SHAPING THE FUTURE, TOGETHER

JOANNEUM RESEARCH

JOANNOVUM

THE MAGAZINE FOR TECHNOLOGICAL INNOVATIONS
PRODUCTION AND MANUFACTURING

02/2025

PRODUCTION AND MANUFACTURING

For humans – quality and sustainability

IN FOCUS

JOANNEUM RESEARCH

EXPLAINING SCIENCE – SCIENCE MADE SIMPLE

Hello, Johan and Resi

Follow Johan and Resi on YouTube and Instagram where they provide a fascinating insight into some of the work being done at JOANNEUM RESEARCH in a series of shorts and reels – clear, easy to understand and in English.

Instagram	YouTube shorts	www.joanneum.at

Editorial

PHOTO: BERGMANN

Heinz Mayer
Managing Director,
JOANNEUM RESEARCH

The current economic and political environment in Europe is the subject of much discussion. And rightly so, with Europe now needing to position itself as a location for business and industry, given that the rapid pace of development is primarily attributable to China and the USA. The challenges of our time are global. So let's respond to them together. This is the inspiration behind the motto for this year's Zukunftstag event: "Global minds, local moves".

We need to concentrate on our strengths: research and development in situ, with a clear commitment to quality, sustainability and the wider benefits to society. Production in Europe is much more than an economic factor for the continent. It's a guarantee of job security, high standards, fair conditions and sustainable value added. European strengths such as technological excellence and a qualified expert workforce as well as a fundamental appreciation of quality and the environment put us in a position to develop innovative solutions for increasingly individualised and resource-saving production. Technologies that are commercially viable for production runs of just a single unit, to take one such example, are the key to greater sustainability: less waste, lower consumption of resources and more security. Here, research provides a foundation for products and processes that are tailored to individual needs without losing sight of efficiencies or responsibilities. And that is where our strength lies.

But it takes more than good ideas to ensure that innovations actually reach the market, rather than being left to gather dust in a drawer somewhere. All of this calls for functioning networks, the conviction to act and close cooperation between all concerned – from research to business and politics. Only by working together can we speed up the transition to manufacturing and services and generate social value added that benefits everyone.

Find out more about our successful joint projects here. We wish you an enjoyable read!

Heinz Mayer

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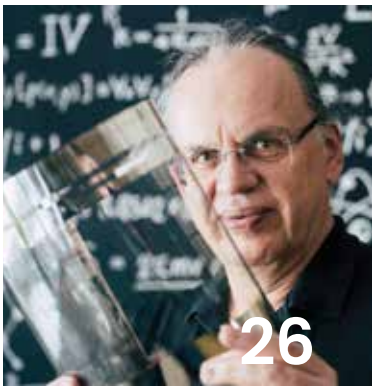

SPECIAL COMMISSION

How specialist research is shaping the industrial world of tomorrow: the unstable international environment is leading to distortions in the world economy, which is posing problems for globally-networked industry. We talked to Ulrich Trog and Daniele Cozzi, coordinators at the JOANNEUM RESEARCH Production and Manufacturing business area, about the latest trends and developments, as well as the challenges facing Austria as an industrial location.

by Petra Mravlak

Ulrich Trog (l) and Daniele Cozzi have been responsible for coordinating the Production and Manufacturing business area since 2024. Their role revolves around unlocking the potential of the internal network and enabling a robust presence in this sector.

PHOTOS: BERGMANN

> We focus on niches such as functionalised surfaces, and laser and plasma technologies, as well as sustainable production processes that are both resource-efficient and climate-friendly.

What are the latest trends in production and manufacturing?
Cozzi: Digitalisation, sustainability, automation and cybersecurity are the big topics. Artificial intelligence is a central driver, with technologies such as machine learning, predictive analysis and digital twins enabling real-time optimisation, quality control and predictive maintenance.
Trog: In future, robotics will feature more heavily in other applications than it has done to date. And not just in situations that involve the production of highly standardised parts and large volumes, either. By way of example, robots can be used in kitchens to make sandwiches containing different ingredients. This is a new form of automation for small runs in service operations.
Cozzi: Exactly. Supported by AI, automation enhances human-machine interaction. Beyond that, it also supports production processes – while additive manufacturing and innovative coating technologies, such as inkjet printing, open the door to even more flexible and individually customised manufacturing.
How are things looking in terms of the competitiveness of the industrial sector in Austria and Europe? Where are the opportunities, what are the challenges?
Cozzi: The opportunities can be found in high-tech areas where precision and quality are in demand, such as the automotive industry, aviation, optics, electronics and medtech. Austria benefits from its excellent research infrastructure and partnerships with industry, which make custom solutions possible. It is qualified experts and its innovative capabilities that make Austria competitive. And thanks to its strong research play, Styria leads the way in Europe when it comes to R&D intensity.
Trog: But still, we can't rest on our laurels, we need to keep moving forward. R&D intensity alone doesn't deliver innovation. What we are missing in Austria is a pronounced culture of entrepreneurialism and investing. There are countries where the R&D density is lower, but the appetite for innovation is much greater.

As coordinators of the Production and Manufacturing business area at JOANNEUM RESEARCH, where are your focuses?
Trog: Our business area brings

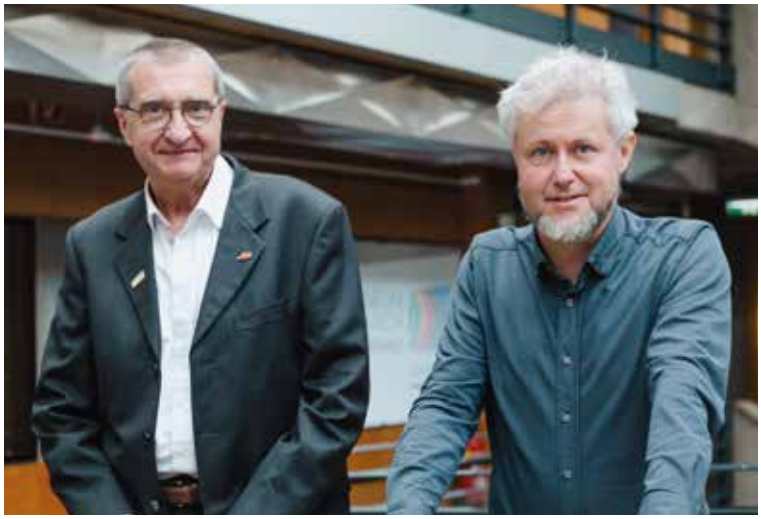

PHOTO: BERGMANN

together different approaches and areas of expertise from the different institutes and research groups, such as artificial intelligence and machine learning, digital twins, additive manufacturing and statistical methods as well as technologies to support the circular economy and life cycle assessments. Our goal is to bundle this far-ranging expertise in the company, while making it visible – and understandable – to the outside world. Which is why, as the Production and Manufacturing team, we are looking to increase our presence at shows, conferences and events.

JOANNEUM RESEARCH is already working in various national and international expert committees and clusters. Here, our goal is to clarify our own positioning and unlock synergies. We will accomplish this by coordinating content across the organisation and communicating with a clearer focus through the individuals who are already established members of the various committees and clusters.

Talking of internationalisation – what are the focuses here?

Cozzi: One of the key regions in this respect is northern Italy. We signed a strategic cooperation agreement with the University of Udinese back in 2018, which has since led to a number of joint projects as well as PhD projects in our laboratories for additive manufacturing. Over the past few years, we intensified partnerships with South Tyrol's innovation system, particularly with the Free University of Bozen-Bolzano and NOI Techpark. In 2024, JOANNEUM RESEARCH became a member of the innovative SMACT Competence Center in north-eastern Italy – making it the first non-Italian research institution to join. This development has opened up partnerships with numerous innovative companies in one of the most technologically advanced regions of Europe.

Trog: We need to take our cue from the global elite. Parts of the world such as the Netherlands and Flanders are already showing how to be a global leader in specific niches. And we ought to work with these regions and learn from them.

Where do JOANNEUM RESEARCH's strengths lie?

Cozzi: Our strengths lie in our interdisciplinary expertise and the ability to develop custom solutions for industry. In the Production and Manufacturing business area, what sets us apart is our top-level research in the fields of surface technologies, photonics, additive manufacturing and collaborative robotics. Precision manufacturing and analytic technologies at the micro- and nanometre scale are among the examples of what our labs make possible. We focus on niches such as functionalised surfaces and laser and plasma technologies, as well as sustainable production processes that are resource-efficient and climate-friendly at the same time.

Trog: Exactly. Interdisciplinarity is our biggest strength. We are on a very broad footing as far as the individual topics are concerned. But it is just as important to concentrate on a number of outstanding niches and build on our already strong standing in these areas. We have established a reputation as a stable and valued parter in national and international collaborations as well as EU projects, often over the course of many years. What will be important for the future is for us to concentrate more on commercialisation though translating our research outcomes into real-world products and services.

PHOTO: BERGMANN

Looking to the future now, what will define Austria as a manufacturing location in 20 years' time?

Cozzi: As a manufacturing location, Austria will assume a pioneering role in high-tech production driven by artificial intelligence, cybersecurity, digitalisation and sustainability.
Trog: Right now, though, we are in the midst of a deep crisis. We basked in the light of past achievements for too long and failed to spot that other parts of the world had caught up. For the future, we need to make sure that we reclaim our place in the international vanguard in a few niche areas. As such, sustainability is an important topic and will remain so, too. Pretending otherwise would be a mistake, as it will actually open up fresh opportunities for doing things differently – and better. And that is what innovation is all about! But we have to be faster and take action.
Cozzi: Additive manufacturing will offer even faster and better production opportunities. And cybersecurity has a decisive role to play when it comes to assuring the resilience of digital production systems and fending off cyber threats. Ultimately, AI will revolutionise manufacturing by optimising processes through predictive analysis, digital twins and autonomous systems.

Are our production facilities set to become "dark factories" in future, i.e. devoid of human beings?
Cozzi: That's only a realistic prospect in some sectors. Dark factories could become more important in standardised applications such as electronics manufacturing, but human expertise will continue to be indispensable in areas like custom production and research. Ethical, social and commercial aspects call for a balanced strategy in which AI and cybersecurity increase productivity, while supporting human beings – instead of replacing them. In areas that call for complex and creative processes, humans will continue to play a central role
Trog: AI use is still in its infancy. In many areas we still need to find out where it really can be a useful tool for us and where it doesn't live up to the hype. I firmly believe that there are things that only people can do: in situations that involve complex and creative processes, such as sales and R&D as well as product design. Education will be key. The task at hand is to identify the overarching trends and ensure that young people are trained appropriately.

