Institute of Microwave and Photonic Engineering

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Institute of Microwave and Photonic Engineering

Univ.-Prof. Dipl.-Ing. Dr. Wolfgang Bösch, MBA

The Institute of Microwave and Photonic Engineering (German: Institut für Hochfrequenztechnik – IHF) of the Graz University of Technology conducts research and teaching in a multinational environment. It focuses on all aspects of RF, microwave, and mm-wave technology, which are of utmost importance for modern data transmission and sensor systems. The IHF works on basic and applied research projects funded by regional, national, and EU-based agencies. Additionally, we maintain close contacts and long-standing cooperation with company partners in the commercial field. The covered research activities focus on all aspects of RF to mm-wave devices, from the system down to the single components.

The five areas of expertise of the IHF:

Systems:
Development of radar, RFID, or 5G systems

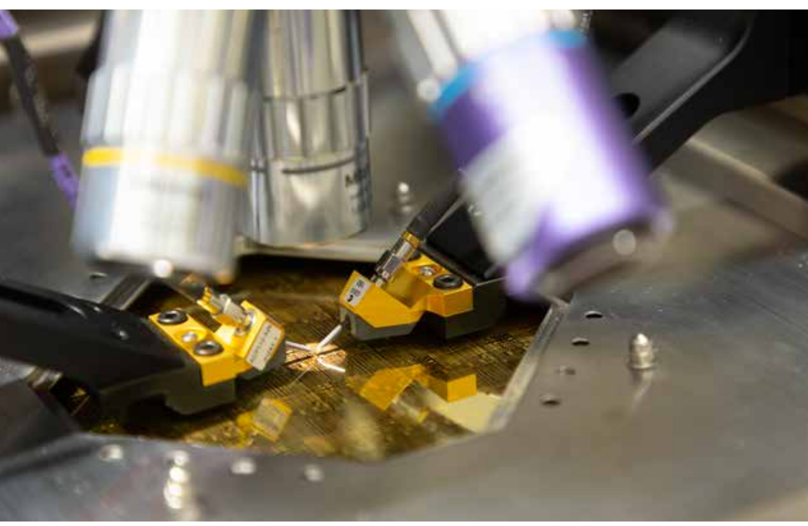
Components:
Design and manufacturing of filters and antennas

Characterization:
Measurement of RF components

Integration:
System integration of RF and optical components

Coexistence and interference:
Field strength measurements, electromagnetic field exposure, simulation of distortion impact, etc.

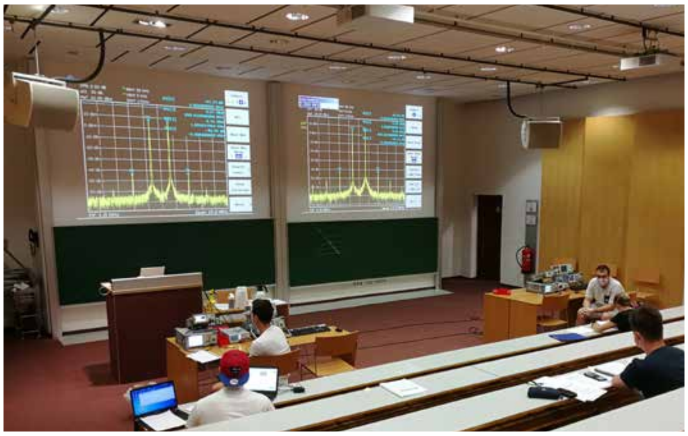
2010	40	1.5 Mio.	40–60	20	10
founded in 2010	staff of 40	1.5 Mio. € revenue/year	40–60 publications/year	20 ongoing PhD's	10 research projects



Latest laboratory facilities

We have a microwave laboratory capable of performing measurements from low frequencies to the mm-wave regime, two clean room facilities to work on integrated circuits, and two anechoic chambers suitable for over-the-air measurements. In 2020 we installed a Christian-Doppler Laboratory for "Technology Guided Electronic Component Design and Characterization," which is organized as a separate business unit with dedicated employees.

