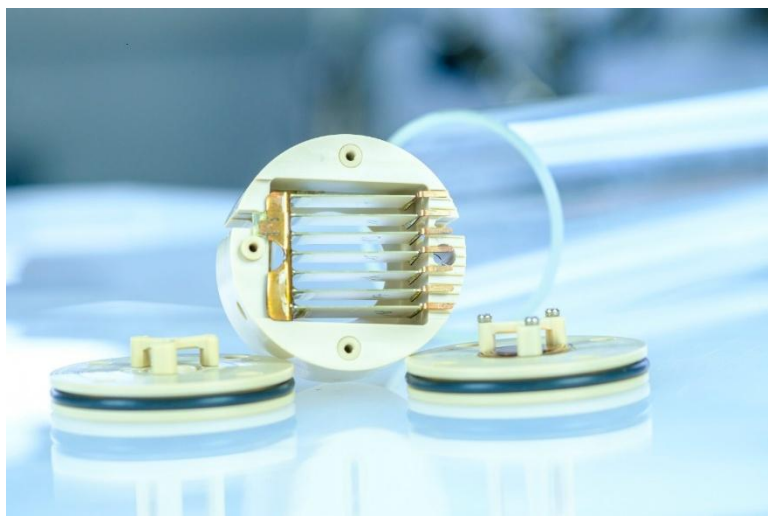
*Feb 2025*

# TECHFLASH

We are pleased to introduce you to Fraunhofer TechFlash - Fraunhofer's Flash News on latest and exciting technologies.
This week's TechFlash is about **New Innovative Techniques in Measuring, Monitoring and Optimizing Industrial Applications.**

The **Fraunhofer Institute for Physical Measurement Techniques (IPM)** develops tailor-made measuring techniques and systems for industry. Many years of experience with optical technologies form the basis for high-tech solutions in the fields of production control, object and shape detection, gas and process technology as well as photonic systems.

## Heat pumps without compressors: Fraunhofer advances electrocalorics



*Electrocaloric segment: Heat pumps based on electrocaloric materials could be a more environmentally friendly and efficient solution for heating and cooling in the future.*

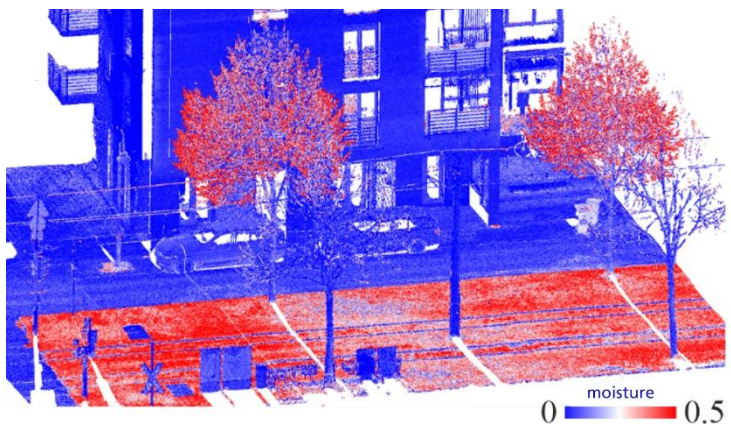
The global demand for advanced refrigeration and air conditioning technologies is increasing at an unprecedented pace. Modern heat pumps, which operate using compressor-based systems, play a crucial role in both heating and cooling applications. When powered by electricity from renewable sources, these systems can significantly contribute to the ongoing energy transition.

In a groundbreaking development, Fraunhofer IPM has pioneered a next-generation approach to heat pump technology. The innovative solid-state heat pumps, based on electrocaloric materials, eliminate the need for environmentally harmful refrigerants and hold the potential to surpass the efficiency of conventional compressor-based systems. This transformative advancement marks a significant step toward sustainable and energy-efficient climate control solutions.

We look forward to hearing of your interest.