JOANNEUM RESEARCH

Rolle-zu-Rolle-Nanoimprint-Lithografie (R2R)

Die R2R-Pilotanlage ermöglicht

- **Umweltverträgliche** Herstellung hochaufgelöster leitender Strukturelemente für die organische Elektronik (feine Leiterbahnen, nanoskalige Elektroden für organische Transistoren)
- **Präzise** Erzeugung optischer 2.5D-Strukturen für das Management von Licht in Folien (Ein- und Auskopplung, Lichtleitung) für Anwendungen in der Photonik
- **Großflächige** Realisierung von strukturierten bionischen Oberflächen und komplexen Nanostrukturen, die Effekte aus der Biologie technisch nutzbar machen (Haifischhaut zur Strömungsreibungsreduktion, Lotuseffekt zur Schmutzabwehr und Selbstreinigung, Geckoeffekt zur klebstofffreien Adhäsion, Mottenaugen zur Antireflexion und Strukturfarben zur farbstofffreien Dekoration)
- **Kostengünstige** Fertigung von komplexen mikrofluidischen Elementen in Folie als Basis von Biosensoren für Lab-on-Foil Analysesysteme
- **Kontinuierliche** Produktion von veredelten High-Tech-Folienoberflächen für Verpackung, Dekor, Sicherheit und Etikettierung, die durch Mikro- und Nanostruktureffekte verbesserte optische, mechanische und chemische Eigenschaften aufweisen

Mehr Informationen
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MITEINANDER ZUKUNFTSRELEVANT

UP GRADE

ATMOSPHERIC PLASMA COATING

by Petra Mravlak

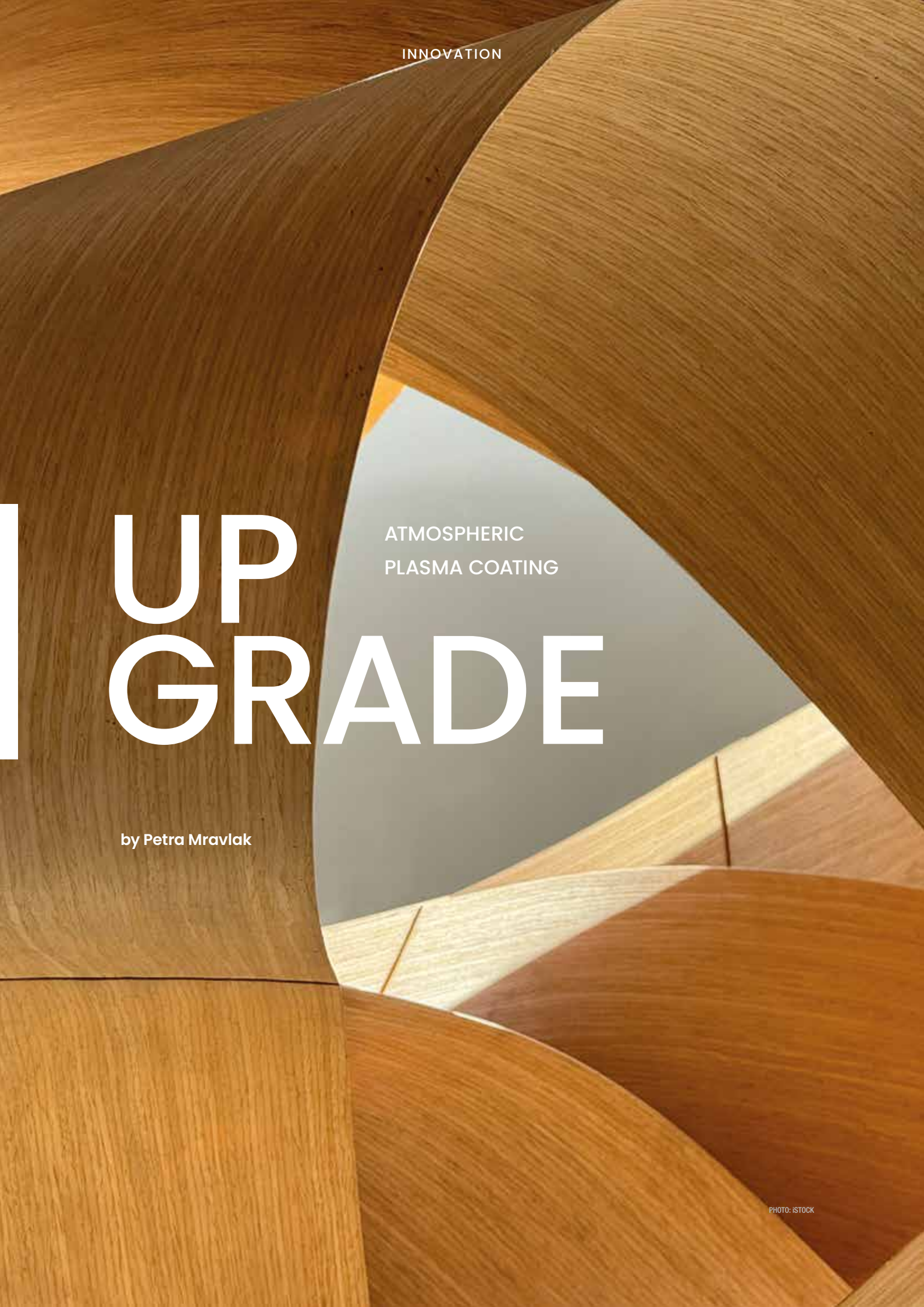


PHOTO: iSTOCK

Atmospheric plasma coating – the process of applying plasma in air without the need for a vacuum – is enabling the direct functionalisation of wood and other bio-based materials. This environment-friendly breakthrough means that conductive tracks can be applied onto materials directly, which eliminates the need for plastic films. JOANNEUM RESEARCH is exploring new avenues for sustainable interior architecture and intelligent material applications at its base in Niklasdorf.

As the name suggests, atmospheric pressure plasma coating uses a type of plasma that is generated at standard atmospheric pressure. Initially, a gas mixture is ionised before being precisely directed onto the material surface. This process enables the deposition of various functional layers, including electrically conductive structures as well as water-repellent coatings and adhesion-promoting interlayers. One of its key advantages is that it does away with the need for vacuum chambers – a development which makes atmospheric plasma coating particularly scalable from a commercial point of view, while delivering exceptional ecological sustainability due to the very low CO_2 footprint now associated with it. "The technology allows us to integrate functions into materials in a completely new way, without the need for environmentally harmful chemicals or energy-intensive processes," explains Jürgen Lackner, a researcher at JOANNEUM RESEARCH MATERIALS.

Applications and advantages
The technology is used to seamlessly integrate functional but invisible elements into wood and natural materials. Under one potential application, heating or sensor elements
can be directly integrated into furniture or wall panelling. And processing the raw material directly allows its natural look and feel to be maintained. "It is in sustainable interior architecture in particular that we are seeing major potential, as it allows us to integrate smart functions into natural materials, without changing their outward appearance," Lackner adds.

Researchers at JOANNEUM RESEARCH are collaborating closely with INO GmbH to advance this technology (see also page 39). While Jürgen Lackner's team focuses on driving fundamental research and process optimisation forward, the INO team is concentrating on scaling the technology for industrial deployment. Another research partnership involves the Wook K plus competence centre for wood research. Various industry partners including EGGER HOLZ, F/List, and Technoholz are testing the technology in real-world product developments. Roll-to-Roll (R2R) processes and robot-supported coating enable large-area application on both sheet and roll materials.

Less plastic
Atmospheric pressure plasma coating significantly reduces the plastic content of functional bio-based materials. This not only results in more durable and repairable surfaces but also facilitates easier recycling. This technology is opening up new possibilities for sustainable and multi-functional material use, especially in interior architecture, vehicle manufacturing and aerospace. Through continuous development and adaptation to industrial requirements, atmospheric plasma coating is set to become a key technology for resource-efficient production and smart material solutions in the future.

Jürgen Lackner and his team were awarded the Styrian Innovation Prize 2025 and secured second place in the 2025 Houska Prize for their atmospheric plasma coating research.

PHOTO: ALEXANDER MÜLLER

Prize winner Jürgen Lackner (third from left) and his colleagues accepted the coveted research award alongside Yasin Kececi from project partner INO.

PHOTO: CHRISTIAN WIND

In 2023, JOANNEUM RESEARCH won the Houska Prize for the HEALTH Institute's OFM technology.

JOANNEUM RESEARCH DIGITAL

LiTrack 360

Intuitive 3D-Erfassung räumlicher Daten mit LiDAR-Technologie

LiTrack 360 bedient sich eines hybriden Festkörper-LiDAR-Sensors, der in Kombination mit SLAM-Methoden (Simultaneous Localization And Mapping) eine präzise Echtzeit-3D-Erfassung von räumlichen Daten ermöglicht. Die Technologie erfasst detaillierte 3D-Informationen von Umgebungen und realisiert so eine präzise Modellierung und Kartierung mit minimalem Einrichtungs- und Rechenaufwand. Über die reine Visualisierung als Nutzerfeedback hinaus wird die Qualität der Daten durch die Integration von Stereoinformationen verbessert, wodurch genaue 3D-Modelle erstellt werden können. Durch die präzisen 3D-Karten ermöglicht die Technologie nicht nur Effizienzsteigerungen in traditionellen Branchen wie Bau, Holzindustrie oder Robotik, sondern eröffnet auch neue Möglichkeiten in Design und Virtual Reality. Die Verortungstechnologie kann auch in anderen Szenarien - wie der Echtzeit-Lokalisierung und Navigation für autonome Fahrzeuge oder Roboter, die in unstrukturierten Umgebungen wie Lagerhäusern oder Baustellen agieren - eingesetzt werden.

Mehr Informationen

INCLUSIVE ROBOTICS

PHOTO: ISTOCK

Human-robot collaboration is opening up new horizons for a more diverse world of work. In the SAFEIVERSE project, the ROBOTICS Institute is working with JOANNEUM RESEARCH's POLICIES Institute to develop production workplaces where machines adapt to people to make sure that they are safe and inclusive spaces. Key Researcher Clara Wiederschwinger-Fischer underlines the importance of the project for society.

By Renate Buchgraber

Funded by the Carinthian Economic Development Fund (KWF), the project is supported by various institutions, including disability advocacy organisations, which are involved in the development process from an early stage. Companies that are looking to make their own production processes more inclusive are also participating.
In addition to workplace design, the project also focuses on adapting machines to people's needs. Rather than simply analysing how people interact with machines, the central question is now: "How can machines adapt to people?" Under one scenario, robots take stock of the situation using sensors. Camera systems or sensors can be used to recognise whether a wheelchair user is approaching and adjust the table height accordingly.
A similar response could also be triggered by registration chips that prompt visual rather than acoustic warning signals, supporting barrier-free use in the process.
Beyond the positive impact of advances like this on society, there are economic benefits, too. Research shows that inclusive technologies can help to reduce long-term absences due to sick leave while also improving ergonomics for employees.
The idea is that workplaces of the future will be more flexible, more autonomous, and more human-centric as they adapt to the abilities of the employees – for example, through individually adjusted working heights or assisting robots that reduce physical strain.
Meanwhile, AI-driven systems will make it possible to recognise employees' needs early and respond to them individually.

