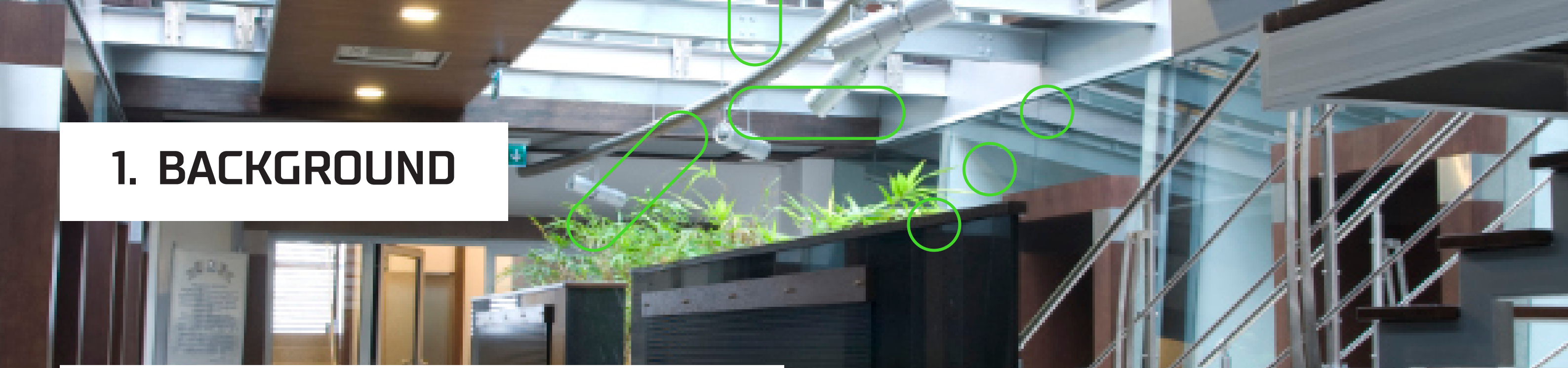


1. BACKGROUND

The Łukasiewicz – Krakow Institute of Technology (Łukasiewicz – KIT) is a unit in the Łukasiewicz Research Network, one of the largest scientific networks in Europe, an integrated market player providing attractive, comprehensive and competitive business solutions. Our key directions of development are health, smart and clean mobility, digital transformation and sustainable, low-carbon economy, which are of strategic importance for the Polish economy.

The Łukasiewicz – KIT focuses primarily on the implementation of R&D projects and services. It develops new technologies, materials, unique instruments and expert surveys for universities, research institutions and research departments of commercial businesses.

The customers for the solutions developed at the Łukasiewicz – KIT include representatives from the automotive, aerospace, foundry, metallurgical, tooling, fuel and energy, medical, pharmaceutical and chemical industries.

The high quality of work carried out at the Łukasiewicz – KIT is ensures by cooperation with many research centres around the world, involving joint research projects, exchange of personnel, as well as valuable experience in research and implementation. The KIT carries out research, development and implementation in its three Research Centres:

CIB

The Centre for Biomedical Engineering (CIB) carries out scientific research and development, as well as design and manufacture of unique research and diagnostic, therapeutic and rehabilitation equipment in the following areas:

- diagnostics,
- biomedical signal analysis,
- telehealth systems,
- medical computer science,
- mechatronics and biomechanics.

CMW

The Centre of Materials and Manufacturing Technologies (CMW) specialises in the design, development of manufacturing techniques as well as technologies relevant to the forming, processing and testing of materials in the following areas:

- casting alloys,
- design and prototyping,
- additive manufacturing technologies,
- sintering techniques,
- machining and tools,
- high-temperature and hot corrosion testing.

CNT

The Centre of New Technologies (CNT) focuses on research and development in the following areas:

- renewable energy sources (RES),
- biofuels,
- energy storage,
- biomaterial,
- technology safety,
- application of artificial intelligence in industry.

Complementary to its scientific and research activities, the Łukasiewicz – KIT provides commercial services, carried out mainly ay the Laboratory Department (DL, including its Accredited Laboratory) and the Certification Department (TC). The Łukasiewicz – KIT also operates the Production Department (DP) with two divisions whose profiled activities are highly specialised material machining, industrial process prototyping and automation, and the manufacture of products for medical applications.

The foundation of the Łukasiewicz – KIT is its people, skilled and experienced experts working on numerous national and international projects to improve existing technologies and develop new advanced solutions.

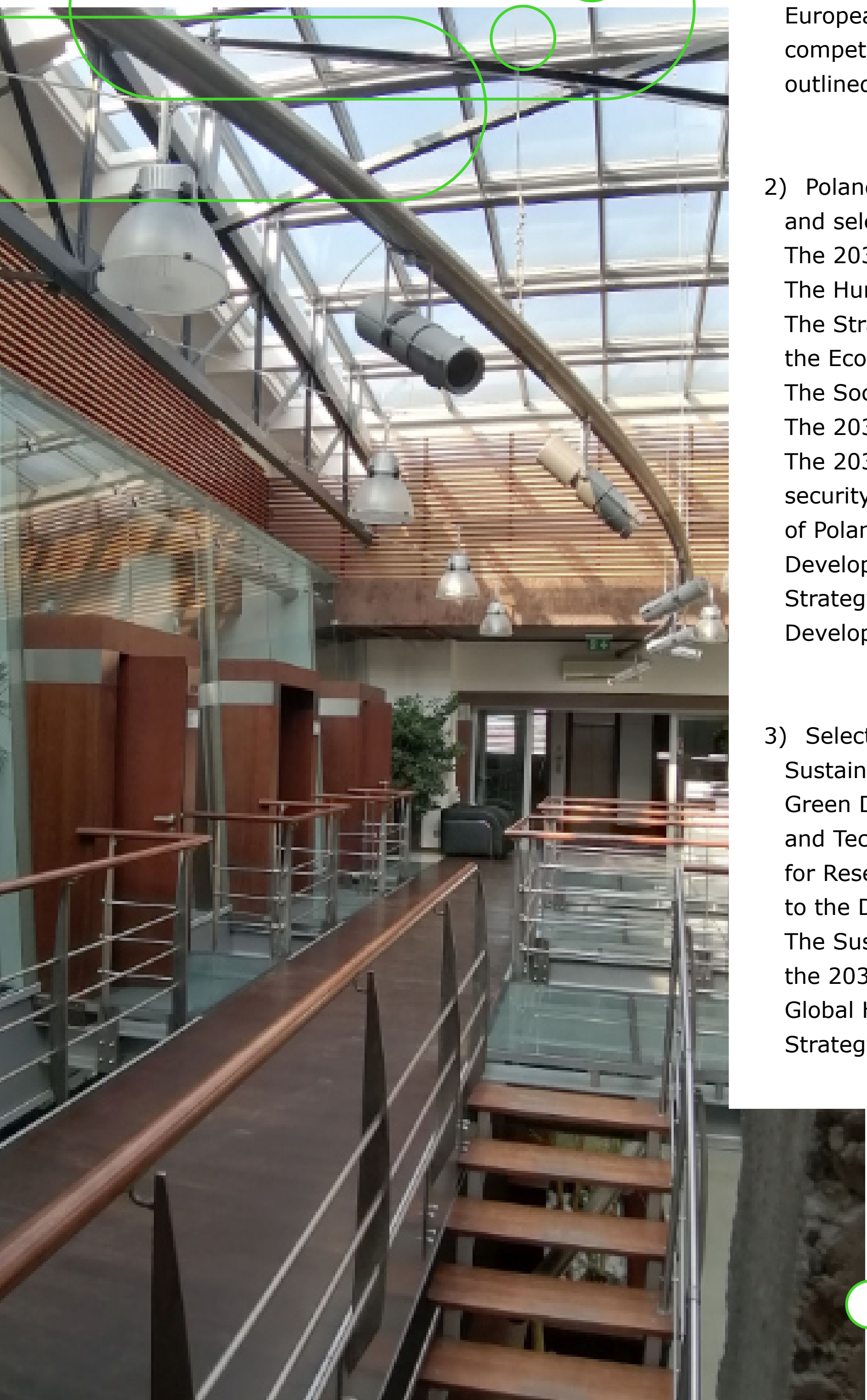
In 2023, the Łukasiewicz - KIT has more than 200 employees. This currently includes 85 people in the Research Division, 16 people in the Laboratory Department, 29 people in the Production Division and three people in the Certification Division. The administration supporting the R&D work is currently staffed by a team of approximately 70. In the coming years, there are plans to develop the R&D team, including acquisition of young, talented scientists from Poland and other countries. In addition, it is planned to change the way the Sales and Business Development Department (DSB) operates in order to reinforce the Łukasiewicz - KIT's cooperation with domestic and foreign industries.

The development strategy for Łukasiewicz - KIT is provided in this document, which links to the strategic research programs defined by the Łukasiewicz Research Network. One of the primary objectives of this strategy is to bring the Łukasiewicz - KIT to an international tier. A priority for the coming years is to increase the Łukasiewicz - KIT’s involvement in international cooperation and increase competitiveness, which requires increasing the share of employees in the Research Division who will be recruited from outside Poland. As such, the Łukasiewicz - KIT plans to recruit and collaborate with the best scientists from home and abroad to build on their knowledge and competence to implement breakthrough technologies for practical applications.

The foundation of the Łukasiewicz - KIT strategy is based on the values set out by the Łukasiewicz Research Network: integrity, courage, collaboration and passion. In the coming years of Łukasiewicz - KIT activities, it is important that these take on a practical meaning and find expression in all aspects of the Łukasiewicz – KIT’s operations.

1.1. The Mission: Science for Business

The mission of the Łukasiewicz – KIT is to support key industrial sectors by creating innovative technological solutions. Our research is designed to respond to the real needs of Polish and foreign business partners.



1.2. National and European strategic context

The overall strategy of the Łukasiewicz Research Network presents a detailed analysis of the national and European strategic context, providing a reference point for the strategies of the individual Institutes in the Network. In the case of the Łukasiewicz – KIT activities, the most important documents providing the foundation for the Łukasiewicz – KIT's strategy include:

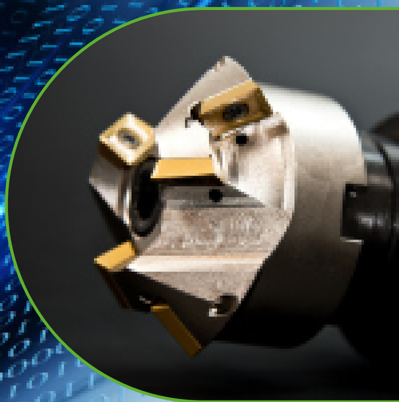
1) Selected Intelligent National Specialisations (INS), which are an important reference point for European R&D funding. The Łukasiewicz – KIT has competence in selected INS subject areas as outlined in this document.

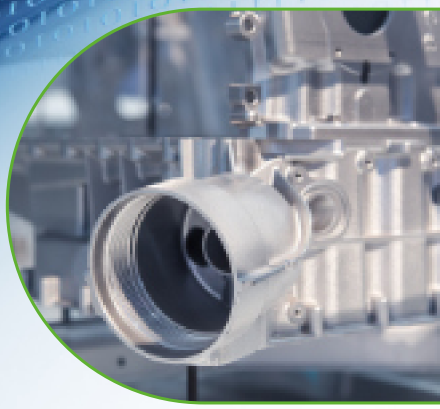
2) Poland's Strategy for Responsible Development and selected industrial sector strategies, including: The 2030 Efficient and Modern State Strategy, The Human Capital Development Strategy, The Strategy for Innovation and Efficiency of the Economy (a.k.a. The Productivity Strategy), The Social Capital Development Strategy, The 2030 National Regional Development Strategy, The 2030 National Ecological Policy, the energy security strategy titled the 2040 Energy Policy of Poland, The 2030 Sustainable Transport Development Strategy, The 2030 Healthy Future Strategy, and The Government Biomedical Sector Development Plan for 2022-2031.

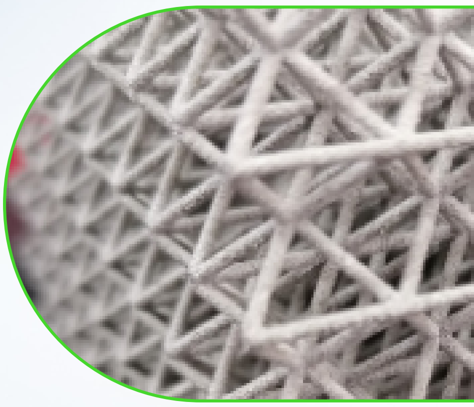
3) Selected European strategies such as The EU Sustainable Development Strategy, The European Green Deal, The European Strategy for Research and Technological Development and The Pact for Research and Innovation in Europe, The Road to the Digital Decade/2030 Digital Compass, The Sustainable and Smart Mobility Strategy, the 2030 European Biodiversity Strategy, the EU Global Health Strategy, and the New Industrial Strategy for Europe.

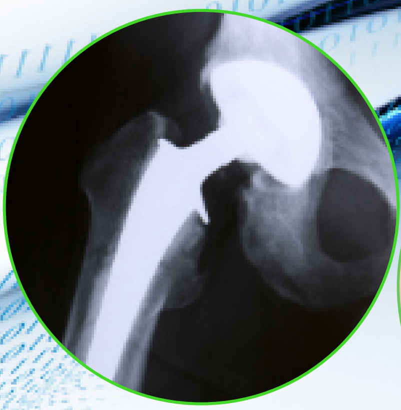
2. RESEARCH SUBSTRATEGY (R&D) and COMMERCIALIZATION

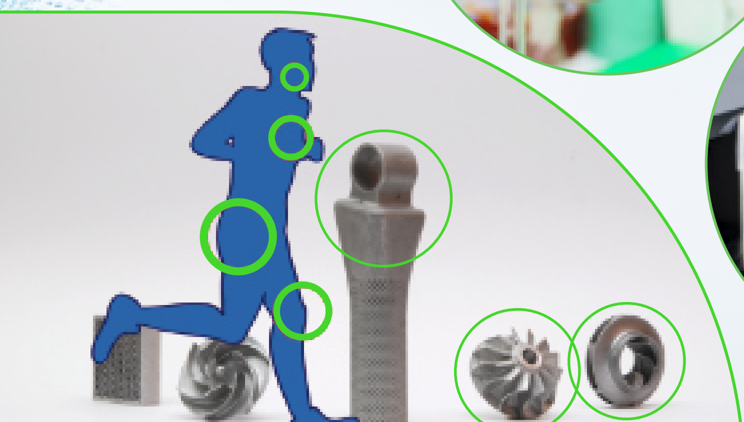
The Łukasiewicz – KIT research and commercialisation substrategy is a part of the Łukasiewicz's Strategic Research Programs, enabling scientific work in key research areas responding to national and global challenges. The most important work and activities done at the three Research Centres of the Łukasiewicz – KIT, which enable the scientific development of the Institute's employees, are outlined below. Operational aspects of the Laboratory Department (DL), the Production Department (DP) and the Certification Department (TC) are presented in turn.