Yes, I am interested

## Increasing safety on transportation routes through efficient tree vitality monitoring




*Measured moisture levels combined with weather and environmental data provide reliable information about the vitality of trees. Multispectral laser scans show the moisture level (here in red) of the soil and trees.*

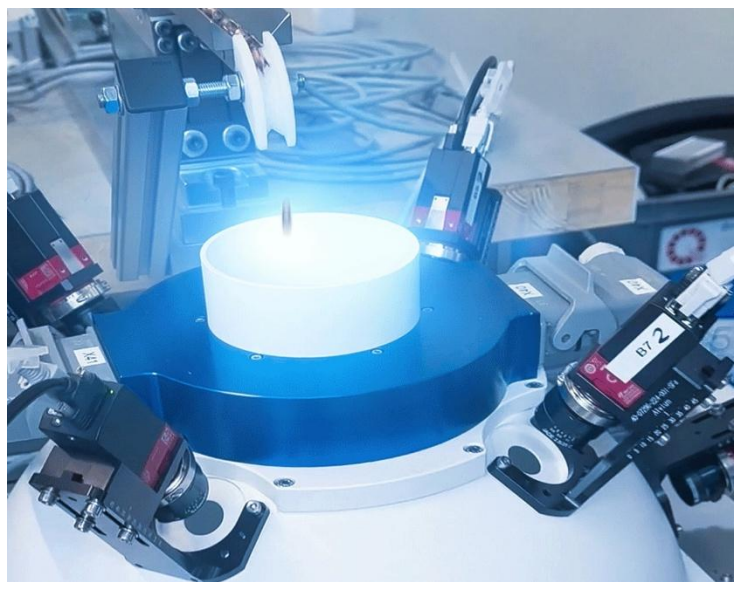
Falling trees and branches not only pose a serious risk to public safety but also result in significant economic losses. According to Railway Authorities, tree-related incidents are one of the leading causes of railway line closures, disrupting operations and necessitating costly maintenance. To address this challenge, Fraunhofer has developed a cutting-edge laser-based measurement system, enhanced by AI-powered data analysis, to revolutionize tree monitoring. This innovative approach enables the creation of a comprehensive data model that accurately assesses the condition of individual trees in real time.

Traditionally, municipalities and road operators conduct tree inspections every two to three years, relying on manual assessments and sporadic measurements—a time-consuming and labour-intensive process. While satellite imagery is commonly used for evaluation, Fraunhofer's advanced method leverages 3D LiDAR technology to provide precise insights into soil and tree moisture levels. By integrating weather and environmental data with existing tree registry information, this novel multispectral 3D LiDAR system—mounted on road or rail vehicles—delivers a more efficient and reliable assessment of tree health. Unlike conventional camera-based monitoring, LiDAR-generated scanner data is easier to interpret, offering a significant advantage for real-time applications and proactive risk management.

We look forward to hearing of your interest.

Yes, I am interested

## Free-fall system inspects the quality of precision stamped parts during the production process



*Several hundred stamped parts per minute are fed into a measuring sphere and captured by 16 cameras while in free fall. This allows geometric defects in the range of 100 micrometers to be detected.*

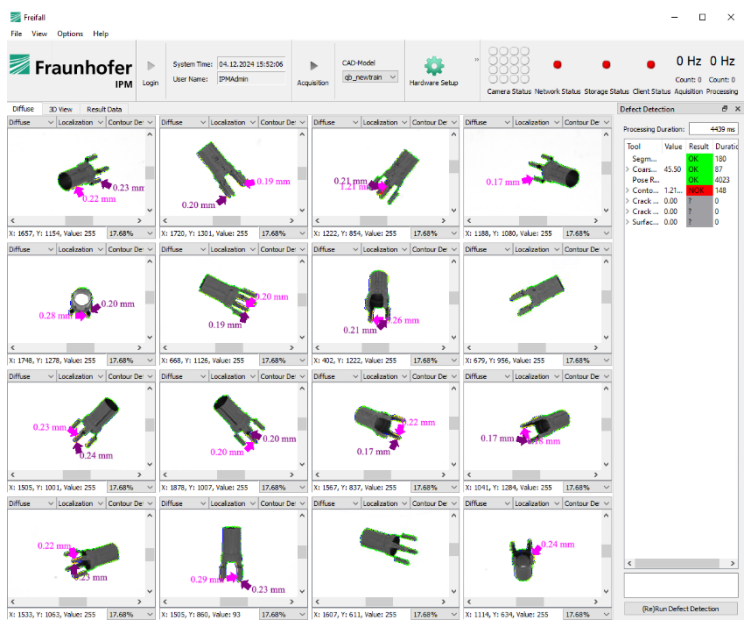
Connectors, sleeves, and pins are stamped from sheet metal with exceptional precision and in high volumes, playing a crucial role in high-tech industries such as automotive, telecommunications, electronics, and medical technology. However, conventional quality assurance methods have struggled to keep pace with the rapid production cycles of stamping processes. Traditionally, inspection is conducted on a random sampling basis through visual checks or CT scans, leaving room for undetected defects.