Clara Wiederschwinger-Fischer is a Key Researcher at the ROBOTICS Institute in Klagenfurt. She studied mechanical engineering at TU Wien and did her doctorate in robot safety. Her research focuses on safe and inclusive human-robot collaboration.

PHOTO: FIEDLER

HYPERSPECTRAL ANALYSIS DELIVERS

DEEP INSIGHTS FOR ZERO DEFECTS

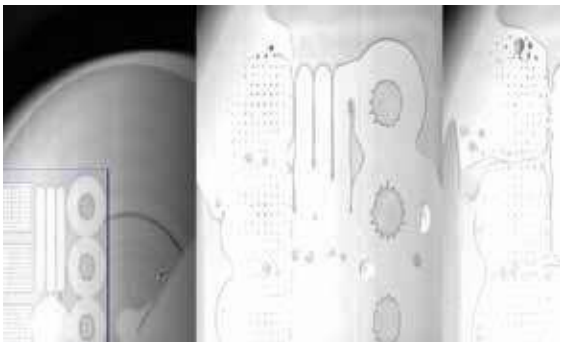
In the FFG-funded MILAM project, a system has been developed that uses hyperspectral analysis and artificial intelligence to detect defects in the 3D printing of ceramic components – before they have a chance to take shape.

By Elke Zenz

In industry, additive manufacturing is used to produce complex ceramic components, such as rods, lattice structures, gears and impellers (rotating parts in pumps) as well as plates with fine internal structures. Of particular relevance are the kinds of applications that call for high precision and material density – for instance in sensor technology, medical engineering and microsystems technology, where even the smallest air inclusions can impair the function of the component.
However, in industrial 3D printing of ceramic parts, fine defects can potentially occur during the manufacturing process – and especially those tiny air inclusions in the material. While often invisible to the naked eye, these bubbles can compromise the stability or functionality of the part in question. In the Austrian Research Agency-funded MILAM project (Production of the Future), Harald Ganster's team at DIGITAL conducted research into how best to identify sources of error during the printing process, rather than after – using image processing, hyperspectral analysis and AI.

Early defect detection during printing
"We developed a camera-based monitoring unit that was integrated directly into a 3D printer supplied by our industry partner Lithoz GmbH. It pinpoints air bubbles as well as potential contaminants in the liquid material – what we call slurry – before each layer is cured. And because these cameras provide high-res images of every single printed layer, we have the basis for automatic analysis already in place," explains Ganster.
The data they gather are not only stored but also evaluated with the help of artificial intelligence. The aim is to detect any bubbles automatically and assess whether they could potentially compromise the integrity of the component. This involves a number of modern deep learning techniques, including convolutional neural networks (CNN) and specially adapted variants such as YOLO (You Only Look Once). The AI identifies structures in the images, classifies them as potentially critical or non-critical bubbles and learns from each new dataset.

Hyperspectral analysis – material insights
In addition to image analysis with standard cameras, the project also employed something called hyperspectral analysis – a measurement technique that not only captures an image, but an entire light spectrum for each pixel. This makes it possible to determine material-specific properties such as the degree to which an individual layer has cured.
"We have our own hyperspectral laboratory at our site in Graz, where these tests were carried out. In the lab, different states of the printing material could be an-



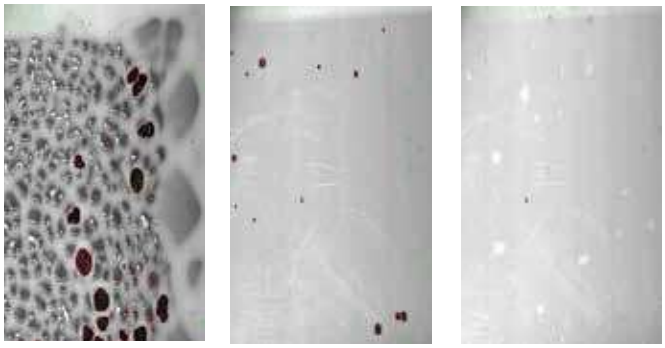


PHOTO: JOANNEUM RESEARCH/DIGITAL

Top: test objects with inline scans
Bottom: inclusions in the material

PHOTO: BERGMANN

Harald Ganster has worked as a Key Researcher in industrial image analysis for 20 years. He is also the Deputy Head of the Intelligent Vision Applications research group. His research interests span pattern recognition, classification (including statistical and AI-based methods), sensor fusion, hyperspectral analysis, and industrial and medical image processing.

alysed and optically distinguished from one another. Initial results show that cured and uncured areas can be clearly differentiated – although there are still challenges at transitions between different degrees of hardness. So hyperspectral analysis provides valuable additional information for process monitoring," Ganster explains.

AI superpower

The use of AI for automatic detection and classification of air bubbles proved particularly successful in the project. To achieve this, large quantities of image data were collected and then labelled manually (annotated) before being used to train neural networks. "Using AI not only allows us to detect air bubbles, but also lets us analyse their shape, size, contrast and position," says Ganster. Defects, such as larger inclusions inside the component, can be identified automatically using this approach. The occurrence of bubble clusters – multiple inclusions in one spot – can also be detected. Ganster: "One major technical advance came through aligning the camera images with the print plan so that we could clearly distinguish whether a bubble was actually inside the part or outside it. This is crucial, as it avoids false alarms that cause costs and delays."

From the lab to real-world use

The "demonstrator", i.e. the developed monitoring system, was successfully deployed several times in the research printer. The data obtained were compared with high-resolution CT scans. The result speak volumes: if the camera does not detect a bubble, the CT shows no defects either. This underlines the reliability of the system. "Our partner Lithoz is currently exploring different ways for the method to be incorporated into future product lines. That's a strong indication of the project's relevance, from both a technological and commercial perspective," the hyperspectral analysis expert confirmed, outlining its potential.

Thanks to MILAM, 3D printing processes for ceramic components have been made significantly more transparent and reliable. The combination of camera-based bubble detection, hyperspectral analysis and AI-supported evaluation is a promising approach to picking up defects early on and fundamentally improving quality assurance in the printing process.

PATRICIA NEUMANN

RESEARCH AS THE KEY

HOW SIEMENS IS STRENGTHENING AUSTRIA AS A LOCATION FOR BUSINESS THROUGH RIE AUT

PHOTO: ANDI BRUCKNER

Patricia Neumann is CEO of Siemens AG Austria.

As a location for business, Austria has come under serious pressure over the past few years and the economy faces a number of major challenges. Global mega-trends such as climate change and digitalisation are compelling us to respond with sustainable and innovative solutions. Without a strong underlying research and development landscape, the competitiveness of our nation is under threat. Siemens Austria is spearheading a mindset shift through its Research & Innovation Ecosystem (RIE AUT), which illustrates how cross-university cooperation can become the engine for progress.

But Siemens RIE AUT is more than just a research project – it's a strategic initiative that is designed to promote key areas like sustainable mobility and energy-efficient production as well as digital transformation. By expanding the scope of the cooperation to now include the Technical University of Leoben and TU Wien alongside the long-standing partnership with TU Graz, we are ensuring that new approaches and research findings are transferred directly into new technologies and solutions. As these solutions are not exclusively aimed at meeting our customers' needs, they also contribute to a more resilient economy by combining innovation and sustainability.

And our approach is not limited to technological advances, either; it also extends to talent development. By collaborating with academic start-ups and supporting young talent like this, we are actively strengthening the foundations for sustained economic success. This investment in people is just as important as developing new technologies, as it's the only way that we can remain competitive in the long term.

Austria has long been a reliable hub in the global innovation landscape, but that alone is no longer sufficient. Without a stronger research sector, we will fall behind. We need targeted collaborations such as RIE AUT so that we can stay relevant in the long run. Siemens is demonstrating that this is a viable path – through impactful research and partnerships that drive innovation. Ultimately, this demonstrates how the future can not only be managed but actively shaped, too – and that is precisely the mission of Siemens Austria.

EMERGING TALENT

PHOTO: BERGMANN

Žiga Pisar is a mechanical engineer specialising in applied industrial and collaborative robotics. As a researcher, he works in the Industrial Robotic Systems Technologies group at ROBOTICS – the Institute for Robotics and Flexible Production – in Klagenfurt.

What is the focus of your research?
Pisar: I work in the field of industrial robotic systems, where we research and develop customised robotics solutions. CAD-based trajectory planning for robots from different manufacturers is one of my core specialisms. This approach makes it possible to simulate and program complex robot movements within a virtual environment, without having to actually program the robot itself. With the support of our team and project partners from MATERIALS, MCL, alphacam, TECHNIA and Aviation Invest, we have applied these methods in the ongoing Austrian Research Promotion Agency project 3D-Strain-Sense. For the first time, we have successfully combined two technologies – inkjet printing and the precision of robots.

What is the broader context of this research? What can it achieve?
Pisar: Fuel efficiency is of critical importance in modern aerospace engineering and has far-reaching implications. Produced using additive manufacturing (3D printing), bionically-optimised aircraft components help to reduce the weight of non-critical structures without compromising structural integrity. By printing electronic sensors directly onto these parts, we are able to monitor internal forces and deformations in real time. This innovation also paves the way for a shift from preventive to predictive maintenance, which reduces the amount of unnecessary replacements made while also improving reliability. In this project, our goal was to find a way to print strain gauges onto complex, double-curved surfaces. To achieve this, the robot moves the part at a constant surface speed beneath a stationary print head. The print head deposits droplets of conductive ink directly onto the curved surface, which forms the sensor geometry.

How did you get into your profession?
Pisar: I've always been fascinated by science and machines. I will never forget the first time that I saw this large, orange industrial robot arm. This initial encounter with robots left a lasting impression on me, and from that moment on I just knew that I had to work with machines in one way or another. So I made sure that I aligned my studies and my career to this interest. After completing my bachelor's degree and master's in mobile robotics, I built up extensive experience working in the research sector. I fine-tuned my abilities in laser welding with robots as well as robot-supported rehabilitation. After several years in industry spent working on the development and construction of robot cells, it was time for me to return to the research world. JOANNEUM RESEARCH offered the perfect environment to take my career forward, while remaining at the cutting edge of innovative robotics.