2.1. The Centre for Biomedical Engineering (CIB)

The CIB carries out research and development work in medical technology and instruments to create and develop advanced technologies for health protection and promotion and their practical application. Biomedical engineering is an interdisciplinary field of knowledge, one of the most dynamically developing disciplines in the technical sciences worldwide. Biomedical engineering is a driver of the medical device industry, significantly contributing to the development of medical technologies that largely determine the quality and efficiency of medical care.

The CIB covers all stages of the process of developing a new medical device, which are research and development, design and prototyping, and, in cooperation with other units at the Łukasiewicz – KIT, conformity assessment, preparation for certification, as well as marketing and use in the EU.

2.1.1. Directions of the CIB's technological development

The areas encompassing the planned R&D activities should be in line with current global development trends in medical technologies, which generally aim to improve the quality and effectiveness of medical treatment, undo adverse changes in the demographic structure, extend human activity and increase the quality of life of the population.

The CIB's forward-looking R&D activities under way include:

Application of computational intelligence methods in medical diagnostics and treatment support systems

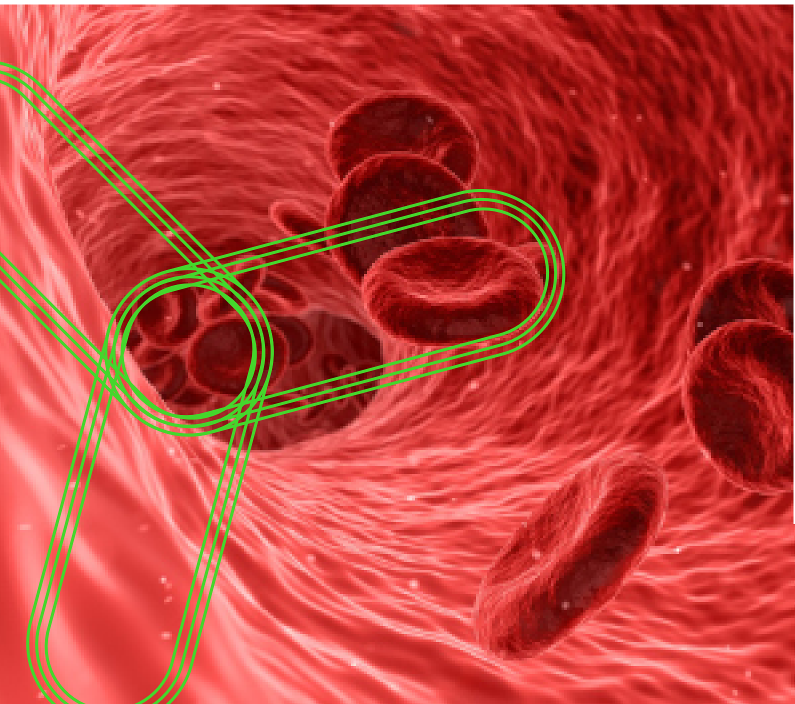
Research in this area concerns the development of efficient algorithms for processing and analysing medical data (feedback signals, images, etc.) in order to extract relevant and reliable diagnostic information, based on computational intelligence methods. The research includes methods based on artificial neural networks, machine learning, support vector machine (SVM), fuzzy clustering and granular computing.

The research should also aim to develop automatic inference methods using artificial intelligence to support medical diagnostics, especially in applications characterised by a large number of inputs that require analysis.

Within the application area of computational intelligence, specific research work (projects) can be identified:

- improvement of cyber-physical systems for maternal and child medicine and their development towards telehealth applications,
- development of methods for automatic inference of health status, based on selected measured vital signs, characteristic features of acquired biomedical feedback signals and other individual characteristics for personalised telehealth in the areas of pulmonology and cardiology, as well as

for home care systems for seniors and the disabled,
- development of new methods for the analysis of cardiovascular lesions based on computed tomography images to improve the efficiency of segmentation of atherosclerotic plaques – both calcified and soft – forming in the coronary vessels, as well as the measurement and analysis of characteristic features that enable appropriate differentiation of lesions and the application of adequate treatment,
- in cooperation with the CNS-Lab operated by the Military Institute of Aviation Medicine and the Institute of Biocybernetics and Biomedical Engineering of the Polish Academy of Sciences, it is possible to carry out fMRI, rsfMRI and impedance cardiography examinations to assess functional connectivity, connectome and plasticity assessments, allowing expansion of the knowledge of how functional brain networks optimise their own organisation during performance of tasks,
- the application of fMRI and rsfMRI in a group of patients rehabilitated for different types of scoliosis, particularly concerning children whose spinal curvatures are idiopathic (IS). Abnormal peripheral sensory input or abnormal sensorimotor integration can lead to impaired postural tone and the development of spinal deformities, which spurs the development of research based on the assessment of the brain network functional connectivity (FC) imaged by fMRI or rsfMRI.



Unobtrusive methods of biomedical parameter measurement for telehealth applications

Telehealth technologies are promising ways of providing healthcare services and optimising the healthcare delivery system, particularly useful in epidemic emergencies. The Covid-19 pandemic has had a significant impact on the implementation of telehealth as a method of providing remote medical consulting, but also of conducting medical surveillance and telemonitoring, the most demanding forms of telehealth technology in terms of application.

The research in this area is concerned with the development of wearable biomedical feedback acquisition systems, comprising biosensors, data processing and communication modules integrated into clothing, and sending the acquired data to a remote monitoring and surveillance centre using ICT technologies.

Within the telehealth area, specific activities or projects can be identified:

- state-of-the-art technologies in the processes of medical diagnosis, treatment and hybrid rehabilitation, as well as in the surveillance of heart failure patients based on non-invasive methods of reliable medical data acquisition,
- wellness products that support the development of health-promoting physical activity by training level (body performance) level while maintaining health safety,
- systems for the monitoring and assessment of mental and physical parameters of individuals in various environments of their life activity, including those intended for military and special forces operatives for the surveillance of their state of health and the assessment of their personal fitness for tasks performed under extreme conditions,
- development and implementation of non-intrusive biosensor systems based on individual, seamless garments, integrated with a textronic system made with ultra-long carbon nanotube technology – a continuation of cooperation with the Faculty of Chemistry of the Silesian University of Technology,
- systems for the remote home care of seniors and the disabled with monitoring of basic vital signs and assessment of physical activity levels using remotely controlled load-setters, like cycloergometers.

Advanced technologies for the diagnosis and treatment of civilisation diseases

The CIB’s R&D remit in the diagnosis and therapy of civilisation diseases, includes various forms of electrostimulation. Electrostimulation is used extensively in cardiology, neurology, anaesthesiology, oncology and many other medical disciplines, improving the effectiveness of treatment and diagnosis.

The demographic changes resulting from the ageing of the population will be accompanied by a further increase in the cost of treating seniors due to the increasing prevalence of typical old age disorders, like neurodegenerative diseases, dementia, Parkinson-like syndromes, as well as an increase in the number of people with geriatric syndromes that prevent unassisted functioning and contribute to expensive dependency on medical care. An important R&D area is the development of easy-to-use and more affordable diagnostic tools for detecting reduced psychomotor performance indicating the early need for environmental and behavioural interventions to minimise or postpone the consequences that comprise metabolic syndromes, vascular damage, accelerated neurodegeneration and susceptibility to falls.

Within this research area, specific activities or projects can be identified:

- development of prototype experimental instruments and initiation of research to evaluate the applicability of a new method of non-thermal electroporation ablation in oncology and cardiology therapy as a more effective and safer alternative to the thermal ablation, a process widely used today for therapeutic tissue destruction,
- development of a methodology and diagnostic system for computer-assisted assessment of mental performance and functional status of people in early old age for screening and early detection of neurodegenerative diseases with a view to including prevention and lifestyle modification and thus extending the period of unassisted living and generally improving quality of life.

Medical robotics and assistance systems

Medical robotics encompasses the use of robotic medical devices to support medical procedures. Medical robots are mechatronic devices that perform specific tasks automatically or semi-automatically, through appropriate control of the actuators (effectors and applicators). The operation of a robot can be controlled by a human or by a program that contains control algorithms which are usually based on computational intelligence methods. Among medical robots, a distinction is made between surgical robots, rehabilitation robots, robots that support the vital functions of senior people and the disabled, as well as nanorobots.

The objective of research in this area should be to develop innovative solutions for the design and control of robots that rehabilitate and support people with motor function deficits in their daily activities, and assist in complex activities performed by clinical personnel and physiotherapists that require precision and repetition.

An example of planned developments in the field of medical robotics with implementation potential is a robotic manipulator for precise localisation and stable movement of optical instruments, supporting the diagnosis and treatment of neoplasmatic lesions on the body surface and in the body core by application of a photodynamic method.

2.1.2. Key directions for commercialisation at the CIB

The results of R&D work in the above-mentioned areas should be innovative deliverables in the field of biomedical engineering, representing products in the form of new medical technologies, devices and systems. These products will be able to be offered on the market directly to individual consumers, healthcare providers, local authorities and commercial businesses.

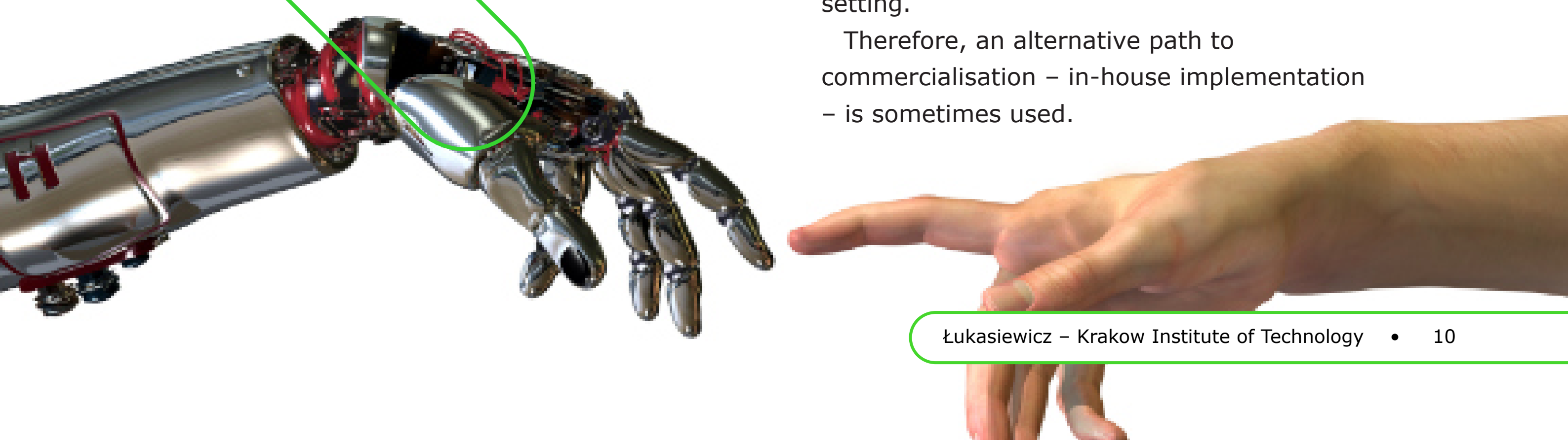
Description of the key commercialisation at the CIB – A diagnosis of the current state

The preferred way to commercialise the Łukasiewicz – KIT's research results is through direct commercialisation based on licensing or selling the ownership rights to the project deliverables to an industrial partner who, once certified, starts manufacturing the developed products and puts them on the market and into use.

The deliverables of the application project titled "Development of the NeuroPlay, an intuitive, portable training device based on the biofeedback method to support cognitive functioning in ageing", in the form of a medical device and software, have been successfully commercialised.
The commercialisation path adopted assumes implementation by a business operator who is external to the project consortium. In the signed contract, the granting of rights consists of an exclusive licence for a fixed term established for the preparation for implementation and the subsequent transfer of rights to the business operator.

Innovative deliverables often face market barriers (the Death Valley) due to buyers' preference for proven solutions provided by global leaders in the medical technology market. This makes it more difficult for Polish companies to enter the market and increases the implementation risk, in addition to incurring high costs for time-consuming validations of new technological solutions in a clinical setting.

Therefore, an alternative path to commercialisation – in-house implementation – is sometimes used.



The CIB, together with the Łukasiewicz – KIT's other organisational units covered by the Quality Management System that is compliant with the MDR regulation for medical devices, has the merit-based, infrastructural and legal competence to carry out the certification, followed by the launch of small batch production and eventually the sale of the deliverables as its own medical devices.

In this way, well-known products were launched, including: The Peleton-Cardiv system for exercise testing and cardiac rehabilitation, the MIP-801 cardiac pacemaker used now in hundreds of hospitals in the country, the Monako Obstetric Surveillance System used with success in more than 110 hospitals and maternity clinics in Poland, which has "assisted" in the birth of more than one million Poles. The development perspective for Monako is the recently developed telehealth system named TeleKaTeG, which allows patients to perform examinations themselves at home, which significantly increases comfort and can reduce costs in the healthcare system.

Description of the key commercialisation at the CIB – Plans for the future

Completion of two projects and the achievement of deliverables ready for implementation in medical practice provides the basis for pursuing activities towards their direct commercialisation.

Significant deliverables from one of the completed projects – Project Strategmed titled "AMULET", a new model of medical care using modern methods of non-invasive clinical assessment and healthcare in patients with heart failure (HF)" – are:

- a mobile device for at-home acquisition and measurements by impedance cardiography with data transmission via GSM,
- 4Heart-Amulet – a software system for the presentation and analysis of measurement results and calculation of haemodynamic parameters.

Three implementation strategies were adopted, for which partners were attracted who are interested in implementing the project's deliverables both in terms of production and the introduction of the proposed model of healthcare for HF patients:

- a cardioimpedance and ECG feedback logger with GSM transmission in a telehealth system with an IT platform developed during the project, for remote monitoring of HF patients at risk of cardiac decompensation or for hybrid or other cardiac rehabilitation,
- a feedback logger with GSM transmission for implementation in another teleheath platform (the Łukasiewicz – KIT provides the communication interface),
- a haemodynamic measurement system consisting of a feedback logger communicating with the 4Heart-Amulet app via Bluetooth LE, for GPs or hospital applications.