In a breakthrough advancement, Fraunhofer IPM has developed a free-fall inspection system capable of verifying the geometric dimensional accuracy of 3D precision parts in real time—directly within the production cycle. For the first time, this technology enables 100% inline inspection, eliminating the need for time-consuming sampling processes.

The system was successfully tested in the manufacturing of plug connectors made from copper sheet, where an impressive 330 parts per minute are produced. By seamlessly integrating high-speed quality control into the stamping process, this innovation paves the way for greater efficiency, accuracy, and reliability in precision component manufacturing.

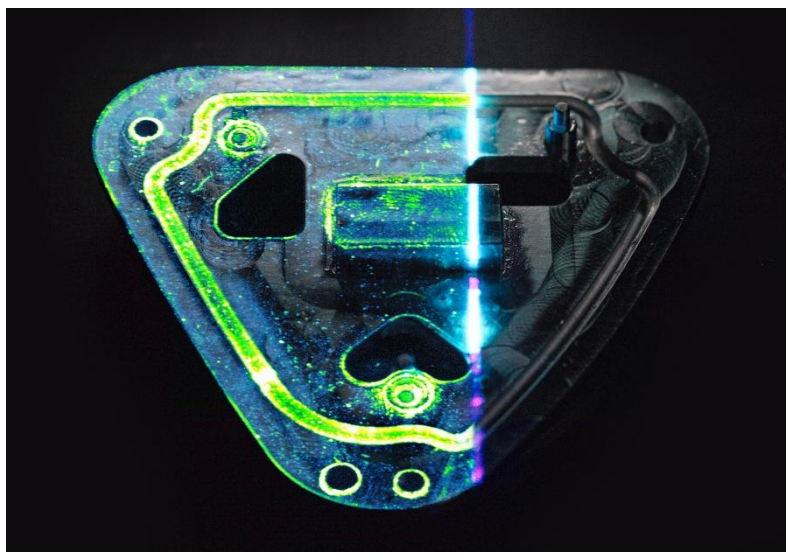
We look forward to hearing of your interest.

Yes, I am interested




*The geometric deviations are depicted in 16 different views on the user interface.*

## Inspection of surface cleanliness for bonding and welding processes



*Organic substances fluoresce in laser light. The F-scanner scans the entire component surface in a matter of seconds, seamlessly detecting even the slightest contamination.*

Advanced joining and bonding processes, such as welding and gluing, enable the creation of exceptionally strong and durable connections. However, achieving optimal results depends on the absolute cleanliness of surface areas—particularly the absence of organic residues. Even minimal contamination, such as lubricant or release agent residues, can compromise downstream production steps, impacting the reliability of welding, bonding, and sealing processes.

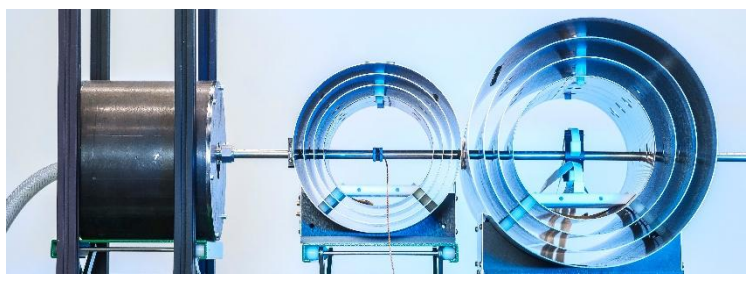
To tackle this challenge, Fraunhofer IPM has developed the F-Scanner, a cutting-edge inspection system that detects even the most minute contaminants with unparalleled precision. This fully automated, large area scanning solution is currently deployed at multiple electric vehicle component manufacturers, ensuring consistently high-quality production standards. Utilizing fluorescence measurement technology, Fraunhofer's laser-based scanners assess surface cleanliness in real time, eliminating the need for time-consuming manual checks.