POLE POWER

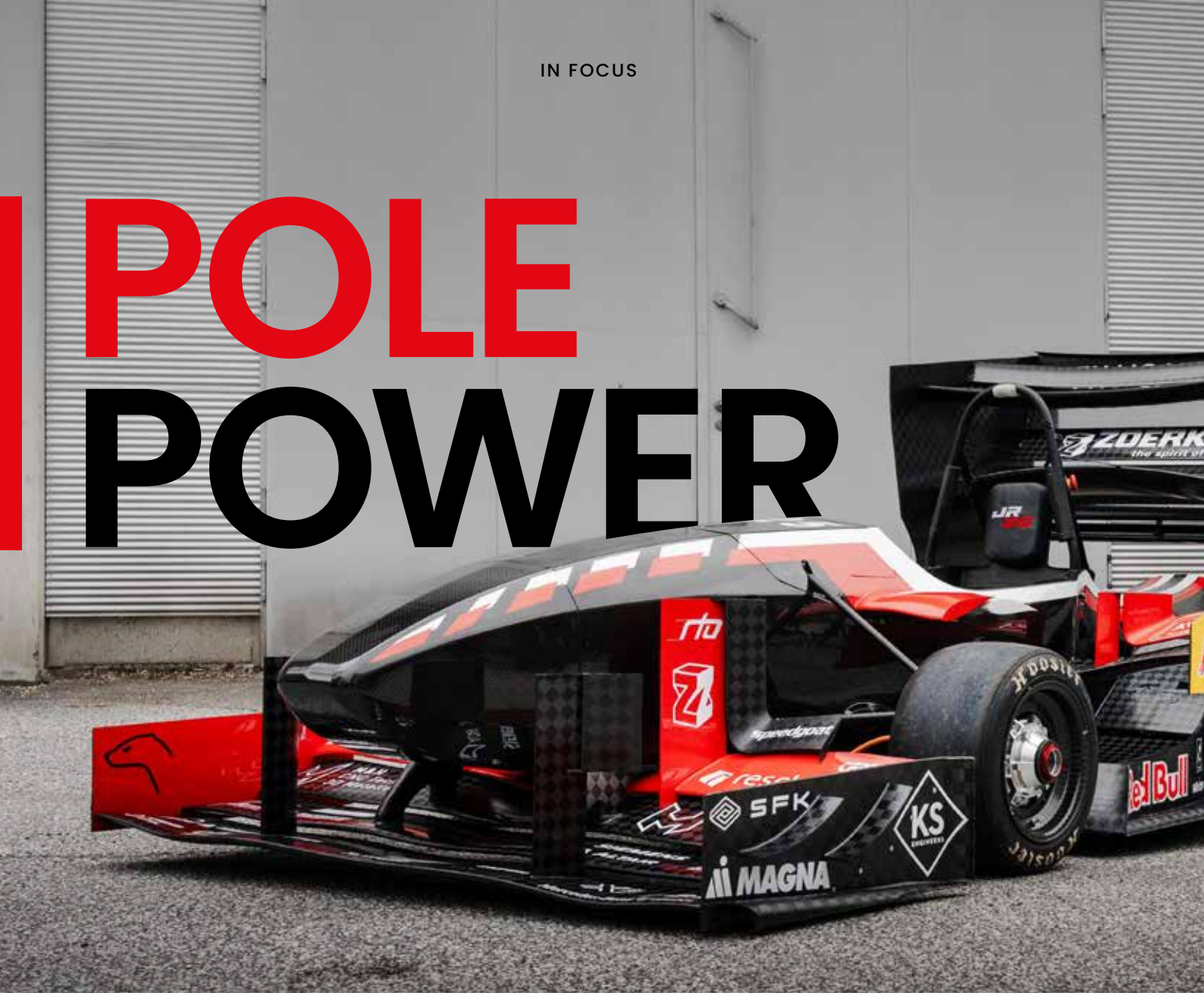


PHOTO: FH JOANNEUM/HASLER

Winning racing car brimming with expertise from the MATERIALS Institute: with two overall wins in a row, the 2025 racing season was a runaway success for FH JOANNEUM's Joanneum racing team. The Niklasdorf-based MATERIALS Institute was on board with a key contribution: the battery and motor housing.

E-racing car kitted out with cutting-edge tech: the Laser and Plasma Technologies research group at JOANNEUM RESEARCH's MATERIALS Institute in Niklasdorf supported the students of Joanneum Racing Graz, the Formula Student team from FH JOANNEUM Graz, with its expertise.

Laser welding of battery contacts

Raimund Krenn and his team put their know-how to good use in the batteries used in the racing car: for each individual cell, a 0.2mm thin copper sheet that the current flows through was joined to a battery terminal with the help of a laser. With ten battery packs installed in the vehicle in total, this amounts to 28 cells and a total of 280 laser-welded contacts – every single one of which must function perfectly. "Long-term durability and low resistance are essential for success," says Krenn. Ever since Joanneum Racing Graz switched to the electric class in 2022, the batteries for each season have been welded at MATERIALS.

By Petra Mravlak

Right: the 3D-printed motor housing

Bottom: the FH JOANNEUM team with Raimund Krenn (second left) and Thomas Prethaler from MATERIALS (middle)

PHOTO: FH JOANNEUM

PHOTO: JOANNEUM RESEARCH/RAISER

Motor housing hot off the 3D printing press

For the first time this year, the housing for the high-performance vehicle's air-cooled motor was also produced in Niklasdorf. The sophisticated structure originated in a 3D printer. With an aluminium alloy at its core, the special printing process at its heart is known as laser powder bed fusion. The material delivers an optimal strength-to-weight ratio, as well as favourable mechanical properties. 3D printing offers several advantages over conventional manufacturing methods: "Complex geometries and structures such as the ones found in this particular motor housing are difficult to produce by turning, milling, casting or forming. 3D printing also supports low-volume production runs and is ideal for integrating internal channels and cavities, which can serve as sensor mounts, among other things," explains Jelena Petrusa from the Laser and Plasma Technologies research group.

Top season for Joanneum Racing Graz

The Weasels – as the FH JOANNEUM racing team is known – secured overall victory in the electric class at two events in the 2025 Formula Student series: at the Red Bull Ring in Spielberg in Austria and at the Autodrom Most in the Czech Republic. And only in 2024, the students achieved an outstanding second place in the Formula Student Electric world rankings. Each year a new team is formed, comprising a group of vehicle engineering students and participants from other degree programmes such as electronics, manufacturing, PR and design. Within the season, a racing car is created in accordance with the Formula Student regulations, before competing on the international circuit against more than 700 teams worldwide.

REAL-WORLD APPLICATIONS

PREDICTIVE MAINTENANCE FOR SAW MILLS

By Renate Buchgraber

PHOTO: iSTOCK

In June 2025, a joint innovation project was launched to explore how data-driven maintenance solutions can be implemented in traditional manufacturing environments such as sawmills – with a focus on condition monitoring and predictive maintenance in the timber industry in this particular instance. The aim is to develop and test digital tools that enable the early detection of maintenance needs in sawmill production equipment. By integrating sensor technologies and artificial intelligence, the project seeks to reduce downtime while optimising maintenance processes and improving overall production efficiency. A team of mathematicians from the POLICIES Institute is providing the data science expertise that underpins the work.

How predictive maintenance works

Predictive maintenance uses existing process and sensor data to forecast the condition of machine components through data-driven models. Ultimately, the goal is to identify potential failures early and initiate targeted maintenance before unplanned stoppages can even occur. The models involved are trained on historical data and continuously updated as new information becomes available. Here, data preparation is a key challenge: sensor data must be extracted, integrated, checked for quality, and correctly interpreted. After all, it is only through a robust, high-quality data foundation that models can deliver reliable predictions and contribute to operational efficiency gains.

Condition monitoring at the sawmill

While the underlying concept may sound straightforward, real-world implementation presents challenges of its own. For example, selecting appropriate physical parameters – such as temperature and vibration – and determining optimal measurement locations is often highly specific to the individual plant. And particularly in older facilities, critical variables and data from machinery can only be captured through retrofitting with additional sensors. The project team has addressed this by expanding the digital infrastructure with retrofitted sensors attached to key machine components (e.g. saw blades, drives, bearings, and conveyor belts). This enables real-time condition data to be collected and fed into a superordinate predictive model. As a result, data can be extracted from computer-controlled systems, linked with external algorithms, used to detect anomalies, and analysed to forecast maintenance requirements – enhancing cost-effectiveness and efficiency.

The joint project is being implemented in cooperation with DIH Süd and FH JOANNEUM.

Four timber processing companies are involved

- Winterholz Sägewerk GmbH, Carinthia
- Bruno Ruhdorfer GmbH, Carinthia
- LSB Lärchenholz Buchhäusl GmbH, Carinthia
- Kaml & Huber Sägewerk Holzexport GmbH, Styria

XR: MORE THAN GAMING

By Elke Zenz

PHOTO: JOANNEUM RESEARCH

A team from ROBOTICS explored hands-on, efficient, and accessible ways to teach complex concepts centred on working with robotic arms — drawing on extended reality or XR for support. An approach that saves both time and costs.

Robotic arms – also known as manipulators – are now an indispensable feature of many industries. They can be found performing welding, assembly and painting tasks in automotive manufacturing, populating circuit boards in electronics production, and picking and packing goods in logistics. They are also used in food processing, pharmaceuticals, and recycling – anywhere that involves precision, repetition or physically demanding operations. As a result, workers in these sectors need continuous upskilling to ensure that they are able to work safely and effectively alongside their new mechanical colleagues.

The fundamentals of robotic arms – their structure, movement and kinematics – can be hard to compute for humans. In an EU-funded project dubbed MANIPULAY XR, Bernhard Reiterer and a team from ROBOTICS in Klagenfurt joined forces with design and technology studio POLYCULAR to lower this particular barrier to entry. Built on the MASTER XR platform, the project delivers an intuitive virtual reality environment that lets users build and program robotic arms. XR is an umbrella term for a number of immersive technologies, including virtual reality (VR), augmented reality (AR) and mixed reality (MR). All of these tools help to bring digital content to life within real or virtual settings. In the case of MANIPULAY XR, the power of XR is harnessed as an interactive channel for communicating technical content relating to robotic arms.

Bernhard Reiterer explains how it works: "Everything revolves around interactive puzzle-based learning sequences. Learners combine basic components – joints, links, and grippers – to solve predefined challenges, such as generating collision-free waypoint sequences. Programming centres on a block-based interface, where different cubes represent the movements of individual joints. A virtual 3D printer even allows users to create their own programming elements. Through repeated adjustments to both the design of the robot and the program itself, users gain intuitive insights into kinematics and control."

A conscious decision was taken to give the system an open and modular design. Besides offering pre-designed learning paths, MANIPULAY XR also supports the development of custom task formats. "Our project provides ready-made learning paths as examples and gives educators the tools they need to design their own puzzles – based on various scenarios such as a real-world robot model or one of the kinematic systems that is outlined in the literature," Reiterer continues. The platform also facilitates the flexible integration of additional content such as text, video and audio guides.

Bernhard Reiterer is a Senior Researcher at the ROBOTICS Institute. He specialises in modern 3D technologies, which he deploys in digital twins and interactive simulations.

PHOTO: FIEDLER

Co-funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union. Neither the European Union nor the granting authority can be held responsible for them.

HUMANS. MACHINES. TOGETHER.