The use of strategies number 1 and 3 is currently being considered during the ongoing negotiations. An initial implementation is under consideration, consisting of launching the production of the first series of certified devices at the Łukasiewicz – KIT and launching a pilot implementation of the proposed model of healthcare for HF patients in selected healthcare units. Once verified in the healthcare system, the market value of the products offered will increase significantly, enabling the industrial/business partner to launch its own production. The licence planned to be granted is to enable further development of the technology at the Łukasiewicz – KIT.

The second of the completed projects is an Application Project titled "EnviroPulmoGuard, a teleheath system for interactive health monitoring of people with respiratory diseases, in a local environment, enabling early prevention and personalised treatment". Based on impartial measurements of the patient's parameters and the environment around the patient, the developed system predicts and warns of an imminent exacerbation of the patient's symptoms.

This solution makes facilitates maintenance of control over the disorder, increases patients' health awareness and contributes to a person's health. The target group is people with respiratory diseases like asthma and chronic obstructive pulmonary disease (COPD). These disorders are considered to be exacerbated by air pollutants, contributing significantly to a reduced quality of life, generating high social and economic costs, and being the main cause of death from respiratory diseases. The system is in the early stages of commercialisation. The implementing entity is, according to the project design, the project consortium member.

2.2. The Centre of Materials and Manufacturing Technologies (CMW)

The CMW works in the development of advanced metallic, ceramic and composite materials, as well as the manufacture and testing of equipment and machine components produced by casting, additive manufacturing, decremental manufacturing (machining/cutting) and powder metallurgy techniques. The CMW provides services in a wide range of material testing expert surveys, targeted in particular at the foundry, tooling, automotive, aerospace, energy and medical industries.
The CMW's operations are focused on circular economy and process automation (Industry 4.0). Research and development are carried out at the CMW and services are provided on commercial terms.

2.2.1. Directions of the CMW's technological development

Sintering Technology Area

Development of ceramic composite technology, including superhard composites and composites from recycled materials obtained by advanced sintering methods (SPS, HPHT, MW, etc.):

1) Superhard materials based on regular boron nitride for applications in machining of Inconel-type nickel superalloys and other materials with difficult machinability, as well as innovative applications for electronic components, including heat dissipation in high-power electronic components.

2) Ceramic composites of various types, mainly produced by SPS (spark plasma sintering) and HPHT (high pressure, high temperature) processing.

Machining and Tooling Area

1) Technologies for the manufacture of highly-processed products, especially by machining and cold finishing methods that contribute to the environmentally-friendly and sustainable growth of a knowledge-based, innovative and productive economy.

2) Research and development of selected surface layer modification technologies to increase the durability of tools, machine parts and other products through the use of various processing methods, including machining (turning and milling), plastic forming (burnishing) or tribologically advanced superhard PVD coatings with targeted utility quality, in line with the Industry 4.0 concept.

Additive Manufacturing Area

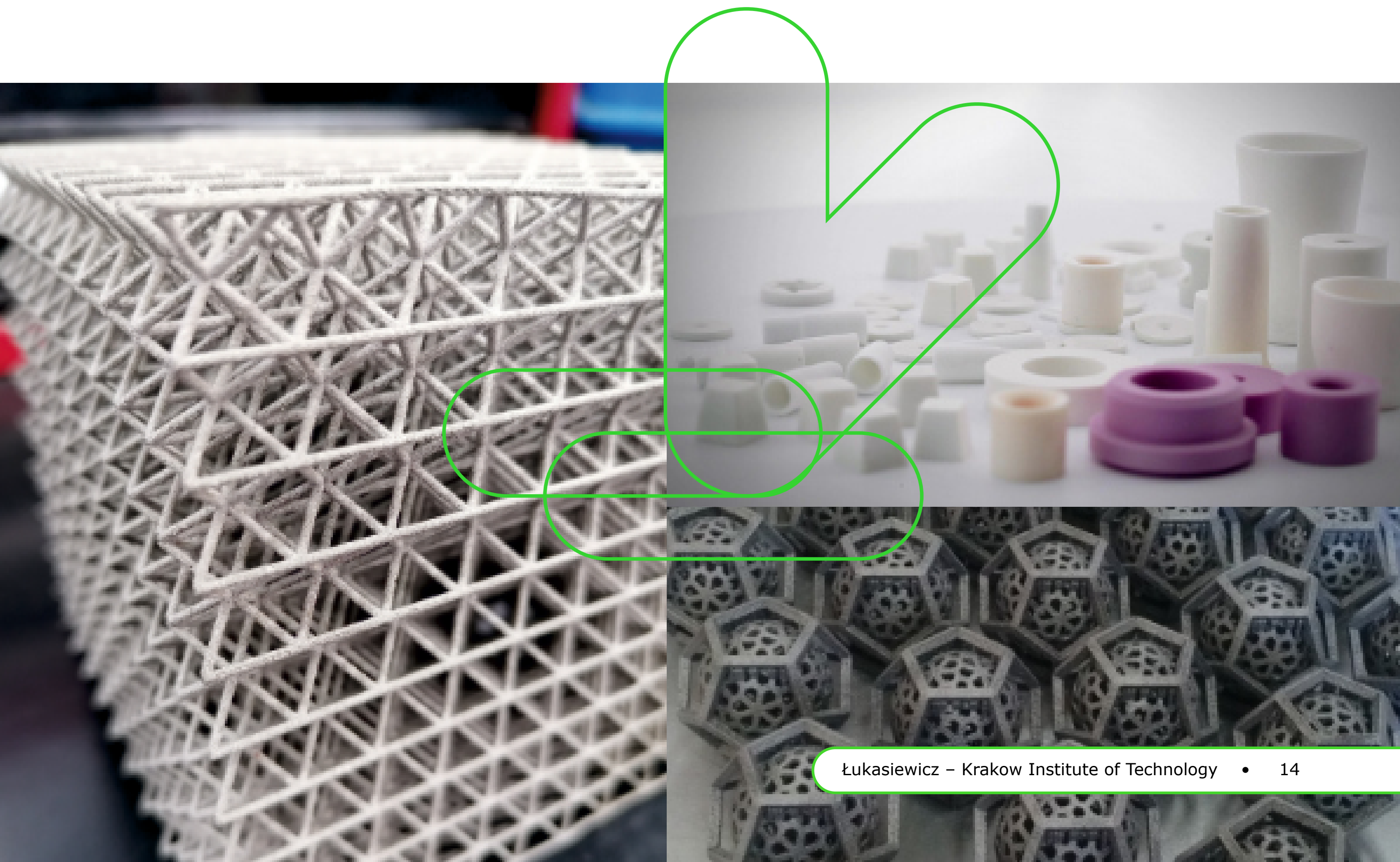
1) Research and optimisation of AM technology based on equipment available at the Łukasiewicz – KIT:

- Binder jetting (Digital Metal/Markforged DMP2500) – fabrication of workpieces from metallic materials, ceramic materials (e.g. oxide ceramics, carbides) and cermets for applications in biomedicine (e.g. implants, surgical instruments and robotic components), engineering (e.g. nozzles for water-jet applications), military and aerospace (components for ballistic vests/personal protective equipment and heat shields made from B4C and other materials).
- SLM (selective laser melting), DED/LMD (direct energy deposition/laser material deposition) or alloying of components from mixtures of metallic powders.
- Sintering and heat treatment of workpieces made by AM applications, including HIP (hot isostatic pressing).
- Topological optimisation of components taking into account available AM and machining technologies.

2) R&D of selected contactless processing technologies:

- Electrochemical machining – forming of complex component surfaces in hardly machinable materials (nickel superalloys and sintered carbides).
- Electrochemical smoothing and plasma electropolishing - improvement of the surface quality of workpieces manufactured by AM from electrically conductive materials.
- Surface layer modification – micro arc oxidation (MAO) coating.

3) Development of a hybrid device based on an industrial robot to enable additive manufacturing of metallic components based on DED/LMD (using a powder fed into the laser beam interaction point) and WAAM (wire arc additive manufacturing) technologies.



High–Temperature Tesearch Area

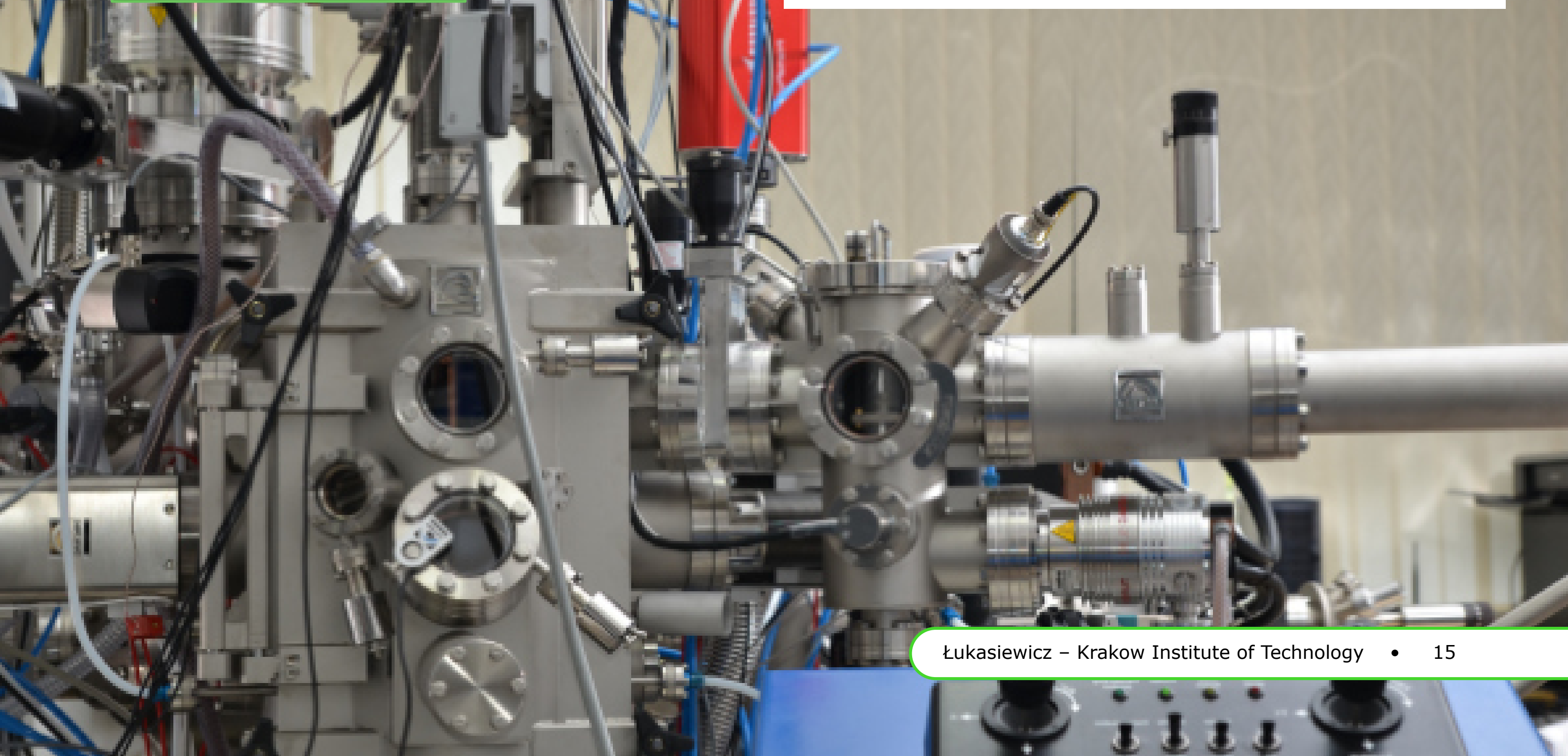
1) Basic, development and industrial research related to the design and manufacture of dedicated structural and functional materials in the groups of:

- ultra-high temperature MMC and CMC including ceramic metal composites with carbon, carbide, silicide, boride and nitride materials,
- new lightweight composites based on high-melting metals and intermetallic phases and interstitial compounds with ultra-high oxidation resistance, super hardness and resistance to high-temperature tribological wear,
- porous materials in modern heat-resistant and refractory alloys for aerospace applications (lightweight heat exchangers, sealing materials, and energy-absorbing materials).

2) Testing of the functional properties of high-temperature materials for thermal energy storage (TES) systems.

Hot Corrosion Research Area

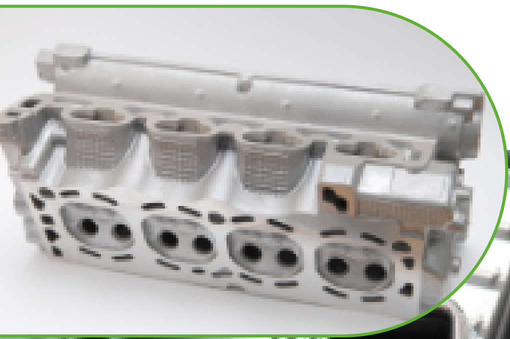
High Temperature Corrosion Area (HTCA) was established in the Materials Research Centre (currently Centre of Materials and Manufacturing Research) in 2018 aimed to launch World Class Centre (WCC) within the research focusing on degradation of materials applicable at high temperatures for special attention to aerospace and energy application. The research area covers the exposures of the metallic alloys (iron, nickel, titanium substrates, oxide dispersion-strengthened alloy (ODS), high entropy alloy (HEA)) as well as exposures of coatings for high temperatures application in various atmospheres including: natural air atmosphere, steam atmosphere taking into account different steam flow and oxygen activity. Furthermore, the research scope in HTCA is addressed as well to help resolve today's critical corrosion issues in aggressive atmospheres (Cl_2, H_2S, SO_2 (up to 1% Vol.), fireside corrosion and finally hot corrosion. Post exposure investigations are conducted on the state of the art equipment that obeys: microstructure and chemical analyses using standard Scanning Electron Microscope (SEM) coupled with Energy-Dispersive X-ray Spectroscopy (EDS), Scanning Electron Microscope – Field Emission Gun (SEM-FEG) + EDS, phase analyses using X-ray diffractometer (XRD), Energy Backscatter Diffraction (EBSD). In addition, HTCA produces diffusion coatings using pack cementation coatings, the coatings are applied on various metallic substrates. The HTCA is active in different projects related to material science with special attention to corrosion issues.