Teaching at the IHF: versatile, exciting, and future-oriented



The students at the IHF benefit from a comprehensive range of courses that cover the entire portfolio of high-frequency technologies – from the individual components to the complete system. The institute offers a wide range of lectures, internships, and various laboratory courses in this field. Furthermore, several Bachelor's, Master's, and PhD theses are regularly carried out.

As part of the research-led teaching, new developments are promptly integrated into the courses so that the latest specialist knowledge is always conveyed. The institute employees also keep themselves up to date with regular supplementary education and training courses, both in their specialist skills and in the area of new learning technologies.

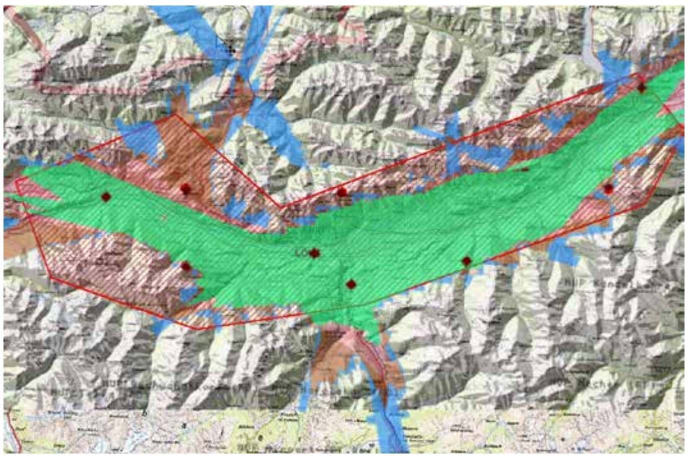
RFID systems

The global interconnections due to information and communication technologies (internet of things – IoT) needs new radiofrequency engineering solutions, which feature small dimensions, low energy consumption, and efficient data transfer.

RFID technology at RF, UHF and mmWave frequencies satisfies these requirements and shows the following properties:

- passive, semi-passive, and active solutions;
- wireless power and data transfer at various frequencies;
- a broad spectrum of new applications.