The EU project FAIRWork is bringing humans, AI and robots to the table – well, the production line. Instead of profit maximisation, the focus is firmly on employee well-being. A team from JOANNEUM RESEARCH's DIGITAL Institute is using the latest technology from the Human Factors Laboratory to strike the necessary balance between efficiency and empathy.

By Elke Zenz

The EU's Industry 5.0 initiative may sound a little like science fiction, but it is aimed at bringing about a very specific change: ensuring that technology is no longer geared solely to boosting efficiency, but to empowering workers, too. Rather than maximising profits, individual well-being is what counts, with top-down decision-making giving way to employee participation – with the support of artificial intelligence. This is where researchers on the European FAIRWork project (which is funded through the HORIZON EUROPE programme) come in. Coordinated by Vienna-based BOC Products & Services AG, the project has brought together numerous partners – including the JOANNEUM RESEARCH DIGITAL Institute, Stellantis, flex, and various European universities. The goal is to design decision-making processes that are more human-centric, democratic and trust-based – cultivating heart and soul in industry, you might say.

Workers under pressure

Demands on manufacturers are growing all the time – which also puts greater pressure on employees. According to Austria's Federal Chamber of Labour, around 2.5 million days of sick leave taken in the country each year are due to mental health- and stress-related conditions. "Through the FAIRWork project, we're addressing this development with specially designed technological solutions," explains Lucas Paletta, Head of the Human Factors Laboratory at DIGITAL. These include automated analysis of calibration certificates – previously performed manually, this process is both time-consuming and prone to errors. Now, though, a newly developed AI can identify missing or contradictory specifications in documentation, which saves time as well as enhancing accuracy. No longer left with mountains of data to trawl through, employees can focus on value-adding tasks instead. A more efficient approach – which also delivers peace of mind. Here, AI serves as an assistant for decision-making: it analyses complex production data, recognises patterns and, on this basis, proposes possible courses of action that are tailored to a given situation – as well as clear and transparent for employees. Ultimately, though, the final decision is always taken by a human – because AI should support people, not replace them.

Delicate touch

Lucas Paletta and DIGITAL Senior Researcher Herwig Zeiner are making an important contribution to the project together with their team. Researchers at the Human Factors Laboratory use the latest wearable technologies as well as biosignal trackers to investigate how stress and resilience can be measured within production environments. "We carry out objective analysis of the ways in which overwork occurs, as well as targeted measures that companies can take in order to increase employee resilience," says Paletta. "The aim is to create a working environment where technology adapts to humans – and not the other way round." The researchers have developed procedures designed to make individual stressors more visible without any stigmatisation. The findings feed directly into a new AI model that can take such factors into account, for instance when it comes to assigning production tasks. All of which will make production smarter and also more worker-friendly in future.

This work has been supported by the FAIRWork project (www.fairwork-project.eu) and has been funded within the European Commission's Horizon Europe Programme under contract number 101069499. This paper expresses the opinions of the authors and not necessarily those of the European Commission. The European Commission is not liable for any use that may be made of the information contained in this paper.

MICHAEL WIESMÜLLER

THE FUTURE OF PRODUCTION

TRANSFORMATION – AN OPPORTUNITY FOR AUSTRIA AS A PRODUCTION LOCATION

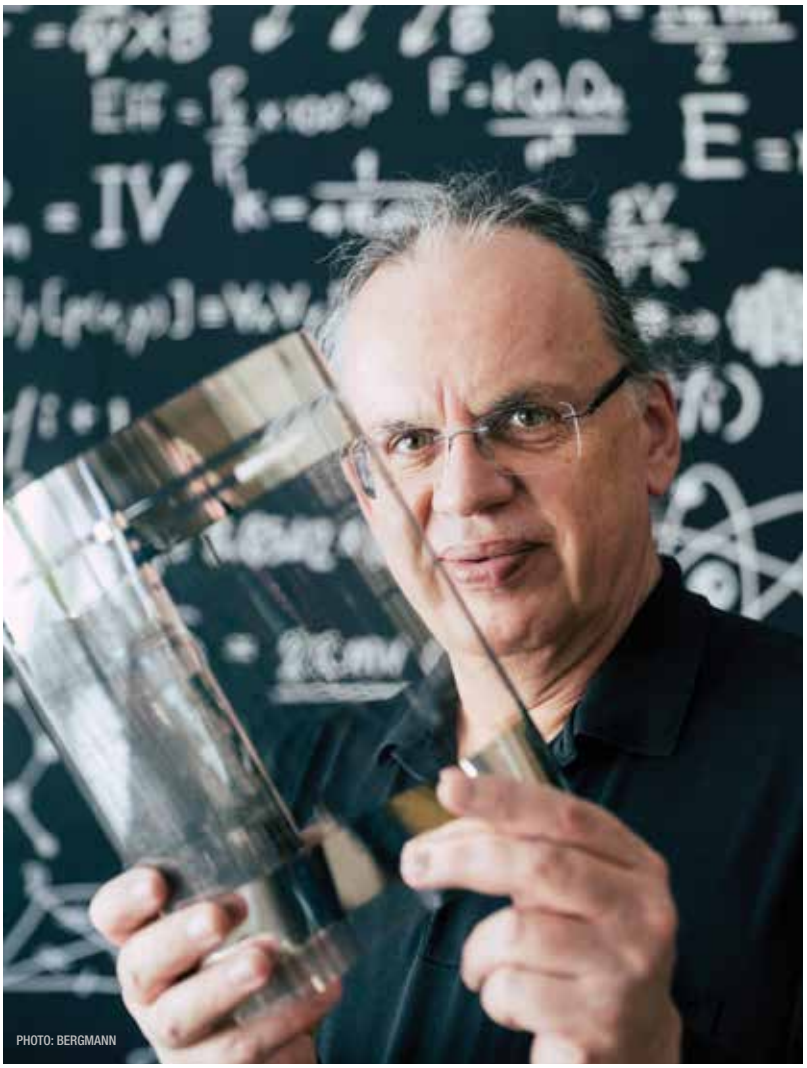
PHOTO: BMIMI

Michael Wiesmüller is Head of the Department of Digital and Key Technologies for Industrial Innovation, part of Section III - Innovation and Technology at the Federal Ministry for Innovation, Mobility and Infrastructure (BMIMI)

The next two decades will be very important, if not crucial, for industrial production in Austria. Climate targets, digitalisation and geopolitical shifts are creating significant pressure for change in a country that has long had a strong record in manufacturing and can draw on world-class industrial expertise in many fields. Bold steps will be required to preserve this edge and capitalise on new opportunities. Here are a few ideas on how to go about this. Key technologies can strengthen Austria's industrial base and innovation capabilities, and making targeted use of them will enable the country to make genuine advances in innovation, differentiate itself on global markets and successfully carve out new niches. They will also open up access to the markets of the future and reduce dependencies. All told, this translates into higher productivity and increased competitiveness. As part of the country's industrial strategy, the BMIMI has identified five priority action areas for a key-technology drive in Austria: artificial intelligence (including data innovation), microelectronics (including software, components and systems), production technologies (including robotics), quantum technology and photonics, and advanced materials. Technological sovereignty is also pivotal for a small country like Austria. In terms of location policy, this means that investments in semiconductors, AI infrastructure and quantum technologies will need to be supported at the European level, but implemented locally. One response is the upcoming AI Factory Austria. A flagship initiative featuring an AI supercomputer, it will serve as a hub for research and SMEs, as well as a test site for industrial applications. It is vital that we view climate-neutral industry as something that is absolutely essential. In this respect, there will be a particular focus on energy-intensive industries such as steel, chemicals and paper. However, a lack of access to affordable renewable energy could jeopardise Austria's standing as a business location. We cannot allow the shortage of skilled workers to hold back growth. Austria needs to prioritise training and development in STEM professions more, while making sure that it attracts international talent. As a leading manufacturing location, we also have to pay closer attention to manufacturability. The ability to see through the transition from an idea to a finished product effectively is what makes the difference between success and failure on the market.

These images were created as part of the Royal Academy of Engineering's 'This is Engineering' campaign. They were developed in order to encourage website operators and users of images to showcase engineers and the industries they work in, portraying them in a wide variety of roles.

PERFORMANCE



AT ALL COSTS?

It's not the case that there are no alternatives to silicon – as a JOANNEUM RESEARCH team intends to show through the GreenOMorph project. The aim is to demonstrate how high-efficiency, resource-saving electronics can be developed using organic semiconductors and neuromorphic architecture. Herbert Gold, Senior Researcher at the MATERIALS Institute for Sensorics, Photonics and Production Technologies, shares his views on how electronic devices can substantially reduce the environmental impact of production.

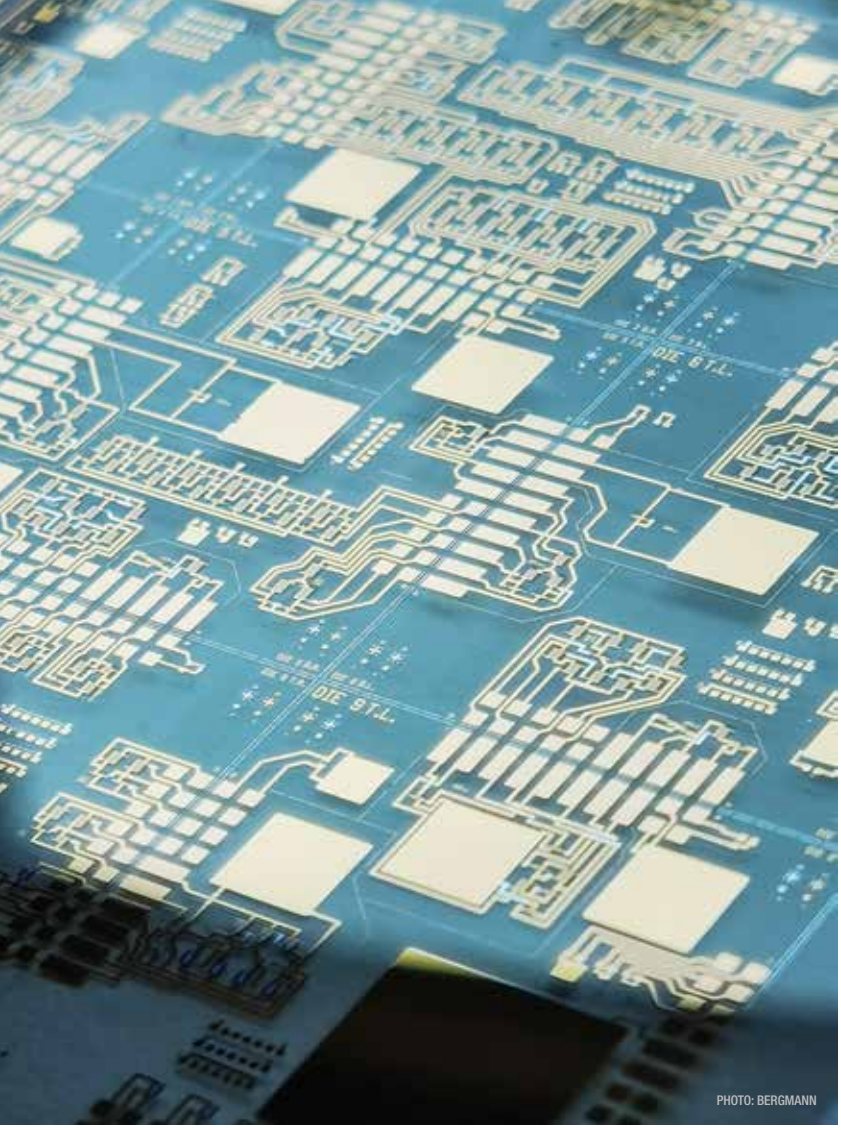
By Elke Zenz

Electronics are an integral part of daily life. But as much as they make our lives easier, manufacturing them is energy-intensive, consumes valuable resources and generates large quantities of problematic waste. For example, studies have shown that production alone accounts for around 74% of the CO_2 emissions attributable to an Apple PC. Since 2016, chip manufacturers have been responsible for higher greenhouse gas emissions than the automotive industry – and the figure is still rising. The cause can be found at the heart of the technology: silicon wafers and their energy-intensive processing.