The laboratory can test the heat resistance of metallic materials in heat-resistant coatings that are produced by:

- thermal spraying (High Velocity Oxy Fuel (HVOF) Air Plasma Spray (APS),
- physical vapour deposition (PVD),
- powder coating (diffusion coatings) using active chemical compounds like $AlCl_3$,
- recycling steel waste with high Cr content.

It is planned to expand the research offer over the next few years by upgrading the Hot Corrosion Research Area with test rigs for the cyclic oxidation processes of heat-resistant materials with and without protective coatings; it is also planned to purchase a machine for thermal spraying of coatings on workpieces operating in aggressive environments, as well as employing two people to strengthen this area of operations at the Łukasiewicz – KIT.



Casting Alloys Area

The main objective in this area is the design engineering of state-of-the-art alloys with unique properties, highly customised for the application requirements of different industrial sectors. Design, manufacture and heat treatment of materials with defined multifunctional properties:

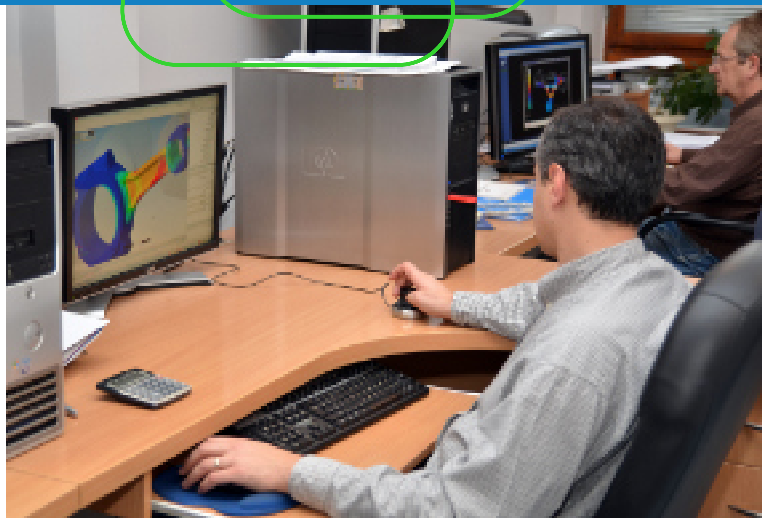
- iron alloys (cast steel and cast iron), with particular focus on solution-strengthened cast irons, ADI cast irons and nanostructural cast steels;
- non-ferrous metals (aluminium, magnesium, and zinc):
  - light alloys based on aluminium and magnesium matrix with improved heat resistance, dimensional stability and corrosion resistance in various environments for applications in the automotive, furniture-making and construction industries,
  - a new generation of nanomodifiers in non-ferrous metal alloy casting as an effective way of enhancing the performance of materials used in the transport industry,
  - new types of magnesium- or zinc-based alloys with biocompatibility and controlled disintegration time in human physiological fluids (biodegradability) for medical applications;

- superalloys (of nickel and cobalt) obtained by induction melting in vacuum or protective atmosphere using optimised chemical composition and modifications by application of Ta, Al or Ti. Development of innovative technologies (additive regeneration technology and preheating technology) focusing on the structural restoration of superalloys;

- modern high-entropy alloys based on aluminium, boron, nickel, cobalt, copper, manganese, molybdenum, iron, carbon and silicon, like AlCoCuFeNi, AlCoCuFeNiSi or CoFeMnMoNi obtained by induction melting with inert gas supply to the melt surface.

These alloys are dedicated to the machine engineering, agricultural, mining, automotive, aerospace, defence and energy sectors.

The newly developed materials will be used to manufacture components operating in aggressive environments, over a wide temperature range and under fatigue loads. These materials can also perform protective (in the form of functional coatings), storage and conductive functions. By virtue of their multiple functions, the developed materials will be environmentally friendly due to their low carbon footprint and will offer a cheaper alternative to current technologies.



Design and Prototyping Area

1) Virtual numerical experiments on casting-related technological processes, simulation of operating conditions of multiphysics phenomena and optimisation areas of structural forming and casting process optimisation. Structural forming and casting technology development using 3D modelling systems:

- Application of MagmaSoft and Flow3D systems for casting process simulation and fluid mechanics analysis of manufacturing processes. Design and analysis of high pressure, low pressure, and gravity casting technologies for reusable and disposable moulds, as well as precision casting, including the application models produced by additive manufacturing.
- Prediction of the emergence of casting defects from the manufacturing technology and the final material and performance properties of castings.
- Verification of design assumptions using numerical multiphysics analyses in ANSYS. Topological optimisation of strength forming of geometric workpiece structure based on boundary condition scheme. Coupling of thermal, fluid and strength analyses.
- Numerical modelling of additive ANSYS manufacturing processes using metal powders. Evaluation of the stress and deformation states during manufacturing; optimisation of operating parameters and material utilisation with prediction and limitation of thermal-strain deformation.

The integration of numerical modelling in the process cycle provides comprehensive design and engineering consulting for the manufacture of cast parts for the automotive, aerospace, mining and energy sectors.

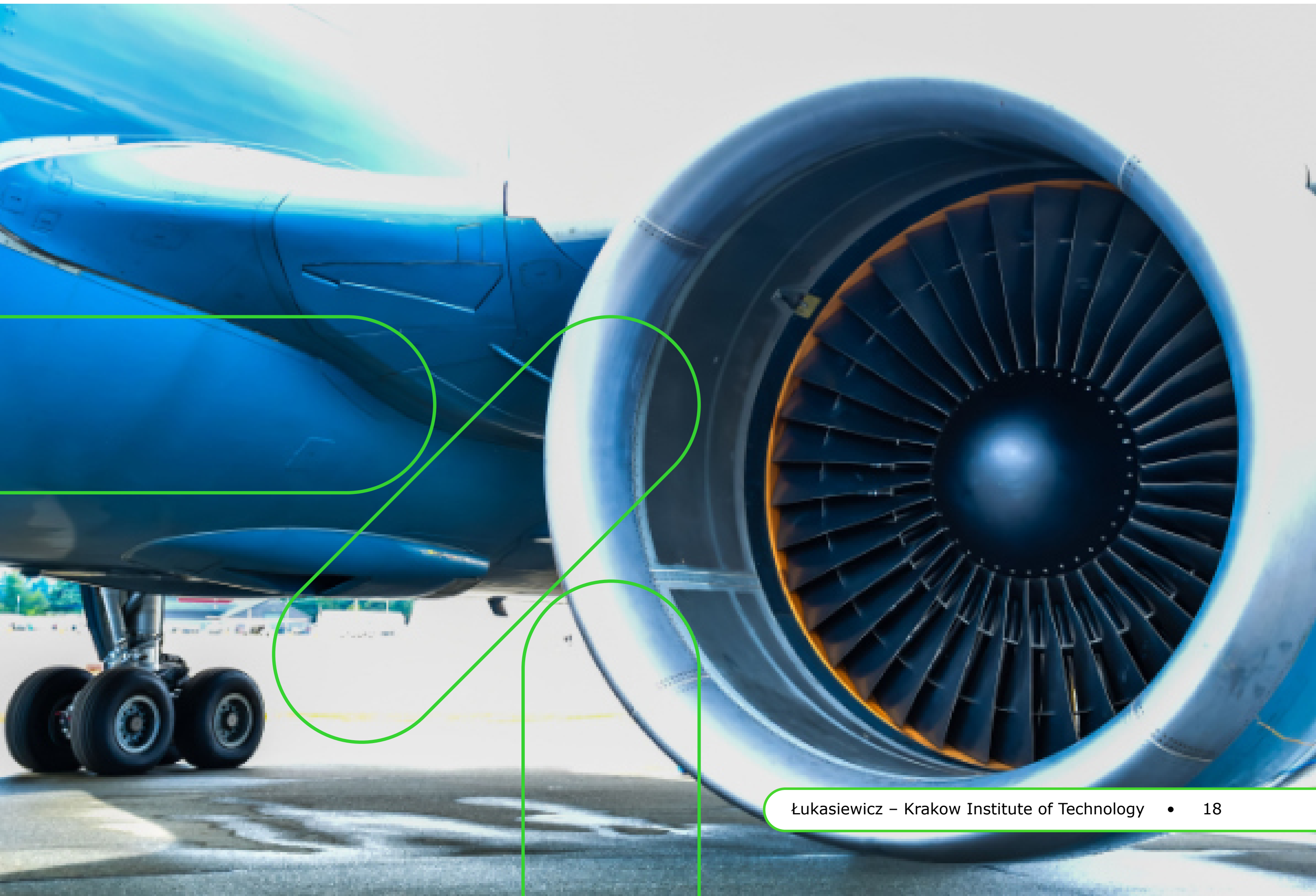
2) Maximising the reuse of waste materials and reducing the harm from casting processes.
The management of casting waste is a major problem for foundries and represents a significant financial burden due to the cost of landfilling these materials. Casting waste, and in particular spent moulding sand, can be reused to a much greater extent than at present.

- Definition and elimination of the most important waste streams in casting processes.
- Recycling and management of waste casting materials in various industries to minimise production costs from reduced use of virgin materials.
- Pro-sustainability of casting cleaning processes by creating an automated cleaning and validation station for casting surfaces using reverse engineering techniques and industrial manipulators.

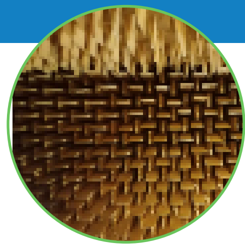
The technologies developed conform to the sustainability policy and the circular economy, as well as BAT (best available techniques).

3) Research into physical and chemical phenomena present in casting processes and development of technologies using modern materials for moulds and cores.

- Determination of phenomena present in the formation of the ceramic layer in terms of improving the surface quality of castings and eliminating internal casting defects.
- Development of technologies with new generations of liquid moulding compounds for reactive metal alloy casting moulds. Modification of casting binders and moulding sand additives.
- Design of innovative structures for casting models and cast components by rapid prototyping. Manufacture of casting tooling and development of technical and construction documentation using reverse engineering tools and 3D printing.

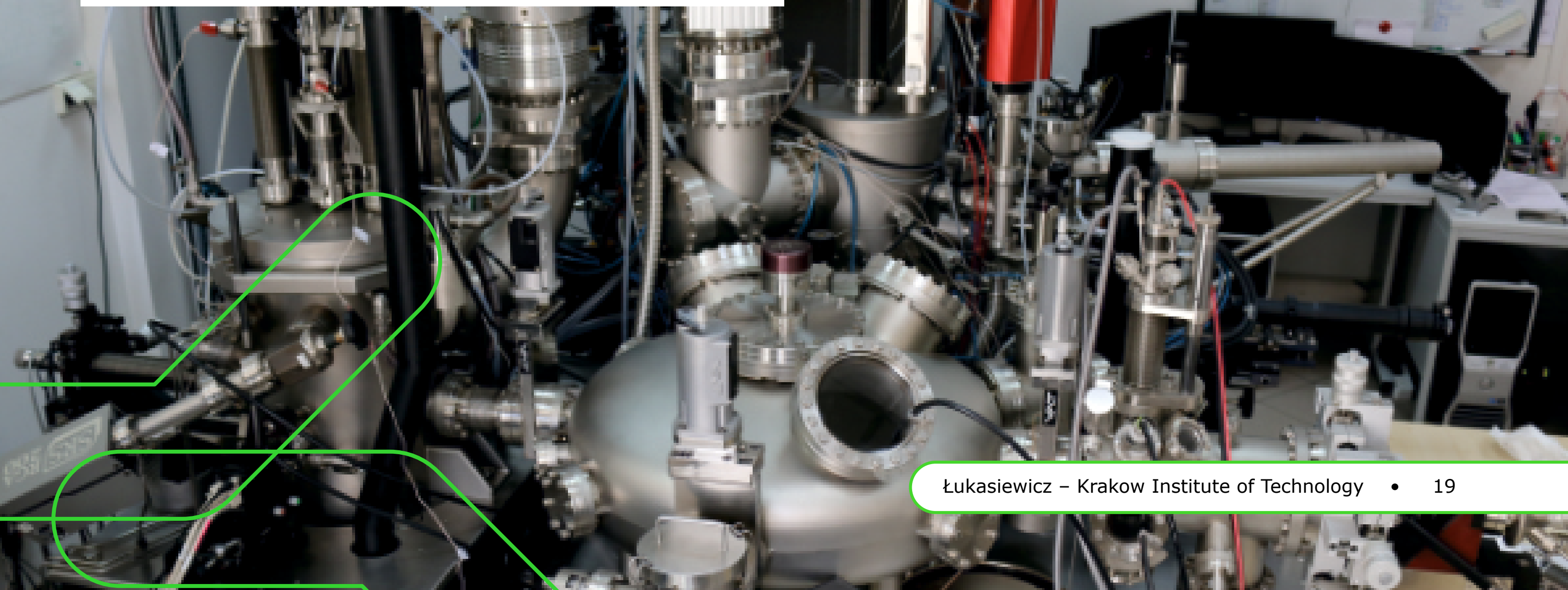


2.2.2. Key directions for commercialisation at the CMW

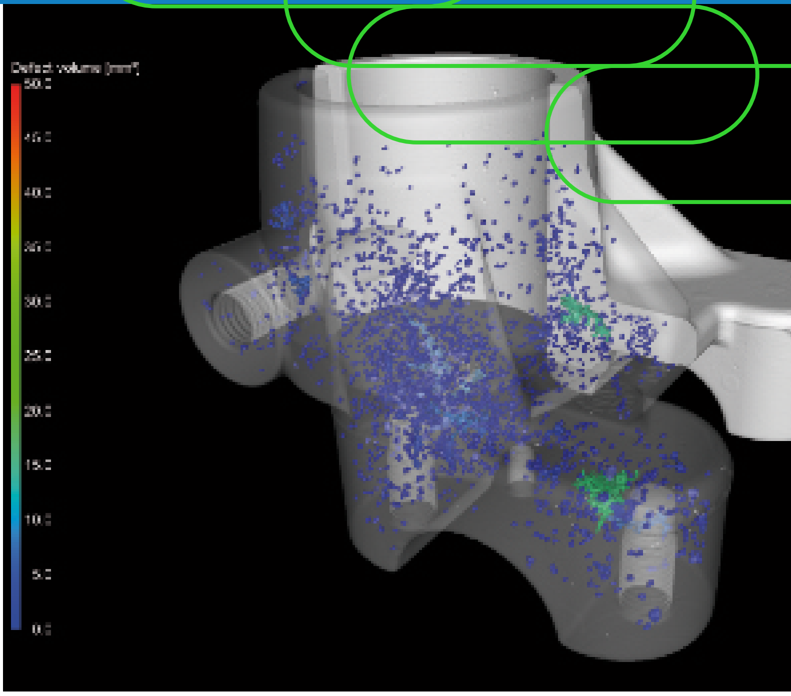


Description of the key commercialisation at the CMW – A diagnosis of the current state