Air-traffic control and transponder load

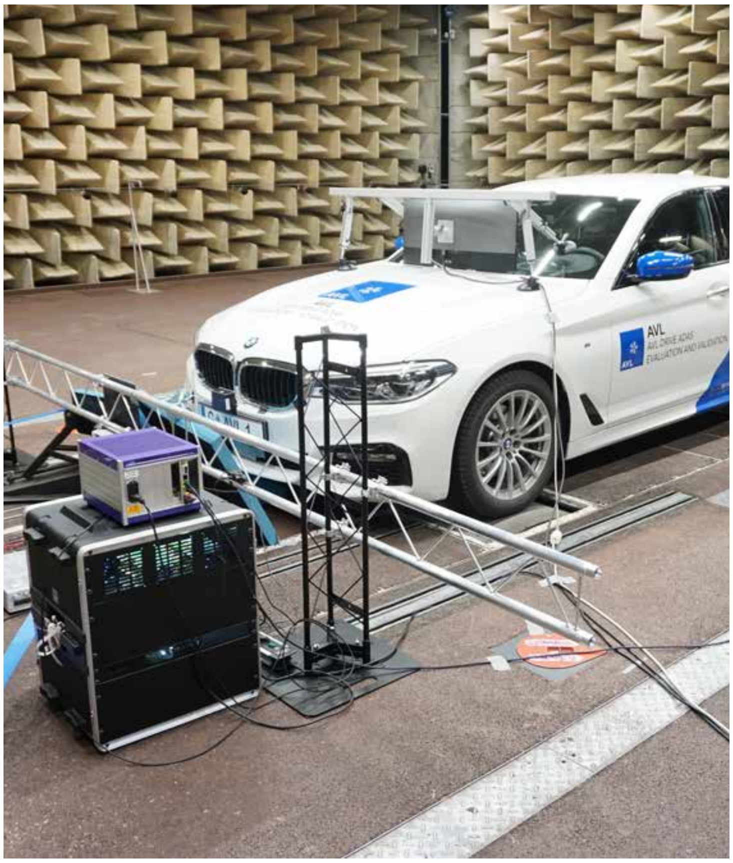


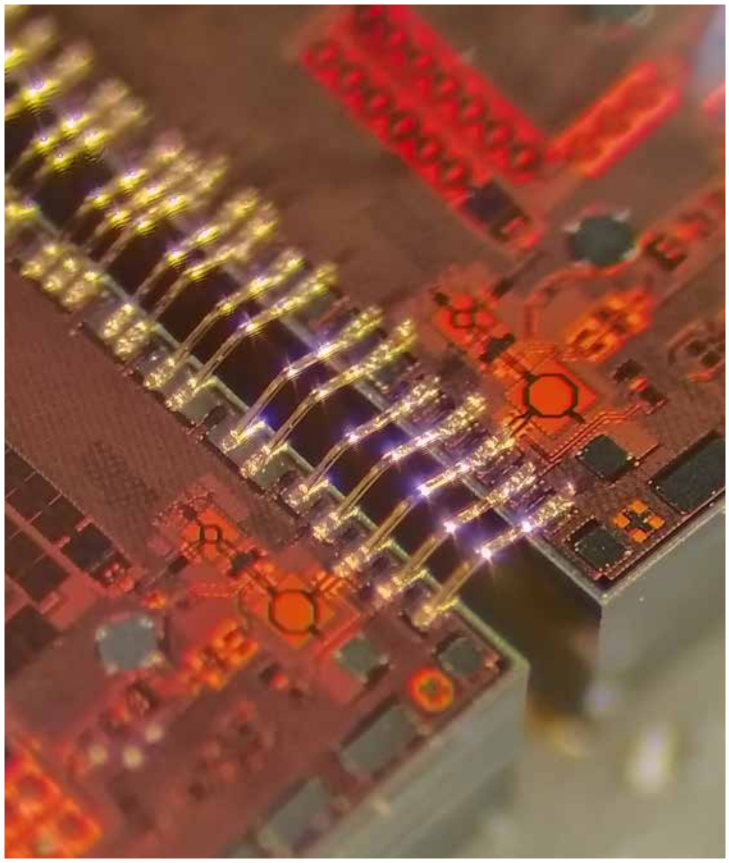
IHF develops a simulation tool for the European air-traffic control agency EUROCONTROL to determine the load of aircraft transponders and ground receivers (radar, ADS-B). This digital twin simulates all 1030/1090 MHz signals and provides an accurate image of the reality, allowing an assessment of existing and better planning for future surveillance infrastructure.

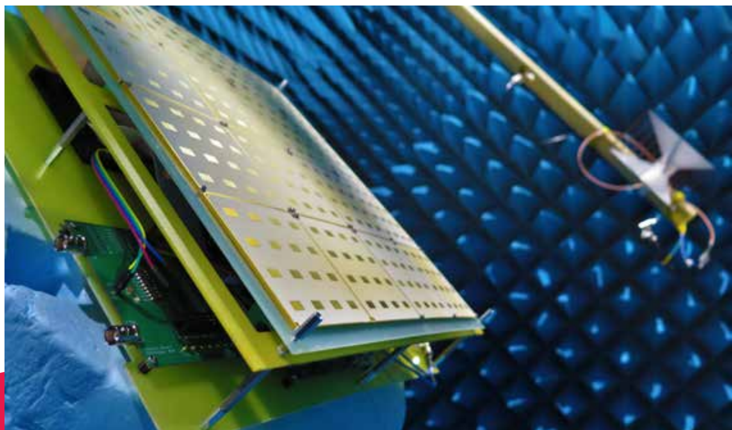
Additionally, IHF analyses radio wave based air surveillance infrastructure (e. g., radar or multi-lateration systems).

Optical communications

In the COST-project framework, new communication systems are researched to overcome the current limits of electronics regarding capacity and connectivity. In the future wireless 5G communications with multi-gigabit transfer rates, the internet of things, upcoming smart car scenarios, and satellite pay-loads will lead to a total convergence between fiber-based and wireless data transfer.