"Under the EU-funded GreenOMorph project, we're moving in a different direction. The goal is to develop innovative, environmentally friendly electronic components based on organic materials – called organic electronics – and move away from the principle of 'performance at all costs'," Herbert Gold explains. He has been researching sustainable electronics solutions for 20 years. His vision: contributing to the evolution of a digital society in a liveable environment and, from an industrial viewpoint, an autonomous Europe.
This topic was the focus of the EU's 'Responsible Electronics' Challenge, a call for proposals aimed at substantially reducing energy consumption in a digital European society, as well as for solutions to two material-related problems: "Firstly, our products must not contain any materials that cannot be recycled and which can even breach the blood-brain barrier. We want to avoid these per- and polyfluoroalkyl substances, or PFASs, at all costs. Secondly, the proposals must exclude any critical raw materials that Europe could become potentially dependent on, geopolitically speaking. Our approaches were selected in the face of very strong competition and we were awarded funding for the GreenOMorph project."

Sustainability for the semiconductor industry
"Under the project, we are looking to identify breakthroughs across the entire product life cycle, with a focus on bio-based materials and additive manufacturing processes," Gold points out. Organic electronics are flexible and low-weight, but the main advantage is their environmentally friendly production. The materials used are completely free of critical and toxic substances. For instance, PET is used as a substrate instead of silicon, while precious metals such as gold and silver take the place of aluminium. The transistors do not require fluorinated chemicals or halogenated solvents, and the researchers have completely dispensed with problematic PFASs – also known as "forever chemicals". For each function, the energy required for production has been cut by two-thirds, while the electricity consumption of the components themselves has been reduced by a factor of 1,000. This was made possible by the neuromorphic principle: signals are processed and stored directly in the components, removing the data traffic seen in conventional von Neumann architectures.
However, there is a drawback – in performance terms, organic electronics do not come close to common semiconductor systems. "You have to ask yourself whether the use of high-performance chips is always strictly necessary," Gold insists. "Lower-performance organic electronics would be perfectly adequate for typical IoT applications. In our view, the semiconductor industry doesn't pay enough attention to actual performance requirements," he adds.

Printing replaces etching
GreenOMorph also relies on sustainable processes for production. Instead of etching or photolithography, features are created by means of printing, embossing or blade coating – all of which are additive methods. "In



European consortium

GreenOMorph will receive EU funding of EUR 4 million over four and a half years. Six partner institutions – from Austria, Italy, France, the Netherlands and Finland – are involved. The project is being coordinated by JOANNEUM RESEARCH's MATERIALS Institute, with significant support from the LIFE Institute.

spite of the small quantities of material used in our additive, thin-film technology, 99% of the metals are recycled and the substrate is also processed for reuse. The E-factor – an indicator of environmental pollution in chemicals production – is ten times lower than with silicon," Gold explains, underlining the highly satisfactory savings in resources.

"Through the GreenOMorph project, we want to demonstrate that sustainability and electronics are not mutually exclusive. With the right design, suitable materials and innovative manufacturing processes, Europe will be in a position to make its electronics industry more eco-friendly, as well as more independent – and to contribute to the creation of a digital society in a liveable world," Herbert Gold concludes.

Neuromorphic IT is based on the combined storage and processing of signals in one and the same component, reflecting the structures found in living organisms. In von Neumann IT architecture, by contrast, storage and processing are separated, and this generates large volumes of data traffic. Although our computers are very high-performance, the amount of energy they need is rising all the time. The brains (as well as muscles and nerves) of living organisms can also do amazing things using incredibly little energy – like the human brain, which runs on just 10 watts.

KURT MAIER

LOCATION REORIENTATION

ENERGY AND BUREAUCRACY PLAYING A DECISIVE ROLE

PHOTO: M. KANIZAJ

Kurt Maier is President of the Federation of Styrian Industries

Fitness for the future isn't measured solely in terms of outstanding technological achievements. Securing added value and jobs is mainly a question of planning reliability and an affordable operating environment – within a region and beyond. For Styria, this also includes ensuring reliable energy supplies at competitive prices and a location that does not strangle projects with red tape.

Backed by 22 industrial companies alongside energy provider Energie Steiermark and the Federation of Styrian Industries, the Green Energy Master Plan provides a clear roadmap for decarbonisation as well as development of the necessary capacity. The analysis speaks for itself: demand for electricity and hydrogen will rise sharply over the coming years, while natural gas consumption is set to fall, provided that green energy is available at sufficiently low prices. The ability to expand wind and photovoltaic capacity, the hydrogen sector and grid infrastructure at the pace needed to satisfy industrial requirements will be a decisive factor. But at the same time, this expansion must not be derailed by the current procedural environment. Approval processes that take years to complete are simply incompatible with the rapidly changing demands of the energy transformation. This is where our federation comes in – and we are taking proactive steps. In consultation with academic and research experts, we have identified areas where our administrative processes could be made faster, more efficient and more highly digitalised. This has given rise to proposals including binding deadlines for public authorities, automatic triggering of default outcomes (i.e. approval), an online platform, and targeted use of external expertise. All of these proposals should help to significantly accelerate procedures and, ultimately, drive forward the energy transformation. This would translate into fewer holdups, deliver better planning reliability, and see administrative bodies serving as partners rather than stumbling blocks.

Production and manufacturing are reliant on attractive locations. And this is why our aim is to ensure affordable, stable energy supplies, as well as approval procedures that do not put the brakes on innovation. Together with our partners, we are showing how industry, energy providers and policymakers can shape the future by working hand in hand. Taking swift, forward-looking action today will lay the foundations for prosperity and competitiveness tomorrow.

Surface Charac-terisa-tion Lab

Part of the MATERIALS Institute, the Surface Characterisation Lab is a central contact point for anyone looking for an ultra-granular understanding of materials and surfaces. The lab can characterise surface topography, material composition, layer thicknesses, wetting characteristics and mechanical properties on a micrometre and nanometre scale. In turn, this is laying research-based foundations for developments in microtechnology, optoelectronics, medical technology, sensor systems and photonics.

1 —— Scanning electron microscope (SEM) – JSM-IT 100/JEOL
2 —— 3D laser scanning microscope – VK-X1050/Keyence
3 —— Atomic force microscope (AFM) – Jupiter XR/Oxford Instruments
4 —— Fluorescence microscope – Zeiss Imager M2.m/Zeiss
5 —— X-ray photoelectron spectroscopy (XPS) – Omicron Nanotechnology
6 —— Contact angle measurement device – DSA100/Krüss
7 —— Tensile testing machine – 3342/Instron
8 —— Advanced mobile luminance and colorimetry camera – LumiCam 2400/Instrument Systems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Scan the QR code for more information

Batteries – the key to sustained value added

Technology Talks Austria 2025

As part of the Technology Talks Austria 2025 event, JOANNEUM RESEARCH staged a workshop devoted entirely to batteries.
They form a core component of a sustainable energy future – but Europe is facing significant challenges across the value chain.
Titled "Batteries – the key to sustained value added", the workshop confirmed that the willingness to change is there, but clear strategies, specialisation and decisive action are essential. In her talk, Assistant Professor Eva Gerold from the Technical University of Leoben highlighted the rapid developments in cell chemistry, including the increasing uptake of lithium iron phosphate batteries. Gerold pointed out that this makes recycling more complex, because the variety of cell types calls for flexible processes, adding that ambitious quotas as well as utilisation of used batteries were essential. Recycling is one of the keys to sustainability and security of supply, she emphasised. The talk was followed by a fascinating panel discussion where contrasting views were put forward. VIRTUAL VEHICLE CEO Jost Bernasch emphasised the potential of digital twins in ensuring chemical and thermal safety. He believed that Europe could build on developments in Asia and leverage home-grown opportunities.
In AVL Vice President Georg List's opinion, Europe's strength lay in testing systems, sustainability and system expertise – not in cell manufacturing. Cooperation and a focus on differentiation would be vital, he said. TU Graz Vice Rector Andrea Höglinger expressed her support for greater specialisation in order to quickly find answers to key questions, particularly relating to bio-based materials.
Georg Knill, President of the Federation of Austrian Industries, saw niche technologies as Europe's only chance: with production of many technologies already lost to China, rapid adaptation of political frameworks was now essential.
In short: Asia is leading the way, so Europe will have to specialise, resize and carry out focused testing. Bold action aimed at closing the gap can be turned into a strength.

PHOTO: VALERIE MALTSEVA

From left: Heinz Mayer, Eva Gerold, Georg Knill, Andrea Höglinger, Georg List and Jost Bernasch

Cybercrime: a mirror on the real world

PHOTO: JOANNEUM RESEARCH/KUBISTA

Fake news, data espionage and cybercrime are among the most pressing issues we currently face. The fourth Lagebild Cyber Security, the leading event focused on this topic in southern Austria, outlined potential strategies for combating these threats. Held on 20 May at Museum Liaunig in Neuhaus, Carinthia, more than 150 people attended the event, with Robert Lamprecht of KPMG sharing the latest insights into the cybersecurity landscape in Austria. The follow-up event took place on 1 July in Graz, where JOANNEUM RESEARCH presented the 'Cybersecurity in Austria' study in cooperation with the Silicon Alps Cluster (SAC).

2025 Pfingstdialog

Schloss Seggau in southern Styria played host to a discussion titled 'Europa im Spannungsfeld', which examined the conflicting forces that Europe is currently facing. JOANNEUM RESEARCH was one of the organisers. The security, economic and social policy challenges identified were outlined in a memorandum.