1) Sale of research services in the field of material development and testing for scientific entities (IWS PAN "Unipress" – HPHT experiments on the development of GaN and InN phase diagrams; AGH – HPHT and SPS, tool fabrication and cutting tests; University of Lund – HPHT cBN sintering; Łukasiewicz - PIT – UHTC material froming post-SPS).
2) Sales of research services for the development and testing of materials for the industry (The Quartz Corp – heat treatment of glass, CREO – tribological testing, JG Group – development and testing of cermet materials; CREATEC – ceramic filter testing (subcontracting)).
3) Leader VIII – an in-house implementation (research carried out under the project allowed the Łukasiewicz – KIT to expand its research offer with new services, which include comprehensive research into bright coal carriers used in the production of bentonite-carbon mixtures) and to secure funding to enable further improvement of the developed technology, like subcontracting R&D work for the development of an innovative mixture processing system (SPM) within Project Fast Track ("Szybka Ścieżka") delivered by Odlewnia Kutno Sp. z o.o. under the title "Lauching the technology for production of high-precision iron castings for the automotive sector using INDUSTRY 4.0 methodology".
4) Crucibles – commercial sale of products developed at the CMW (with a patent application).
5) Tango 2 – implementation of developed methods for air-casting of nickel alloys at Ferro-Term, a commercial business.
6) Sale of integrated design and modelling services for engineering structures using numerical analysis and optimisation of casting technology (Project EDIH).
7) Sale of electric discharge machining and micro-machining (WEDM) and conventional machining services – INNERCO, IMIM PAN, and PROGRESJA S.A.
8) EDM and micro-EDM – Arendt; the Institute for Plasma Physics and Laser Microsynthesis.
9) Machining: turning and milling of SLM workpieces; SLM plate machining (PROGRESJA S.A.; KLGS).
10) Additive manufacturing and thermal processing services: SLM of metal workpieces (KLGS, IMIM PAN, and the Opole University of Technology).
11) Thermal treatment of SLM workpieces (PROGRESJA S.A., Łukasiewicz - Aerospace Institute).
12) Sale of kits for determining the corrosive effect of machining fluids (Herbert method and Ford-Test).
13) Sale of the "Roadmap for the Industry 4.0 Transformation of STALMAX Sp. z o.o.".



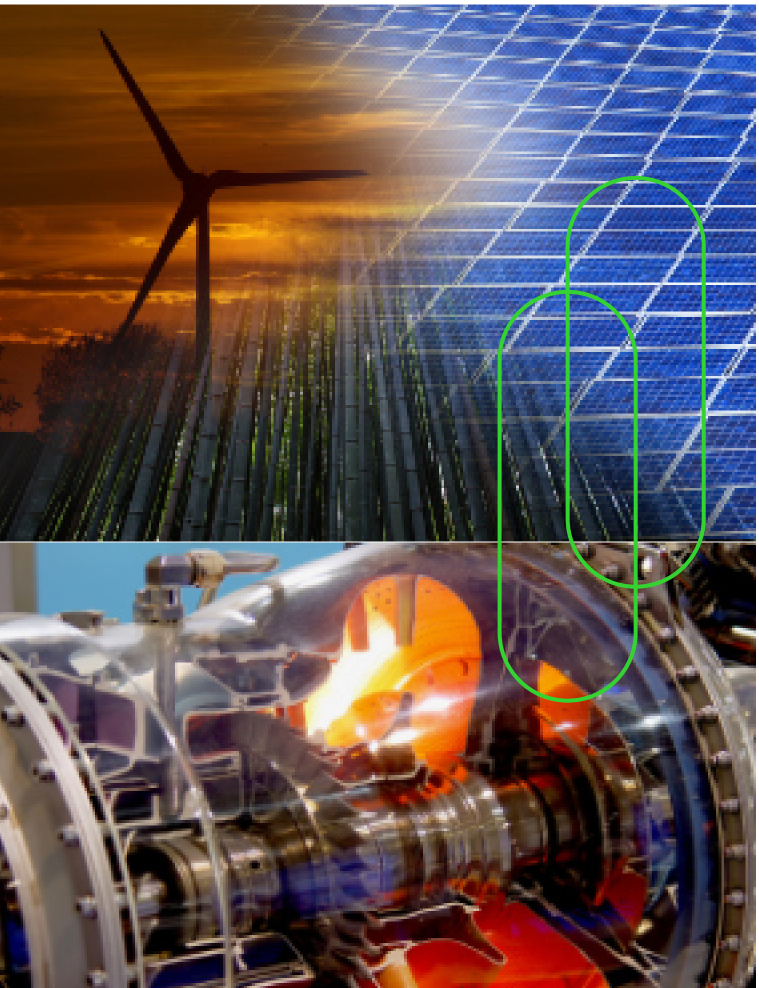
Description of the key commercialisation at the CMW – Plans for the future



1) Sale of research services in the field of material development and testing for scientific operations (negotations of HPHT sintering service for IMIM PAN; continued fulfilment of orders for SPS and HPHT sintering for AGH and other universities).
2) Sale of research services for materials development and testing for the industry (signed conditional contracts for materials testing – subcontracting for two FENG projects managed by POLCOMM and JG Group; negotiation with the commercial business on the collaboration in the production of novel materials for ballistic vest inserts).
3) Sale of licences and implementation of solutions developed as part of R&D work in Project Leader 13. These solutions are intended to address the emergence of defects that disqualify components during inspection. It is assumed that the technology will fit into the production cycle and that the structural reconstruction of a casting rejected due to existing defects will be carried out. CPP, a commercial business, is interested in this work.
4) Sale of ownership rights to projects (including the RANB ŻYWFUR project, the KRÓLMET application project and others).
5) Project subcontracting – testing with a machine of the Łukasiewicz – KIT's proprietary design (Kaw-Met Foundry: thermal fatigue testing; Verdent – thermal shock testing).
6) Development of an ICME concept of integrated engineering structural design, material and technology conversion, topological shape optimisation and additive modelling together with the design and implementation of various casting technologies using ANSYS, MagmaSOFT and Flow3D.
7) Additive manufacturing of metal parts and cermets/ceramics by binder jetting (PROGRESJA – Project FENG; Phenix Systems; JG Group) - the perspective is less than 1 year (for metal parts) and ca. 18 months (for cermets and ceramics).
8) Topological optimisation and delivery of workpieces (e.g Prat&Whitney and IMIM PAN): the perspective is 12 to 18 months (in collaboration with the Design and Prototyping Area).
9) Finishing of AM workpieces (316L steel, Ti/Ti6Al4V, Inconel): the perspective is 18 to 24 months.
10) Equipment and technology for electrochemical machining of 30-40 mm artillery barrel bores (Huta Stalowa Wola): the perspective is 18 to 24 months.
11) Device for hybrid additive manufacturing by WAAM and DED/LMD using an industrial robot (the perspesctive is 2 to 3 years).
12) Micro arc oxidation (MAO) coating and surface layer modification technology: the perspective is ca. 36 months.
13) Sale of kits for determining the corrosive effect of machining fluids (Herbert method and Ford-Test).
14) Sale of the Roadmap for the Industry 4.0 Transformation of Business.
15) PVD coating services with modern types of sources (e.g. HIPIMS, DC sputtering, and APA arc).
16) Sale of the rights to use the invention (Polish Patent no. 232267 – "A method of modifying stresses in the surface layer of hardened metal alloys").

2.3. The Centre of New Technologies (CNT)

The CNT carries out research and scientific works targeted on the development of modern and environmentally friendly materials and technological processes in the fields of sustainable energy, valorization and application of biomaterials, as well as technological safety and the application and development of artificial intelligence methods and algorithms in solving industrial problems. The Centre focuses on developing and applying low-carbon footprint processes with low energy demand, implementing abundant and renewable raw materials, and on technological security based on current normative and legal requirements.
The Centre also undertakes activities involving developing new and adapting existing methods and algorithms for machine learning, data analysis, and classification. The research efforts at the CNT are directed towards fuel, energy, metallurgical, medical, chemical, and pharmaceutical industries.



2.3.1. Directions of the CNT's technological development

Renewable Energy Sources (RES) Technology Area

1) High purity materials for photovoltaic applications.

The quality of PV cells is ensured by high purity of silicon wafers. High-purity quartz glass (with an impurity content of less than 30 ppm) is a crucial material during silicon ingots production, which ensures its high quality. To date, purified quartz sand has been used to produce this type of glass, however, the supply of raw quartz suitable for this application is limited. An alternative is to use purified silica.
This material is cheap and abundant, however, the purification to level needed in PV industry, is challenging. In the RES Technology Area new purification techniques will be developed to meet the purity standard of PV industry.

2) Recycling of wind and photovoltaic farm components.

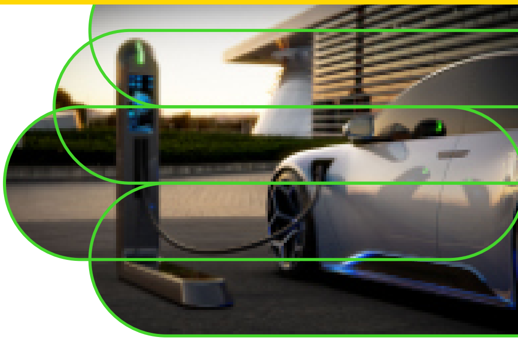
Spent silicon wafers as well as the materials used in their manufacture (like high-purity glass) can be recycled and provide a source of high-quality materials for industry. However, the production process often introduces impurities that must be removed to make the material reusable. Similarly, in the case of wind turbine blades, the materials recovered from spent blades, like glass, could be reused after separation and cleaning. In the RES Technology Area, new techniques will be developed to recycle glass and silicon materials to facilitate their reuse in the production of photovoltaic cells and wind turbine components.

3) Photocells and photocatalysts.

An alternative to electricity generation from PV cells is the direct production of hydrogen and other fuels using photoelectrochemical cells (PEC) and photocatalysts. This direct fuel production facilitates storage and the fuel production at a lower cost than in indirect production. In the RES Technology Area new materials based on TiO_2, iron oxides and other compounds with potential photocatalytic properties will be developed.

4) Testing and optimisation of PV, AgroPV, BIPV and FloatingPV systems.

A number of systems are available worldwide that facilitate application of photovoltaics in agriculture, floating installations, as well as integrated systems with buildings. However, the performance and safety of these technologies, especially in regards of fire protection, requires long-term testing under conditions (e.g. weather) which are typical for Poland. The RES Technology Group together with partners will test such systems in order to ensure their efficient and safety use for Polish users.



Energy Storage Technology Area

1) Recycling of waste lithium-ion batteries.

Spent Li-ion batteries pose a major environmental hazard due to their toxic components, but on the other hand, they are an excellent source of critical metals for reuse. Currently, less than 20% of waste batteries under go any processing, while the technologies used to extract key elements from the waste are based on costly and environmentally harmful chemical and thermal treatment.
The Energy Storage Technology Group, develops sustainable and safe processes for the recovery and reuse of metals from spent Li-ion batteries works on the valorisation of the recovered materials for modern energy storage systems.

2) Development of modern materials for thermal energy storage.

Huge amounts of thermal energy are generated in technological processes or by home appliances, which are unfortunately lost to the atmosphere for the most part. One way to reuse thermal energy (heat) is to capture it in materials that enable long-term storage and controlled release-therefore for utilisation of a strategic resource that is the natural result of various chemical or physical processes.
A research group in the Energy Storage Technology Area is working on development of novel metallic phase-change composites for the storage and reuse of thermal energy.

3) Research on modern materials for Li-ion, Zn-ion and Na-ion batteries.

Due to the high demand for battery technology as well as limited access to the raw materials that build the battery components, there is a necessity for the development of new alternative electrode materials with greater availability, as well as next-generation batteries that provide improved performance and greater safety of operation (which includes protection against shock or ignition) compared to the existing batteries. The Group will study recycled cathode materials from used Li-ion batteries, as well as the use of other, more accessible and cheaper metals for new Li-based batteries. In addition, modern materials for Zn-ion or Na-ion batteries will be developed as alternatives to current solutions.

4) Sustainable production of H_2 gas.

Hydrogen gas as a fuel of the future is a solution with many environmental benefits. There are many sources of H_2 and its use is associated with no toxic or harmful gasses emissions into the atmosphere. Current research works are focused on the production of H_2 by catalytic methods involving aqueous solutions of alkali metal borohydrides, which enable the efficient and safe production of hydrogen gas that can be used in the fuel industry. In addition, planned research will include photochemical electrolysis of water or brine, along with the development of safe hydrogen storage systems for various industrial applications.

5) Treatment of industrial wastewater by sorption and filtration.

Wastewaters from various industries may contain impurities of toxic metals, dyes or organic compounds – such as drug or oil residues – hazardous to environment and humans. The treatment of contaminated water is therefore crucial for the environmental safety. The research is focused on the use of composite materials originating from nature to facilitate the removal and reuse of water pollutants.

Sorption or filtration methods allow efficient wastewater treatment from harmful substances (event from low concentration), providing a water of high quality that meets the municipal tap water or even drinking water standards.