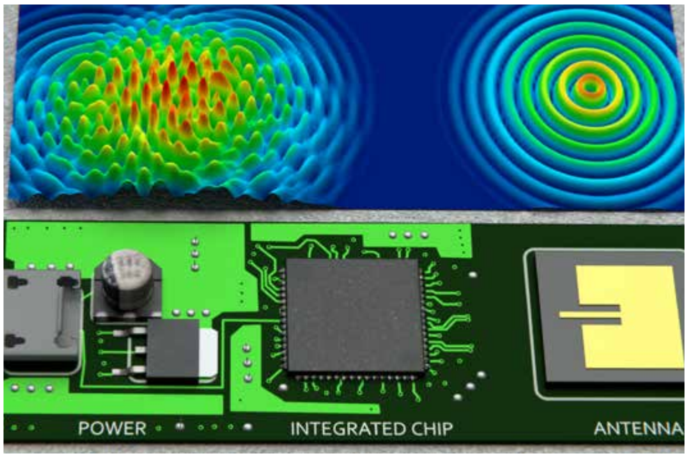


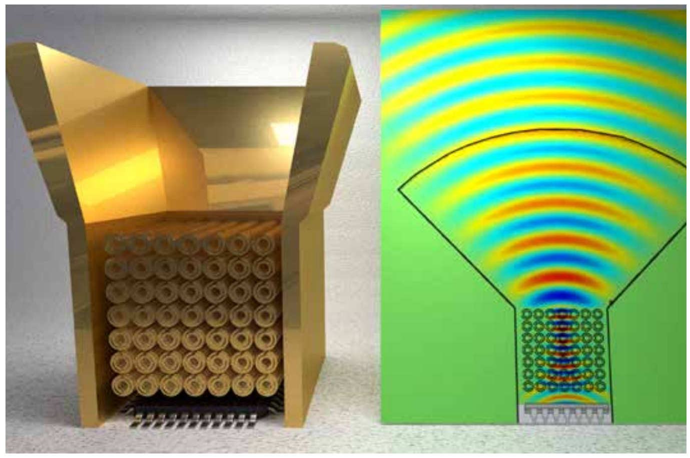


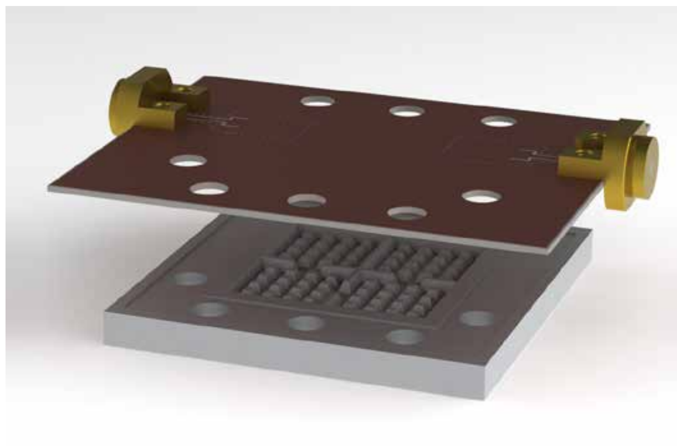


System design: examples of further projects

- Development of compact radar systems for remote environmental measurements like precipitation or bird migration monitoring;
- Detection and tracking of unmanned aerial vehicles using radar (in cooperation with Airlabs Innovation Lab);
- Development of a target stimulator for automotive radars at 77 GHz for testing driver-assistance systems and autonomous driving functions;
- Complete development cycle from low-level hardware to high-level signal processing and software systems;
- RF amplifier design with high efficiency and large bandwidth for radar and communication systems;
- 5G/6G phased array frontends based on innovative GaN semiconductors and PCB embedding technologies.







Antennas and Filters: design and manufacture

In the competence area of RF components, IHF is engaged in designing and manufacturing planar, semi-planar, and non-planar filters and antennas. This research is done in cooperation with European research institutions and partner organizations in additive manufacturing, materials research, and surface technologies.