PHOTO: BMI/TUMA

From left: Herwig Hösele, patron of the Geist & Gegenwart event series, Provincial Councillor Willibald Ehrenhöfer, event host Sandra Thier, historian Christopher Clark, Deputy Provincial Governor Manuela Khom and JR Managing Director Heinz Mayer Photo: Fischer

New ROBOTICS Director

PHOTO: BERGMANN

Christian Oswald took over as Director of the ROBOTICS Institute in October.

Christian Oswald, formerly a research group leader at ROBOTICS in Klagenfurt, has taken over as the Institute's Director from Anton Scheibelmasser, who retired on 1 October 2025. An industrial and mechanical engineer, Oswald's research specialism is the economic feasibility of innovative and experimental technological solutions for flexible production. He has experience of the industrial side as well as the early-stage landscape. Previously he headed the Production Automation research group.

PUBLICATIONS

Cool, green and fair: a blueprint for the city of the future

LIFE

PHOTO: ADOBE FIREFLY

Periods of extreme heat are now one of the biggest challenges facing cities all over the world. Particularly in highly built-up areas, the health risks are rising, too: heat waves cause more deaths than many other natural hazards. But they affect people to differing degrees – as confirmed in a study by Sebastian Seebauer of the LIFE Institute. He found that it has a disproportionate impact on the elderly, children, chronically ill individuals and low-income households, as a result of poorly insulated housing and a lack of access to cooling green spaces, among other reasons.

Nature-based solutions such as greened roofs and facades or new parks are promising approaches to reducing the effect of urban heat islands. Besides making cities more attractive, solutions like these promote biodiversity and are cost-effective in the long run. However, measures like this also involve some risks. A higher quality of life often pushes up property prices, carrying the threat of "green gentrification" – as rents increase, people who are in the greatest need of cooling find themselves pushed out. In their paper, the research team describes an approach that enables cities to avoid this form of social inequality. Taking Vienna as an example, the researchers developed a three-stage decision-making framework. Firstly, a climate risk assessment is carried out to identify at-risk groups and locations. Secondly, possible adaptation measures such as green spaces are analysed, and thirdly, an impact analysis assesses whether the measures actually benefit everyone concerned.

The authors conclude that successful climate change adaptation calls for more than just technological solutions. It needs to help bring about greater social justice, and feature a blend of environmental and social policies. Vienna shows how both of these objectives can be combined. The approach can be applied worldwide and provides cities with a clear blueprint for dealing equitably with rising temperatures.

Socially equitable climate risk management of urban heat: Michael Friesenecker, Antonia Schneider, Marianne Bügelmayer-Blaschek, Michael Getzner, Claudia Hahn, Martin Schneider, Sebastian Seebauer, Wojciech Zawadzki, Maja Zuvela-Aloise, Thomas Thaler | Nature, npj Urban Sustainability 5, 8 (2025)

Unexpected vibrations

DIGITAL

In their article, Andreas Windisch of DIGITAL and co-author Markus Wenin of Computational Physics and Engineering (CPE) describe formulas that can be used to calculate vibrations and their damping in small spheres made from a viscoelastic material. The research focused on the natural frequencies (or eigenfrequencies) and how they change in the presence of damping. This was based on the assumption of an isolated system where no energy or heat transfer to the environment is allowed. The researchers demonstrated that certain types of vibration – called breathing and torsional modes – behave uniformly or "monotonically": as the frequency increases, it is possible to predict the change in damping. By contrast, with spheroidal modes, the behaviour was non-monotonic and damping was uneven. There were also differences in frequency shifts: in most cases, as expected, the frequencies decreased, while with certain spheroidal modes, the frequencies were anomalous and increased in line with the damping. The findings will help to explain the vibration characteristics of complex materials – an important step for material research and nanotechnology applications.

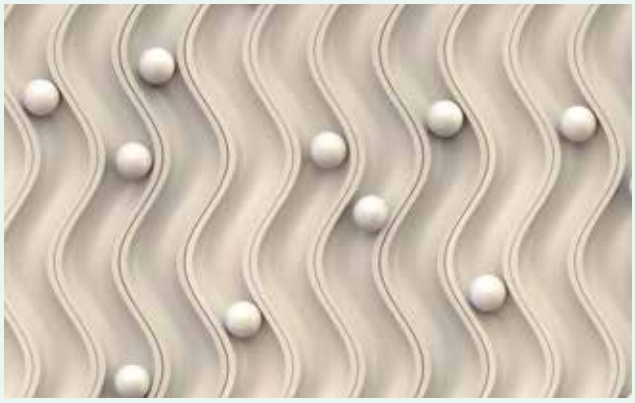

PHOTO: ISTOCK

Vibrations and damping of the eigenmodes of viscoelastic nanospheres with thermal conductivity
Markus Wenin, Andreas Windisch | Springer Nature, Archive of Applied Mechanics 95, 122 (2025)

Insights into brain-tumour metabolism

HEALTH

Glioblastomas are among the most aggressive types of brain tumour, and they remain difficult to treat. A precise understanding of metabolic processes in the brain is crucial in order to develop new therapies. The study published by a research team from the HEALTH Institute combines cerebral open flow microperfusion (cOFM) with HILIC-HRMS-based metabolomics in order to visualise these particular processes. cOFM enables samples to be taken directly from the brain tissue continuously without damaging it. Numerous tiny molecules can then be identified using HILIC-HRMS-based analysis. This allows for monitoring of the slightest changes in brain metabolism – when tumour cells grow or respond to medication, for instance. As a result, the platform will open up new avenues to understanding the complex metabolic pathways of glioblastomas. And in the long run, it could support the development of more effective treatments, improving the prognosis for patients.

PHOTO: ADOBE FIREFLY

Cerebral open flow microperfusion (cOFM)-HILIC-HRMS platform for in vivo and in situ monitoring of tumor microenvironment in glioblastoma
Fernanda Monedeiro, Denise Schimek, Eva-Maria Prugger, Thomas Altendorfer-Kroath, Elmar Zügner, Christoph Magnes | Analytica Chimica Acta, Volume 1363, 2025, 344183, ISSN 0003-2670

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Freeform micro-optics made in Weiz: "Printing optics like newspapers"

By Renate Buchgraber

PHOTO: BERGMANN

Physicist Claude Leiner is a member of the Light and Optical Technologies research group

Developed by the JOANNEUM RESEARCH MATERIALS Institute in Weiz, freeform micro-optic structures (FF-MOSs) are a concept for ultra-thin freeform micro-optics that can precisely guide and distribute light. What makes these optical structures so special is that – in contrast to conventional freeform optics – they are thinner than a human hair, meaning they can be "printed like newspapers". This enables industrial scalability and potential new applications while minimising the use of materials – which translates into greater sustainability.

Modern freeform optics

Fundamentally different from conventional lenses, modern freeform optics direct light to places where it is actually needed. Take street lights, for example: a freeform surface forms the light beam in such a way that the road below is uniformly lit – while avoiding glare and preventing light from shining unnecessarily on pavements or through windows. Production of the complex surfaces used in freeform optics is highly complicated and expensive, but now JOANNEUM RESEARCH has developed a brand new concept. Known as freeform micro-optic structures (FF-MOSs), the concept applies the basic idea behind freeform optics to microscopic structures that are integrated into foils or substrates in the form of thin reliefs. This enables the use of modern production methods such as greyscale laser lithography and roll-to-roll nanoimprint lithography. Freeform surfaces also allow for the design of functions that are tailored to a customer's needs. "I analyse the optical challenge, and consider the incident light distribution as well as the desired output distribution," Claude Leiner explains. "Then I use algorithms to work out a structure that precisely enables this transition. The result is a freeform micro-optic structure." As opposed to an individual component with volume, the structure is a relief composed of microforms that together shape the light beam as required. The resulting systems are ultra-thin, lightweight, scalable over a wide area and cost-effective – making them ideal for lighting or security features. This also allows for replication by means of an in-house roll-to-roll process: here, the structures are repeatedly printed in a UV-hardened embossing lacquer on a foil that can be several kilometres in length – precisely and scalable as required.

Practical application

The process was put into practice in wall wash lighting for Leoben-based company EcoCan GmbH. The brief was for a light source installed close to the ceiling that would uniformly light a particular wall. As Leiner explains: "This is a fairly significant challenge for light guidance. It's almost impossible to achieve this efficiently without complex optics. Either parts of the wall remain dark or much of the light is lost. But with the help of freeform micro-optics, we can guide the light precisely onto the surface in question. The result is even lighting – with no glare and no wasted light."

Security features on products and packaging are another area where freeform micro-optics come into their own. The researchers have developed structures that create animations – including a jumping figure, a logo or dynamic lettering. In contrast to conventional lenticular images or "tilt cards", these effects are integrated into the optical microstructure, and not created by prisms stuck onto a picture. This makes them significantly harder to falsify. It's a highly promising technology, particularly for companies looking for anti-counterfeiting and decorative solutions.

Functions that previously called for thick glass lenses can now be integrated into wafer-thin layers. The MATERIALS research team has shown how functionality, efficiency and attractive design can be combined in tiny optical structures – as well as opening the door for new, customised lighting applications in the future.

PHOTO: JOANNEUM RESEARCH/RAISER

Scan the QR code for more information on life cycle assessment

Sara Carniello is part of the Climate-Neutral Energy Systems and Lifestyles research group and one of the two coordinators for JOANNEUM RESEARCH's Environment and Sustainability business area.

VALUE ADDED

Everything we do and every product that comes onto the market has an effect on our surroundings and the environment. The impacts of products and services can be determined using life cycle assessment (LCA). To find out more, we spoke to Sara Carniello from the LIFE Institute.

By Petra Mravlak

What is life cycle assessment?
Carniello: LCA is a method that enables us to evaluate the impacts of a product or service over the entire life cycle – from raw material extraction right through to disposal or recycling. However, the added value generated goes beyond environmental aspects, because it can also take social and economic dimensions into account. This enables us to highlight potential innovations and risks along the supply chain. The analysis pinpoints "hot spots" or levers that can be exploited in order to improve products. But it's important to make use of them during the product development phase.

What does JOANNEUM RESEARCH use LCA for?
Carniello: Firstly, in research projects – it's a tool for assessing different technological options and steering technological development in the desired direction. Secondly, we act as consultants for companies that want to understand, compare or optimise the impacts of their products. The benefit we offer is that – thanks to our experience with R&D projects – we can evaluate technologies as early as in the development phase. Our team is made up of technicians, sociologists and economists who can carry out effective analysis of complex questions while also considering all three key dimensions: environmental, social and economic.

Are these measures always expensive?
Carniello: Not necessarily. The focus is often on designing more efficient processes or on staff deployment; it doesn't have to revolve around major investments. Initially, there are costs associated with building new facilities or energy supply systems, but in the long term they deliver savings, planning certainty and independence. Investments in sustainable innovations are usually made on a long-term basis, and they need to be aligned with the company's strategy.