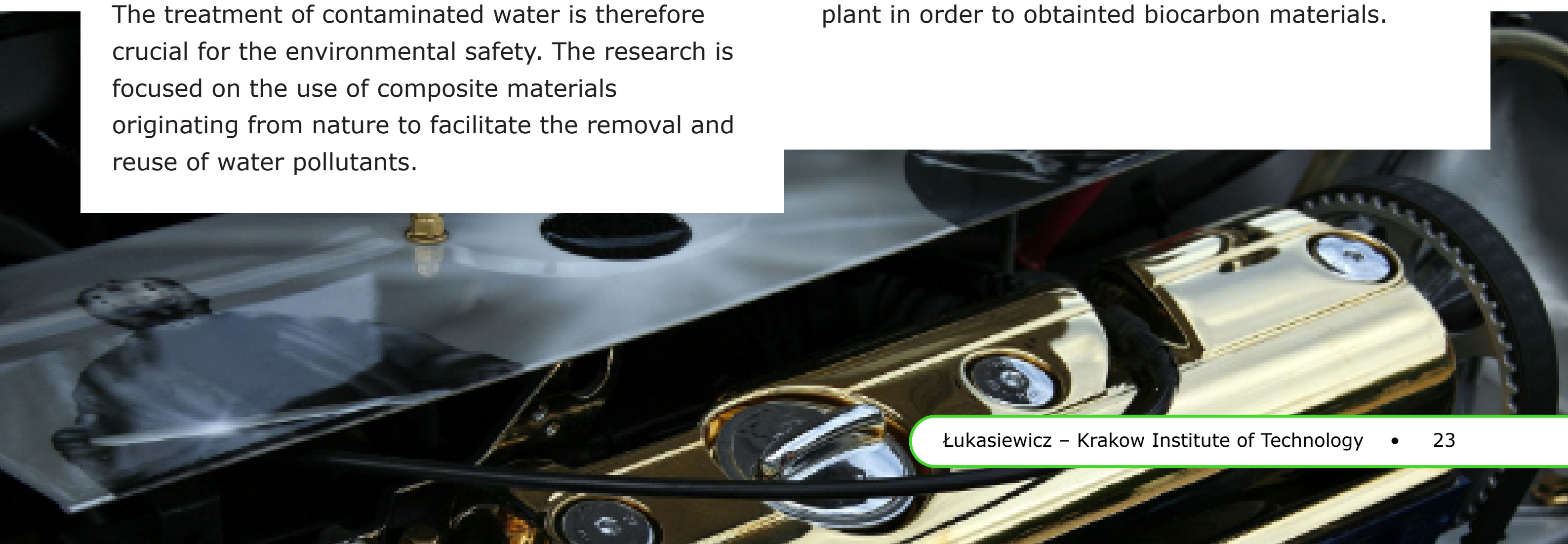
Biofuels Area

1) Electrochemical depolymerisation of lignin.

As one of the most abundant polymers occurring in nature, lignin is currently considered as a by-product of the paper production process. Lignin is a material of a complex structure that contains various functional groups, which makes it a good candidate for the production of less complex chemical compounds (like phenols and alcohols). The electrochemical depolymerisation of lignin carried under controlled conditions facilitates the synthesis of compounds, which can be use for the production of biofuels. In the Biofuels Area, the research works to develop a technology for the production of organic compounds as precursors in biofuels production through depolymerisation of complex polymers of natural origin are planned to be carried out.

2) Production of biocarbon in solar furnaces.

Biocarbon with alkaline properties is particularly attractive as a pH increasing agent for acidic soils. This material is obtained by torrefaction, or mild pyrolysis of biomas. The main product of the torrefaction is a solid biocarbon material with a higher carbon and lower moisture content relative to the substrate. The processing take place at temperatures within 200-300°C, without the presence of air, and under atmospheric pressure. Such processing conditions can be achieved using concentrated solar energy, reducing the toxic impact on the environment. In the Centre development of a new technology based on contracted solar light is plant in order to obtainted biocarbon materials.



Biomaterials Area

1) Delivery of macromolecular biological drugs and low-molecular hydrophobic drugs to diseased tissues.

The main focus of the Biomaterials Group is to design novel carriers for hydrophobic and biological drugs with higher efficacy compared to their commercially available counterparts. The newly designed carriers should protect the drug from degradation during its transport from the site of administration all the way to the diseased tissue, allow the drug to be released directly into the diseased tissue, maximise the efficacy of the drug in the diseased tissue and minimise the number of side effects. The new carriers being developed at the CNT are based on uncrosslinked and crosslinked polymers (both natural and synthetic), surfactants and proteins.

2) Antimicrobial and antifouling coatings.

Conventional coatings of this type contain biocidal substances. The Biomaterial Group focuses on designing coatings that are free of such toxic biocidal additives, while effectively preventing the adhesion of biological material in the form of bacterial biofil, marine plant, and animal organisms. Such coatings are designed using polymers, nanomaterials and electrochemically active particles.

3) Tissue engineering.

This field involves developing biological tissue substitutes to enable the regeneration or replacement of damaged portions of original tissues or even whole organs. It often requires the use of suitable substrates to enable regeneration. It is required that such 'scaffolding' performs at least some of the functions of the natural extracellular matrix, so as to provide a suitable environment for the free differentiation and proliferation of the cells deposited on it. The scaffolding should support the transport of nutrients, signalling molecules and products of cellular metabolism. The research group focuses on the design of scaffolds based on hybrid organic and inorganic materials, in particular those of natural origin for bone tissue and skin regeneration.

4) Safety of biomaterials.

The design of new biomaterials intended for contact with the body tissues and fluids, particularly using synthetic materials and nanomaterials, requires special consideration of safety aspects. The safe use of biomaterials is governed by many factors, including biotolerance, corrosion resistance and mechanical stability. Our focus is on analysing requirements for mechanical properties and chemical resistance under body fluid conditions of biomaterials, and in the future, it is planned to purchase infrastructure that should enable mechanical testing and degradation of biomaterials.

5) Transducers in biosensors.

Transducers are essential elements by which the chemical signal resulting from the presence of the bioanalyte can be translated into another signal, be it optical, electrical, magnetic, mechanical or else. The Group designs transducers for electrochemical and optical sensors and biosensors. The Group's experience includes the design and engineering of:

- electrochemical sensors for the detection of pharmaceuticals in wastewater and/or tap or surface water;
- hydrogel glucose sensors for continuous monitoring;
- hydrogel sensors for specific oligomeric DNA sequences, compatible with e.g. interferometric detection.

Technology Safety Area

1) Ensuring a high level of technology safety.

The Area focuses on the analysis of standardized and legal requirements, as well as risk management for the safety of innovative technologies that may find direct or indirect application in healthcare and other sectors. These technologies combine many scientific fields, contributing to the dynamic development of medical technologies intended to achieve a high level of healthcare, increasing patient safety and improving the quality and length of human life.

2) Demonstration the clinical effectiveness of technologies used in medicine.

The Technology Safety Area is closely related to the area of clinical research, which is intended to assess the safety not only of drugs and treatments, but also of new diagnostic and therapeutic methods. Technology safety is a process that starts with the identification of the relevant standardised and legal requirements and is inextricably linked to evidence based medicine (EBM) and the correct approach to the process of scientific data verification. The EBM approach is related to clinical evaluation – the already mentioned clinical trials – which are part of a full biomedical technology assessment and provide scientific evidence on the effectiveness, clinical efficacy and safety of a biomedical technology.

3) Provision of services to manufacturers and support to other units at Łukasiewicz – KIT.

The Area is involved in R&D projects dedicated to the quality and safety of technologies used in medicine. The CEB's team of experts provides a range of training courses focused on the design, manufacture, conformity assessment and marketing of medical devices, as well as technical, legal and organisational aspects of medical device safety. The team also provides consulting, expert reports and analyses, as well as out quality management audits in the design and manufacture of medical devices.

An additional scope of activity in the Technology Safety Area is to support other units of the Łukasiewicz – KIT in conformity assessment and preparation for certification, marketing and use of medical devices in the EU.

Area of application of artificial intelligence in industry

The area called "applications of artificial intelligence in industry" deals with research in the field of adapting existing and developing new methods and tools in the field of artificial intelligence, machine learning, classification, and data analysis for various industries.

The team has extensive experience and knowledge in creating decision support systems, expert systems, predictive models, data analysis, and defect detection methods. The group has access to the required software and creates its own IT tools.

The scope of the area's activities includes:

- development of expert systems,
- development of digital twins,
- development of predictive models,
- adaptation of existing and development of new algorithms and methods,
- data analysis and classification.

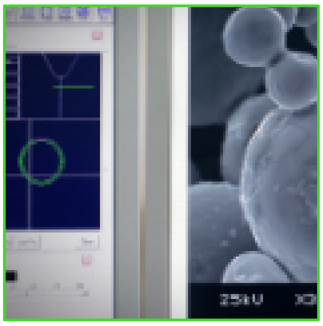
2.3.2. Key directions for commercialisation at the CNT

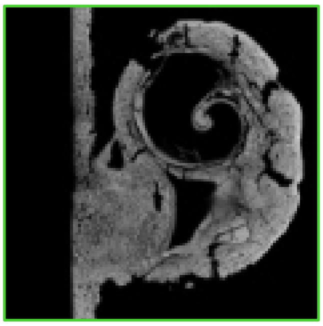
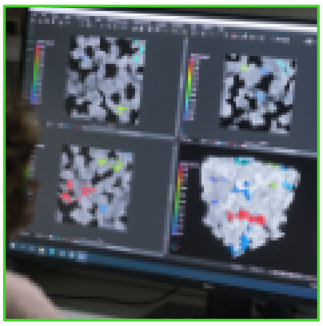
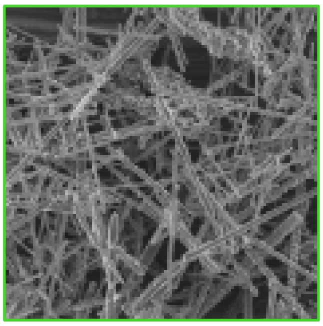
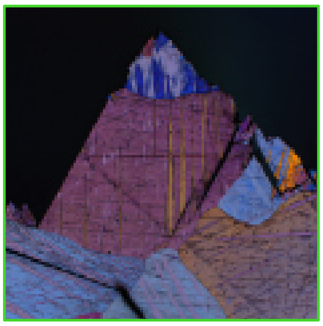
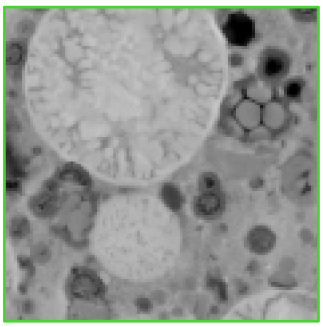
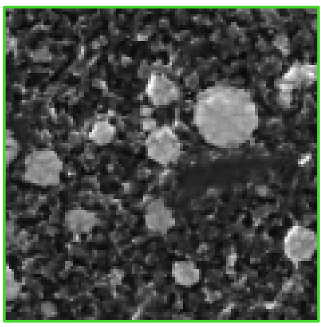
Description of the key commercialisation at the CNT – A diagnosis of the current state

1) Sale of research services for the materials development and testing for the industry (testing of glass and quartz powder samples).

2) Drug polymorphism assay by powder XRD.

3) Execution of expert opinions on the applicability of artificial intelligence methods in industrial processes.



Description of the key commercialisation at the CNT – Plans for the future

1) Sale of research services for the materials development and testing for the industry (development of new high-purity silica-based materials).

2) Testing of photovoltaic cells and batteries.

3) Photoelectrochemical testing.

4) Materials characterisation: SEM-EDS, XRD, phase analysis, texture, structure determination, Raman spectroscopy, UV-VIS, AFM, fluorescence spectroscopy (testing of drug carriers, contaminants, and food).

5) Pilot-scale hydrometallurgical processing.

6) Attachment of dyes and fluorescent molecular probes to proteins, DNA and polymers (chemical modification).

7) Testing of active ingredient permeability through the skin.

8) Building awareness of technology safety through training and technical consulting for technology manufacturers and consumers.

9) Sale of services for analyses and production of clinical data assessments.

10) Consultancy services for risk management, documenting and providing evidence of compliance with safety standards and performance requirements for technologies used medicine, energy and other sectors.

11) Sale of services for the development of a concept for an intelligent information and decision-making system and the designation of key locations requiring automation.

12) Sale of services for the development of the digital twin concept and the predictive model concept.

2.4. Laboratory Department (DL), Production Department (DP), Certification Department (TC), Sales and Business Development Department (DSB)

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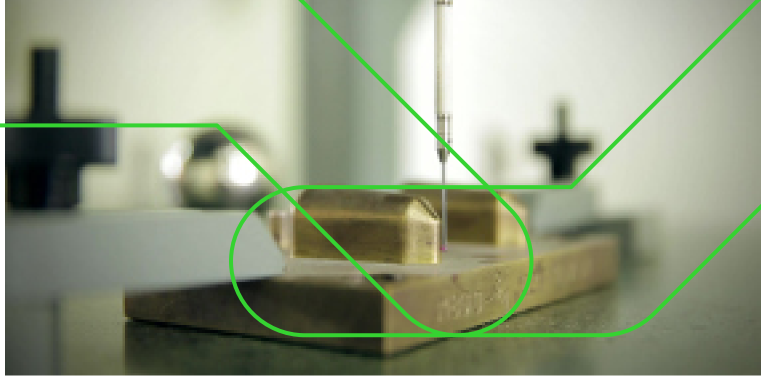
The Laboratory Departmentat at the Łukasiewicz – KIT is accredited by the Polish Centre for Accreditation (PCA) and its operations include these areas:

- Chemistry and Environment;
- Structure and Properties Research;
- Machinery and Equipment Research;
- Geometric Metrology;
- Medical Research, Electrical Equipment and Medical Systems.

Further development of commercial services is planned in the following areas:

1) chemical, mechanical, metallographic, non-destructive testing of products and construction materials (including metals and their alloys, composites, and ceramics);
2) testing of working environment, facilities, buildings, machinery and equipment for:
   - chemical agents (testing of air samples in the working environment: type of particulate matter and concentration of oxides and metals);
   - physical factors (noise, vibration, illumination, indoor climate, and particulate matter levels);
3) acoustic, electrical, electronic and EMC testing;
4) measurements of geometrical quantities:
   - length,
   - angle,
   - surface topography;
5) testing of medical electrical equipment and medical systems in these safety areas:
   - electrical,
   - mechanical,
   - thermal,
   - functional.



Safety testing of medical devices is required for their marketing and is carried out both in the form of in-house testing as part of ongoing R&D work and on behalf of third parties.

Meeting the market's increasing demands on the utility quality of products puts the industry in a position to strictly control technological processes and the quality of materials used in various sectors with high growth potential. The research carried out in the specialised DL laboratory facilities at the Łukasiewicz – KIT and their results are one of the important elements in the process of diagnosing the root causes and formulating conclusions in material expert reports, such as on structural failure, critical material defects, or identification of specific effects of technological process modifications. The implementation of research programs in advanced materials and technologies requires the adaptation of instruments to meet the ever-increasing expectations for precision and accuracy of measurements. The planned development in this area will be the continuous improvement of research techniques and the establishment of a comprehensive laboratory infrastructure, enabling an increase in the number of international projects carried out, as well as work orders commissioned by the industry.

In addition, the Łukasiewicz – KIT operates the Production Department (DP), focusing on the design and manufacture of medical devices primarily for the medical industry (including the area of cardiology and obstetrics) and packaging lines for the pharmaceutical, cosmetic, chemical and food industries. The DP services also include highly specialised machining, as well as prototyping and upgrading of equipment for the automation of production processes and the packaging of liquids and solids. The Łukasiewicz – KIT has the specialised apparatus and infrastructure to perform testing of manufactured products on both laboratory and semi-industrial scales. The planned expansion of the DP range will be driven by the results of the Łukasiewicz – KIT's R&D activities and market demand diagnosed by the growing Sales and Business Development Department (DSB).