- For Perfect Welding Joints - In power electronics manufacturing, ensuring pristine surfaces before welding is crucial. The F-Scanner enables 100% inspection of components, verifying the cleanliness of up to 100 welding points in a single step. An advanced algorithm automatically evaluates each component based on application-specific criteria, ensuring only flawless parts proceed to the next production stage.
- For Perfect Bonding: High-performance electric motors generate immense forces, requiring adhesive bonds that meet the highest durability standards. To guarantee optimal surface conditions before bonding, a leading German automaker and its supplier have integrated F-Scanners into their production lines. These specialized inspection systems are engineered for industrial environments, featuring modular, dust-tight, and splash-proof housings with active cooling to ensure reliable operation in demanding settings.

We look forward to hearing of your interest.

Yes, I am interested

## Quantum sensors: Fraunhofer IPM Advances Contactless Flow Measurement with Magnetic Field Technology



*In magnetic flow measurement, a strong magnet polarizes the fluid that flows through the structure from left to right in a steel pipe. The middle shield contains the HF coil, which imprints the marking into the fluid. A quantum sensor in the right shield detects this marking.*

Fraunhofer IPM has pioneered a contactless flow measurement method using magnetic fields, marking a significant breakthrough in industrial process monitoring. For the first time, researchers have quantitatively demonstrated the impact of flow profiles on magnetic signals, paving the way for enhanced measurement precision. The findings were recently published in the Journal of Applied Physics.

Flowing liquids are integral to numerous manufacturing processes, requiring precise flow rate data for effective control and automation. Fraunhofer IPM's magnetic field-based measurement technique enables accurate, non-invasive flow monitoring. The process begins by magnetically polarizing the liquid with a permanent magnet. High-frequency impulses then reverse this polarity, creating local magnetic markers in the fluid. These markers are detected through pipe walls by quantum sensors, allowing precise flow velocity determination without direct contact with the liquid.

This innovative approach enhances reliability in industrial applications, offering a highly accurate, non-intrusive solution for flow measurement in magnetizable fluids.

We look forward to hearing of your interest.

Yes, I am interested

## Fraunhofer IPM develops powerful, compact and fast High-Load Shape-Memory Actuators for Dynamic Applications

*High load actuators based on thermal shape-memory alloys developed by researchers at Fraunhofer can generate high forces in a small space at a high dynamic range. These novel actuators can be used to accurately position components in production machines, among other applications. A Peltier temperature control system (I.) operates the SMA actuator (M.). Shown on the right side are additively and conventionally manufactured SMA components.*

Fraunhofer IPM has introduced a new class of high-load shape-memory actuators, delivering fast switching of large forces within an ultra-compact design. These actuators, based on thermal shape-memory alloys (SMA), overcome the traditional limitation of slow cooling, offering significantly improved dynamics. With a 15 mm diameter and 16 mm length, the novel actuators can lift 500 kg by up to 200 µm. An advanced Peltier temperature control system enables operation at frequencies above 0.3 Hz, significantly enhancing response times. The system requires only two cables for connection to a decentralized, cost-effective control unit, ensuring seamless integration into various applications.

Innovations in cooling, system design and manufacturing: To achieve rapid cooling, Fraunhofer IPM developed switchable heat pipes and round thermoelectric modules, with the latter enabling high dynamic performance despite the compact size. These innovations open new possibilities for SMA actuators, offering greater compactness, control precision, and ease of use in toolmaking, mechanical engineering, and other demanding applications.

We look forward to hearing of your interest.

Yes, I am interested

***About Fraunhofer-Gesellschaft:***

*Founded in 1949, the Fraunhofer-Gesellschaft based in Germany is the world's leading applied research organization. It offers contract-based R&D services for specific industry demand, application-oriented technology development from proof-of-principle up to market-readiness across the value chain and offers technical consultancy and feasibility studies to nearly all the industry sectors. The Fraunhofer-Gesellschaft currently operates 76 institutes and research units throughout Germany. Over 30,800 employees, predominantly scientists and engineers, work with an annual research budget of €3.4 billion. Fraunhofer generates €3 billion of this from contract research. Our global footprint is very strong, with offices and research centres in the USA, Europe and Asia. Some of our renowned innovations are the MP3 software, white LED's and the smallest of cameras. Fraunhofer has been a long-time trusted innovation partner in India, collaborating with some of the major players in the fields of Material Science, Energy, Environment, Automotive, Electro-mobility, Production Technology, Microelectronics and Smart Cities, working with Industry, Government and Public Sector.*

*Kindly contact Mr. Aditya Fuke, Senior Manager – Strategic Projects, Smart Cities & IoT at Fraunhofer Office India for further details.*

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