Can you give us some examples of businesses you're currently cooperating with?
Carniello: We're supporting Ino GmbH in the development of a new coating process that was designed in collaboration with the MATERIALS Institute. We identified all of the key hot spots. Another of our projects involves comparing an Austrian start-up's hydrogen production process with conventional processes. And for Rosenbauer we analysed the environmental impacts of electric and diesel fire engines, as part of a technology partnership with the IEA, the International Energy Agency.

We've seen some backsliding on environmental measures at the global level, and also in the EU. What effect will that have?
Carniello: Obviously it's detrimental for the environment. And ultimately for the economy, too, because the debates about environmental regulations draw attention away from the true cause of the problems. But many companies are continuing to take action because they recognise the benefits for their innovation capabilities and business models. Environmental standards are often perceived as an inconvenience because of the negative connotations – they're seen as burdensome and expensive. But they really can promote innovation: by cutting resource consumption, boosting efficiency and creating more resilient supply chains.

You worked in technology development in the private sector for many years. Why did you make the switch to sustainability assessment at JOANNEUM RESEARCH?
Carniello: When you work for a company, you're focused on a particular product or sector. Here, we cover a much broader spectrum: a wide range of topics, technological, economic and regulatory issues, and cooperation with a variety of different stakeholders. This creates synergies, and ideas can be transferred from one sector to another – for me, that's what makes the work more fascinating and rewarding.

Light therapy for fruit and vegetables

PHOTO: BERGMANN

Light as a means to stop spoilage: how LEDs can keep supermarket fruit and vegetables fresh for longer

PHOTO: FIEDLER

Christian Krutzler is a project manager at the MATERIALS site in Pinkafeld, where he specialises in the combination of sensors and light technologies in a wide variety of different applications.

According to WWF, food waste accounts for around 10% of global greenhouse gas emissions. About 40% of all of the food produced worldwide is lost or wasted along the value chain. And Austria generates one million tonnes of avoidable food waste every year, although there is a lack of reliable data for the agriculture sector. More than enough reasons, then, to carry out a detailed analysis of ways to reduce food waste – which is the focus of researchers on the Austrian Research Promotion Agency's (FFG) LED4foods project. Coordinated by the JOANNEUM RESEARCH MATERIALS Institute in Pinkafeld, LED4foods is examining the effects of specifically directed LED lighting in supermarkets on the shelf life of fresh products. The idea was proposed by Burgenland-based company Lumitech Lighting Solution GmbH, which has previously developed lighting solutions for fresh and cured meat display cabinets. This expertise is now being applied to perishable fruit and vegetable varieties.

"Until now, research has mainly investigated the effect of light on foodstuffs during storage and transportation, but hardly any attention has been paid to its application in supermarkets," explains Christian Krutzler, the project manager at JOANNEUM RESEARCH.

The goal is to slow microbial and ageing processes using particular wavelengths of light, because wilted greens and shrivelled produce are unappealing to shoppers. Krutzler is working with a team from the TU Graz Institute of Analytical Chemistry and Food Chemistry as well as Lumitech Lighting Solution GmbH to find out what effects light of different colours has on foods including radishes, bananas and tomatoes.

One particularly promising approach is the use of blue light, which initial findings suggest could limit the growth of microorganisms. "And this removes the health risks that can occur with UV-C irradiation," says Krutzler of the encouraging results. The researchers devised a set-up and corresponding methodology in order to record the effect of different spectral light distributions on the ageing and spoilage of fruit and vegetables under controlled conditions. This involved setting up lighting where the spectral intensity distribution from 12 different LED components can be combined and adjusted over wide ranges , and adapted in line with the desired distribution. In addition to the usual wavelengths in the visible spectrum, the 12 LED components also included two LEDs in the UVA spectrum (at 385nm and 395nm) and two in the deep red and near-IR spectrum, at 660nm and 730nm respectively. This approach enables the reproducible analysis of different spectral distributions in a series of controlled tests, as well as recording of the effects of each distribution on established quality parameters for fruit and vegetables, including loss of mass and changes in colour. This research breakthrough could deliver significant advantages for retailers as well as the environment, as the lighting technology can be installed without the need for major renovations. "The lighting concept could be deployed immediately – but, of course, it depends on whether the retail chains get on board," Krutzler comments. "In terms of practical implementation, the challenge is ensuring that the products remain visually appealing."

CONGRESS AWARD

Staged in cooperation with the Styrian business development agency SFG, the Zukunftstag 2024 event was named as the winner of the City of Graz Congress Award on 25 June 2025.

The joint project team with City Councillor Günter Riegler (right) and TU Graz Vice Rector Andrea Höglinger (fifth from left), who gave the award speech

Held last October at Messe Congress Graz, our Zukunftstag event was a huge success, attracting around 1,300 participants from the business, science and public sectors. In recognition, JOANNEUM RESEARCH was presented with the City of Graz's Congress Award. "We're absolutely delighted to receive the award," says Gabriele Katz, Head of Corporate Communications at JOANNEUM RESEARCH. "Especially in challenging times like these, it's important to work as part of a network and make knowledge accessible to a wide audience. Congresses are an ideal platform for living up to these demands." Titled #bettertogether, the event was staged in collaboration with the SFG for the first time. It provided a platform for discussing bold ideas, uncovering new synergies and initiating groundbreaking projects. In line with the core theme of cooperation, the event brought together stakeholders from the worlds of business and science – with the aim of developing joint solutions to current challenges. Besides promoting integration between the economy, science and public institutions, the Zukunftstag also positioned Styria as a dynamic hub for innovation and cooperation.

SAFE DRUG PRODUCTION

HEALTH is supporting pharmaceutical companies to ensure safe manufacturing of high-efficacy medications.

The institute has developed a highly sensitive procedure based on mass spectrometry, which is designed to minimise the risk of cross-contamination in production. Cross-contamination refers to the unintended transfer of active agents between different products. This must be avoided at all costs, particularly with high-efficacy substances that can produce a pharmacological effect even in extremely small doses, such as hormonal medications. "Using the mass spectrometry procedure, we can detect the tiniest traces of active ingredients, weighing as little as a nanogram, on production surfaces," explains research group head Christoph Magnes. This benefits pharmaceutical companies in a variety of ways: the practicable, validated detection method enhances safety when working with highly potent active ingredients, facilitates compliance with strict regulatory requirements and contributes to the continuous optimisation of cleaning and manufacturing processes.

ANY QUESTIONS?

If you are looking for a reliable partner for your research project or would like to find out more about our technologies, feel free to contact us:

Headquartered in Graz, JOANNEUM RESEARCH provides innovation and technology services in the field of applied research. Working as a research company on behalf of various federal provinces and regions in Austria, our expertise shapes the development of our modern society and economy – sustainably, and always with a focus on people. A multidisciplinary team working in flexible structures that foster innovation, we always live up to the highest social and scientific standards. As a research institute backed by the public sector, JOANNEUM RESEARCH plays a key role in identifying and generating solutions for challenges facing society, including climate change, energy supply, digital transformation, mobility, civil and military security, and social change.

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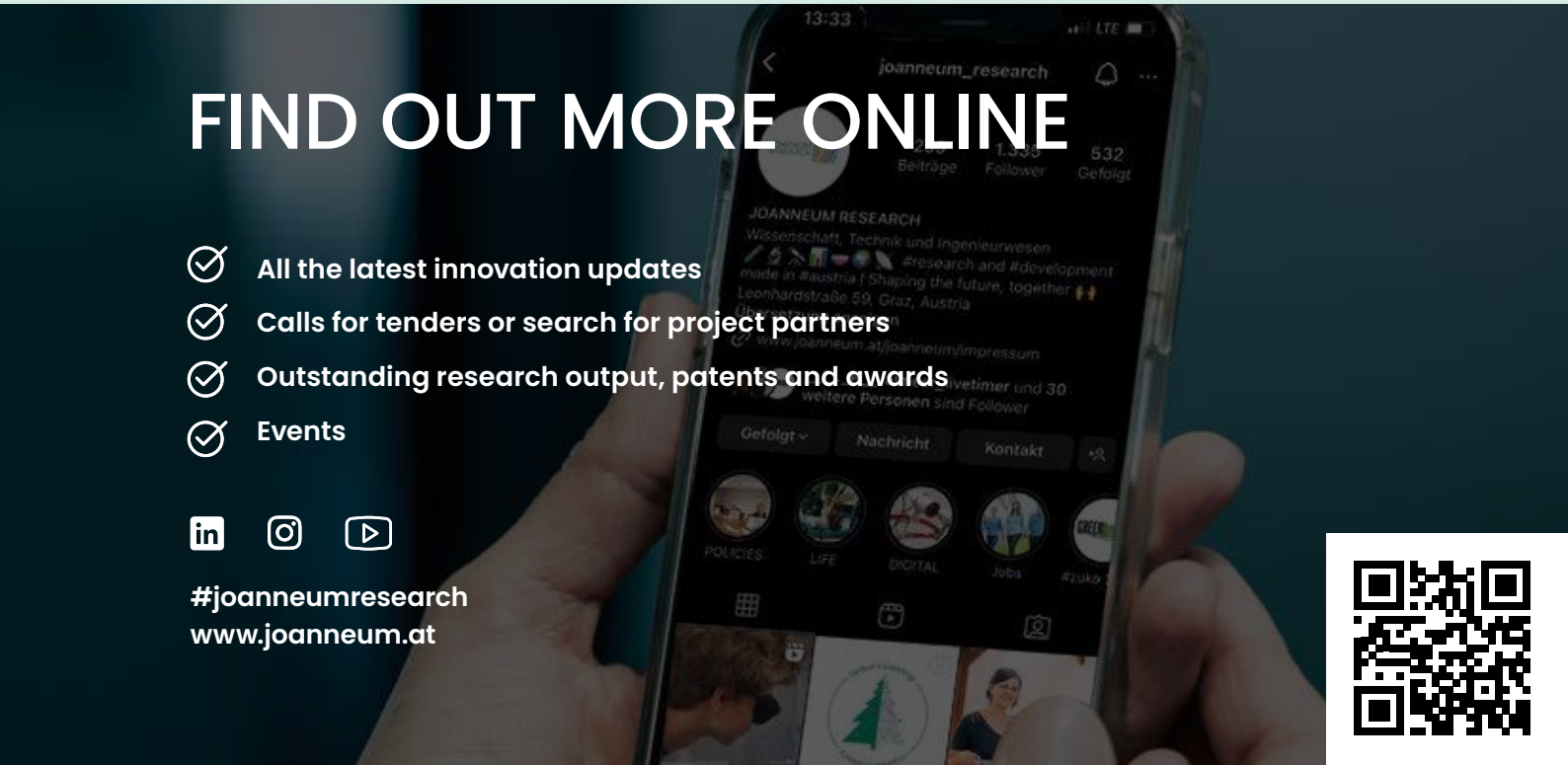

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