The scope of services offered by the Certification Department (TC) at the Łukasiewicz – KIT as an independent product certification body in the area covered by the accreditation of the Polish Centre for Accreditation and beyond, as well as in the area notified to the European Commission, includes:

- **Certification of constancy of performance and conformity of factory production control of construction products in the national and European regulatory area, especially for:**

  - products for concrete reinforcement and prestressing,
  - covers and manhole tops, inspection chambers and gullies,
  - structural metal products and ancillary components,
  - rockfall protection kits and steel nets and cages for gabions.

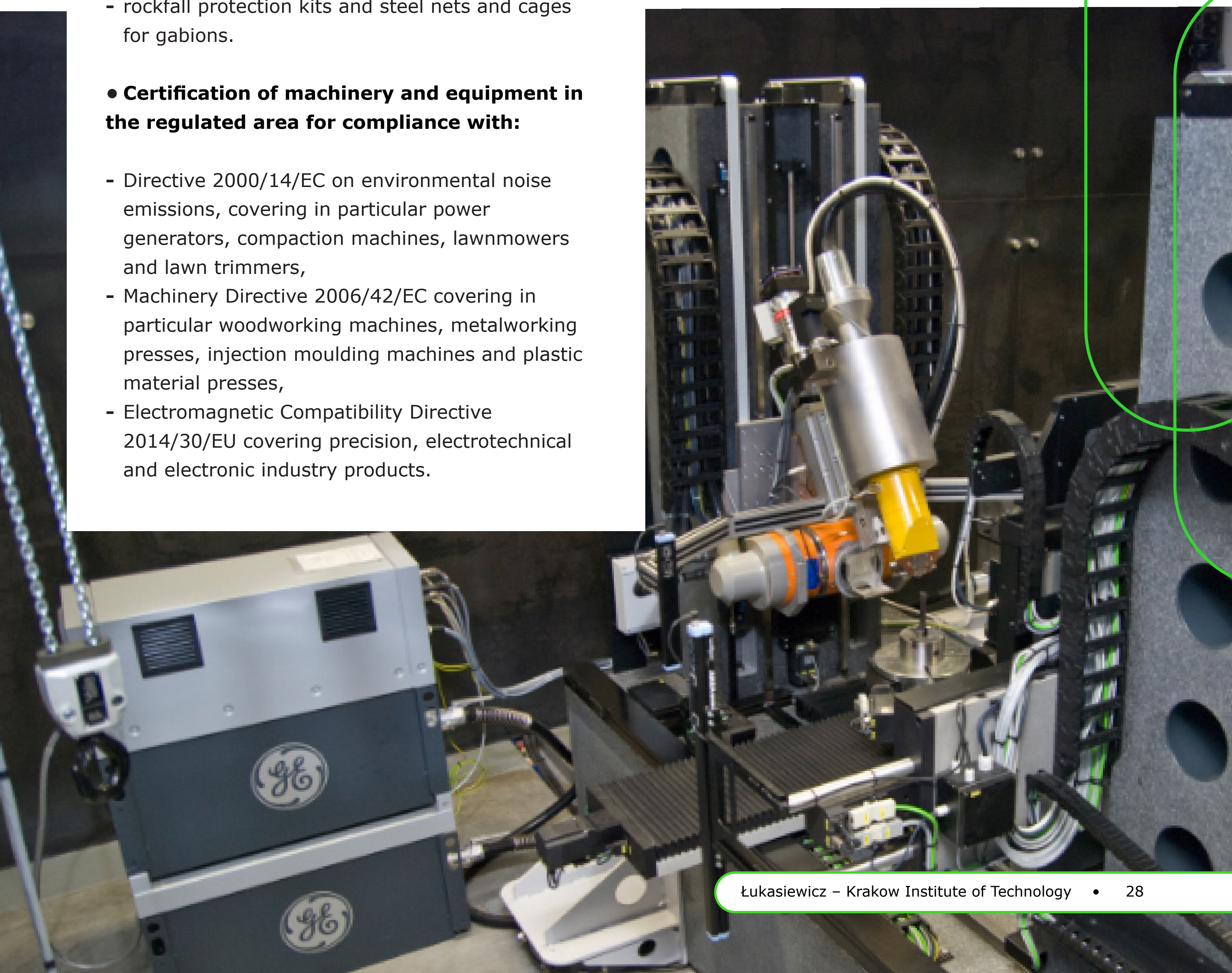
- **Certification of machinery and equipment in the regulated area for compliance with:**

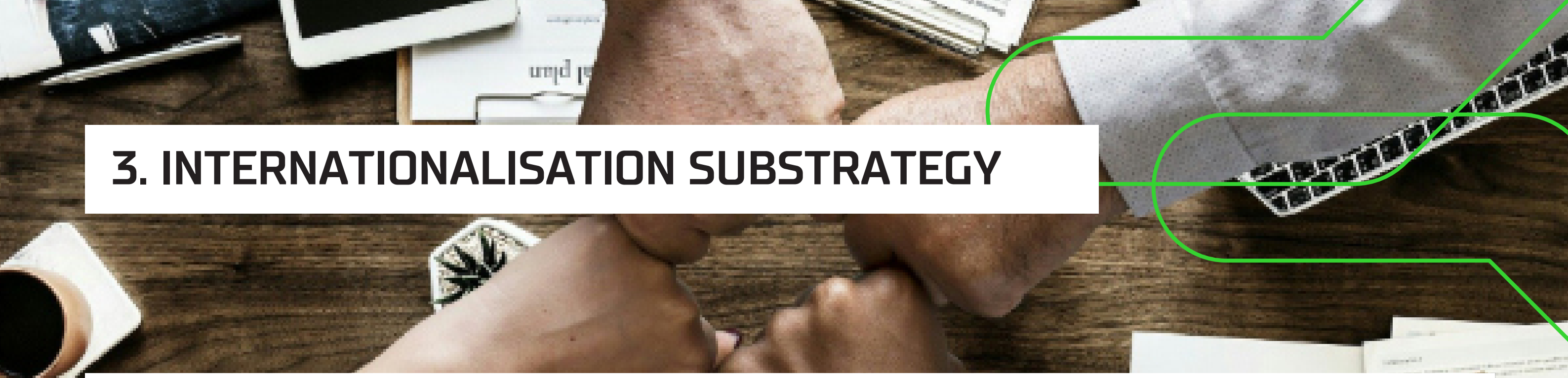
  - Directive 2000/14/EC on environmental noise emissions, covering in particular power generators, compaction machines, lawnmowers and lawn trimmers,
  - Machinery Directive 2006/42/EC covering in particular woodworking machines, metalworking presses, injection moulding machines and plastic material presses,
  - Electromagnetic Compatibility Directive 2014/30/EU covering precision, electrotechnical and electronic industry products.

- **Voluntary product conformity certification for e.g. sewerage systems and road equipment, pipes and fittings, water and central heating systems valves, auxiliary materials for the casting and metallurgy industries, as well as machinery and equipment for the metal, wood and food industries.**

- **Voluntary B-mark certification of conformity for abrasive tools, rotary brushes, and cutting tools for metals, wood and plastics.**

The Certification Department (TC) is planned to have its work task team expanded and continue its current business. There are also plans to expand the scope of accreditation and subsequent notification to the European Commission for the new European Union Machinery Regulation.





3. INTERNATIONALISATION SUBSTRATEGY

There are plans to increase the level internationalisation of personnel at the Łukasiewicz – KIT, the share of foreign workers in which is now very low. There is virtually no documentation in English, and the Łukasiewicz – KIT does not have adequate support mechanisms in place for international recruitment and hiring.

The HR operations that should be carried out at the Łukasiewicz – KIT in to increase the level of internationalisation should include several key areas: increasing communication in English, fostering the employer brand, increasing the competitiveness of the Łukasiewicz – KIT's offer, deployment of relevant recruitment panels, continued DEI (Diversity, Equity and Inclusion) policy and the need to implement transparency in the Łukasiewicz – KIT's operating principles.

It is planned to saturate the Łukasiewicz – KIT research teams with scientists from abroad, create joint research teams with foreign scientists, increase the Łukasiewicz – KIT's participation in international projects – especially those financed by the HE Program – sell products and services, and to commercialise the technologies from the Łukasiewicz – KIT on foreign markets.

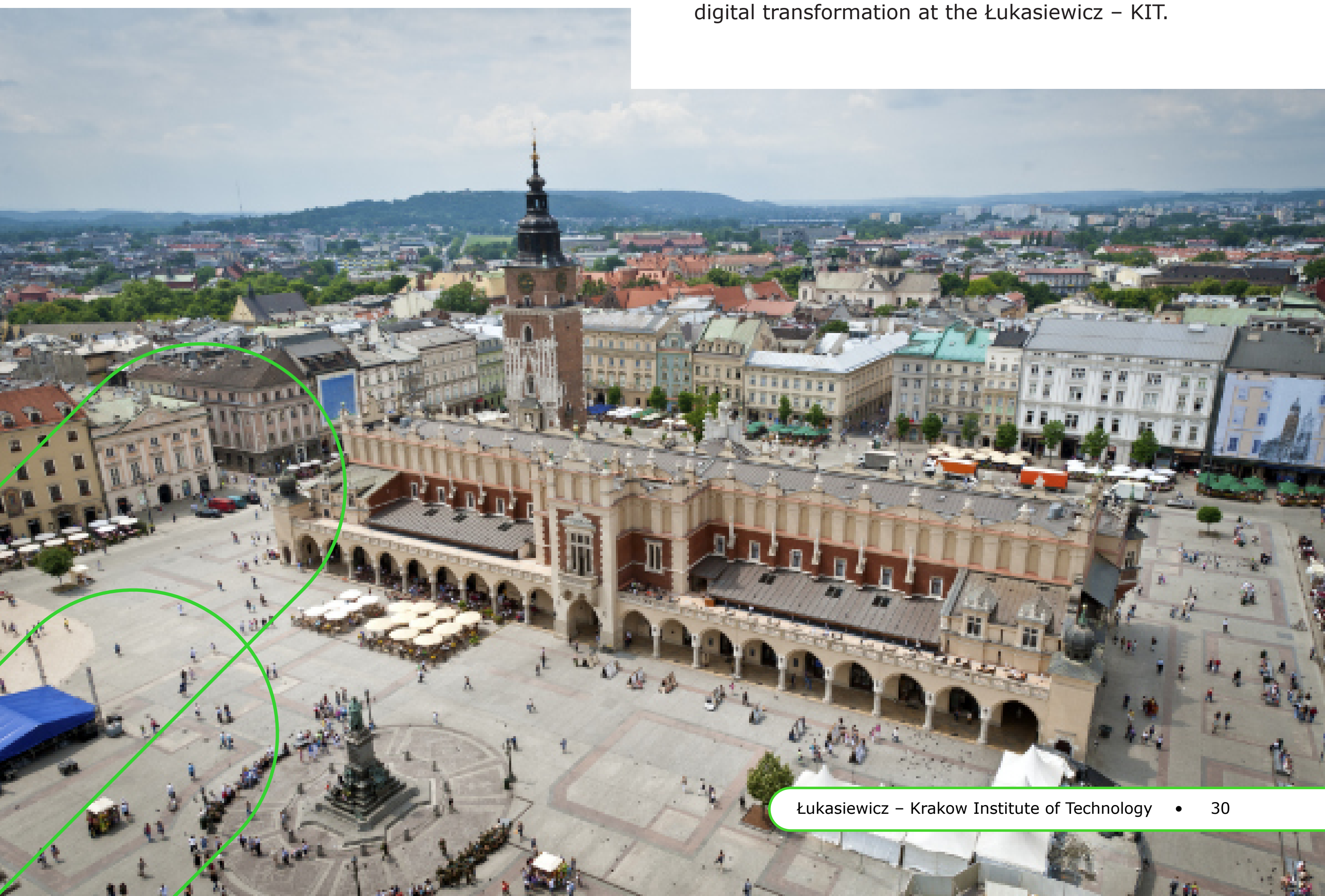
The strength of the Łukasiewicz – KIT is its R&D staff, which, as of 2019, has enabled the KIT to win and implement many international projects and to start collaborations in many fields. These activities must be supported and continued.

Sale of products and services		R&D projects	
Countries to which products and services have been sold in the years 2019-2023 (since the founding creation of Łukasiewicz)	Countries planned to sell products and services to	Countries with which there has been collaboration on R&D projects in the years 2019-2023 (since the founding creation of Łukasiewicz)	Countries planned to have cooperation in R&D projects with
Germany, Spain, United Kingdom, Norway, France, Sweden, Finland, Lithuania, Tunisia, Canada	Norway, Germany, Czech Republic, Slovakia, Ukraine	Tunisia, Slovakia, Estonia, Spain, France, Germany, Sweden, Czech Republic, Austria, Brazil, USA, UK, Greece, Norway	Italy, Norway, Ukraine, Austria, Italy, Germany, UK, China Spain, South Korea, Slovenia, Croatia, Lithuania, Switzerland, USA, Sweden

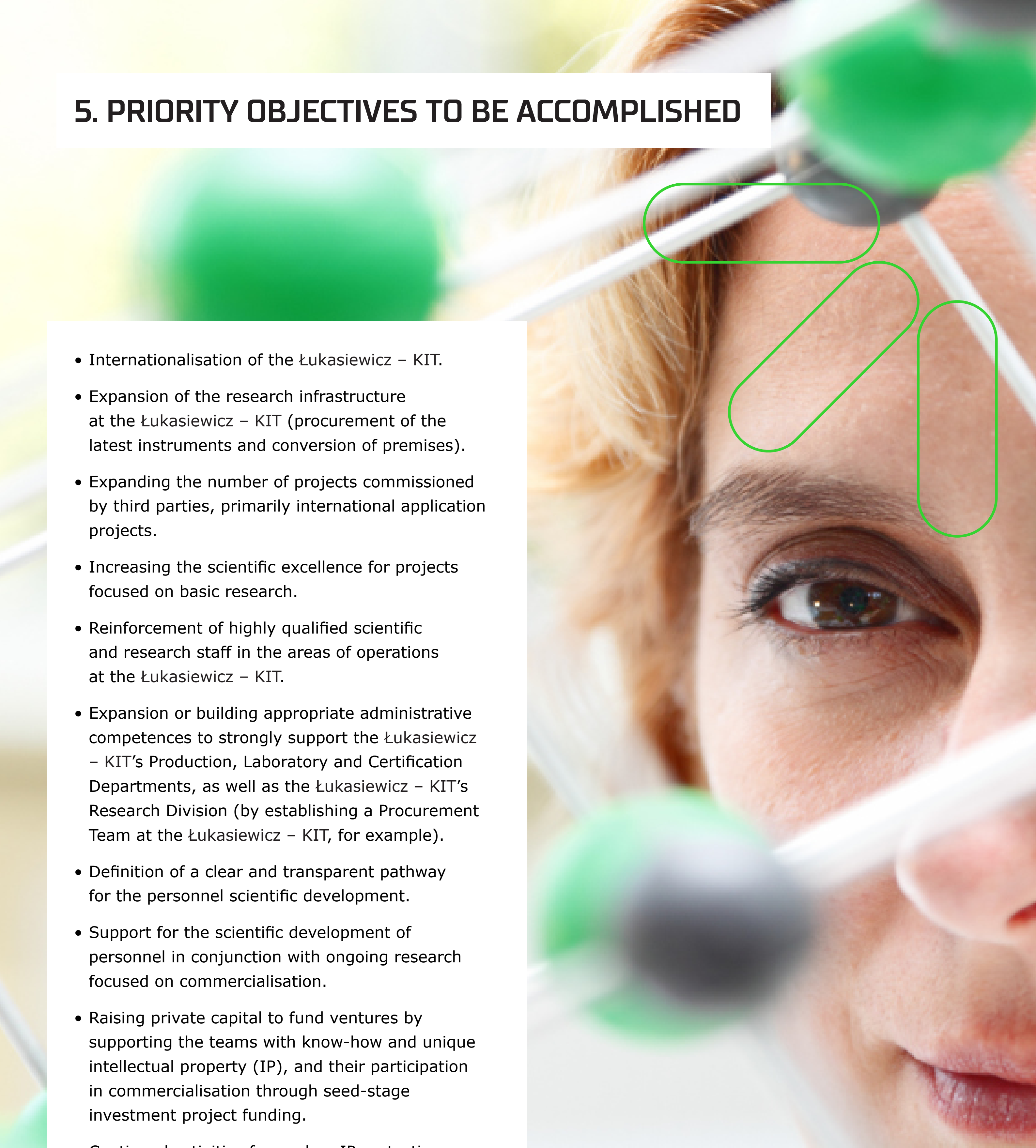
4. INFRASTRUCTURE SUBSTRATEGY

The Łukasiewicz – KIT has a number of properties in attractive locations in Krakow and Zabrze. Together they are an important asset that provides great opportunities; however, considering the age and repair of both heavy and light infrastructure, the asset demands multiple retrofitting actions. The plans for the coming years include both the upgrading of specific buildings and actions towards better use of the property, considering the guidelines of the Charman of the Łukasiewicz Centre which regulate the basic issues related to the Łukasiewicz Research Network Institutes' legal transactions concerning the disposal of fixed assets which will be served by the model lease agreement implemented at the Łukasiewicz – KIT and prevailing in the Łukasiewicz Research Network.

Together with other Łukasiewicz Institutes, the Łukasiewicz – KIT completed the data in the Research Infrastructure Database. The Łukasiewicz – KIT is confronted with the need to renew and purchase selected light infrastructure, as well as to develop a decision-making process to ensure clear decision-making criteria for the procurement of new research equipment. One of Łukasiewicz – KIT's priorities is to urgently provide modern IT infrastructure to establish a new server room and enable secure data storage (backup storage). To improve the work efficiency and make its IT services professional, including an improved level of cybersecurity, it is necessary to continue the digital transformation at the Łukasiewicz – KIT.



5. PRIORITY OBJECTIVES TO BE ACCOMPLISHED



- Internationalisation of the Łukasiewicz – KIT.
- Expansion of the research infrastructure at the Łukasiewicz – KIT (procurement of the latest instruments and conversion of premises).
- Expanding the number of projects commissioned by third parties, primarily international application projects.
- Increasing the scientific excellence for projects focused on basic research.
- Reinforcement of highly qualified scientific and research staff in the areas of operations at the Łukasiewicz – KIT.
- Expansion or building appropriate administrative competences to strongly support the Łukasiewicz – KIT's Production, Laboratory and Certification Departments, as well as the Łukasiewicz – KIT's Research Division (by establishing a Procurement Team at the Łukasiewicz – KIT, for example).
- Definition of a clear and transparent pathway for the personnel scientific development.
- Support for the scientific development of personnel in conjunction with ongoing research focused on commercialisation.
- Raising private capital to fund ventures by supporting the teams with know-how and unique intellectual property (IP), and their participation in commercialisation through seed-stage investment project funding.
- Continued activities focused on IP protection, knowledge and technology transfer to the economy, and implementation programs.

6. INTELLIGENT NATIONAL SPECIALISATIONS (INS) AT THE ŁUKASIEWICZ – KIT

INS #1. HEALTHY SOCIETY

I. RESEARCH AND DEVELOPMENT OF MEDICINAL PRODUCTS
III. RESEARCH AND DEVELOPMENT OF INNOVATIVE FOOD SUPPLEMENTS AND FOODSTUFFS FOR SPECIAL NUTRITIONAL USES
IV. MEDICAL DEVICES AND EQUIPMENT
V. MEDICAL TECHNOLOGIES
VI. MEDICAL INFORMATION TECHNOLOGY TOOLS
VIII. MARKERS/TESTS
IX. TELEHEALTH
X. COORDINATED HEALTHCARE
XII. CLINICAL TRIALS

INS #2. MODERN AGRICULTURE, FORESTRY AND FOOD

XIII. CUSTOMISED FURNITURE PRODUCTION

INS #3. SUSTAINABLE (BIO)PRODUCTS, (BIO)PROCESSES AND THE ENVIRONMENT

II. INNOVATIVE (BIO)TECHNOLOGICAL PROCESSES

INS #4. SUSTAINABLE ENERGY

I. ENERGY GENERATION
III. ENERGY STORAGE
IV. RES
V. PROSUMER ENERGY

INS #6. SUSTAINABLE TRANSPORT

I. INNOVATIVE MEANS OF TRANSPORT
II. SUSTAINABLE DESIGN SOLUTIONS AND COMPONENTS IN THE MEANS OF TRANSPORT
IV. INNOVATIVE MATERIALS IN THE MEANS OF TRANSPORT
V. INNOVATIVE TECHNOLOGIES FOR THE MANUFACTURE OF MEANS OF TRANSPORT AND THEIR COMPONENTS

INS #7. CIRCULAR ECONOMY

I. ECODESIGN FOR CIRCULAR ECONOMY
II. EXTRACTION AND USE OF RENEWABLE AND NON-RENEWABLE RESOURCES
III. PROCESSING AND PRODUCTION
V. SOLID AND LIQUID WASTE

INS #8. ADVANCED MATERIALS AND NANOTECHNOLOGY

I. ECOLOGICAL, BIOMIMETIC, BIONIC AND BIODEGRADABLE MATERIALS AND NANOMATERIALS WITH ENVIRONMENTAL FOOTPRINT, CIRCULARITY, WASTE GENERATION MINIMISATION, CLEANER TECHNOLOGY AND NANOTECHNOLOGY, INCLUDING REASONABLE USE OF POLYMERIC MATERIALS
II. MULTIFUNCTIONAL AND NANOSTRUCTURAL MATERIALS WITH RADICALLY ENHANCED NEW FUNCTIONALITY AND THEIR TECHNOLOGIES
III. ULTRALIGHT, ULTRA-SMALL AND RADICALLY ENHANCED HEAT-RESISTANT AND REFRACTORY COMPOSITE MATERIALS AND NANOMATERIALS
IV. ADVANCED MATERIALS AND NANOMATERIALS FOR RENEWABLE ENERGY, ENERGY CONVERSION, STORAGE AND ENERGY EFFICIENCY
V. COMPOSITE MATERIALS AND NANOMATERIALS WITH MATRICES OR REINFORCEMENT OF NANOFIBRES, NANOWIRES AND NANOTUBES, INCLUDING CARBON NANOMATERIALS, AND THEIR TECHNOLOGIES
VI. ADVANCED MATERIALS, TECHNOLOGIES AND NANOTECHNOLOGIES FOR PRODUCTS WITH HIGH ADDED VALUE AND HIGH RELEVANCE TO INDUSTRIAL VALUE CHAINS, INCLUDING 3D AND 4D ADDITIVE MANUFACTURING TECHNOLOGIES

VII. ADVANCED MATERIALS AND NANOMATERIALS AND TECHNOLOGIES AND NANOTECHNOLOGIES FOR MEDICAL AND HEALTHCARE USE AND ENGINEERINGM, AND BIOLOGICAL MATERIALS INVOLVING LIVING TISSUES AND CELLS
VIII. ADVANCED MATERIALS AND NANOMATERIALS AND TECHNOLOGIES AND NANOTECHNOLOGIES FOR SECURITY APPLICATIONS
X. MODELLING AND SIMULATION, USE OF DATABASES AND DIGITAL TWINS FOR STRUCTURES AND PROPERTIES, AND COMPUTER AIDED DESIGN AND MANUFACTURING OF MATERIALS AND NANOMATERIALS

INS #9. ELECTRONICS AND PHOTONICS

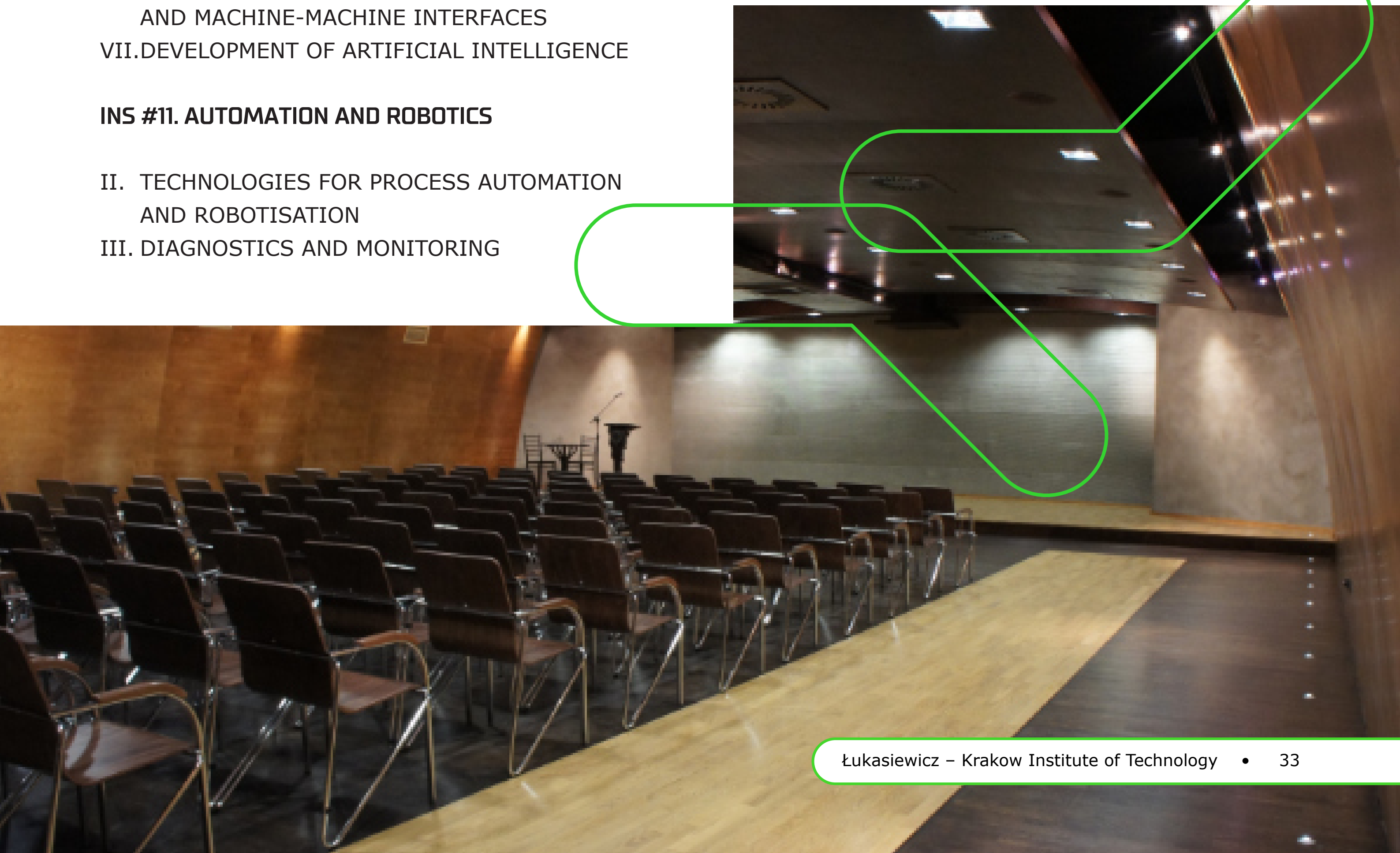
I. SENSORS AND DETECTORS (DESIGN, TECHNOLOGY AND MATERIALS)
V. SENSOR AND TELECOMMUNICATIONS SYSTEMS AND NETWORKS
VII. INNOVATIVE TECHNOLOGIES AND SYSTEMS FOR PRINTED ELECTRONICS
VIII. APPLICATION PROBLEMS

INS #10. INFORMATION, COMMUNICATION AND GEOSPATIAL TECHNOLOGIES

III. ARCHITECTURES, SYSTEMS AND APPLICATIONS FOR SMART GRIDS
V. MIXED REALITY, HUMAN-MACHINE AND MACHINE-MACHINE INTERFACES
VII. DEVELOPMENT OF ARTIFICIAL INTELLIGENCE

INS #11. AUTOMATION AND ROBOTICS

II. TECHNOLOGIES FOR PROCESS AUTOMATION AND ROBOTISATION
III. DIAGNOSTICS AND MONITORING



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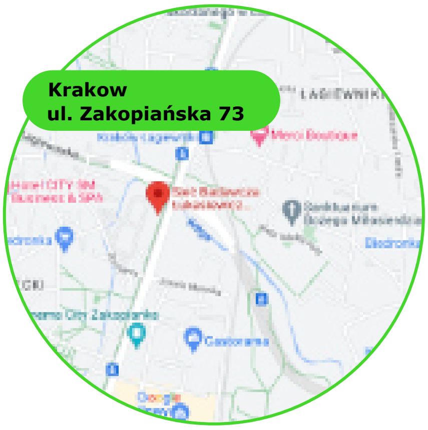

Headquarter
entrance from Zbrojarzy street