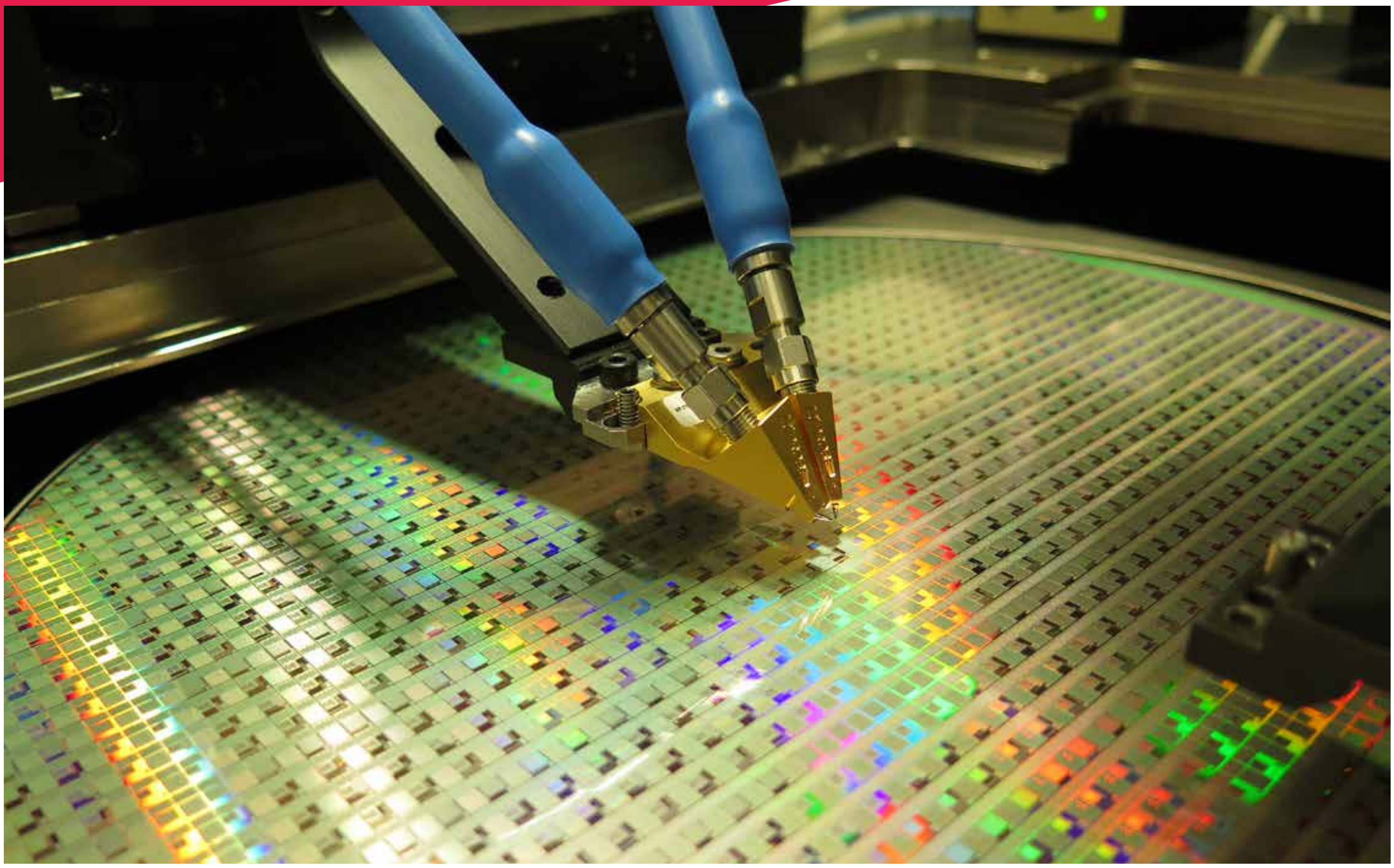
- Utilization of PCB-based as well as additive manufacturing processes for the design of antennas and filters;
- Design of periodic (metallic) structures for the miniaturization and optimization of RF and mmW components (metamaterials);
- Application of high-performance ceramics in filter and antenna design;
- 3D printing of gradient-index ceramic lattice structures for the implementation of specific microwave properties;
- Conception of multi-mode filters in the millimeter wave range;
- Multifunctional antennas and antenna arrays.

RFID: automatic and contactless identification and localization

RFID is a fast-growing technology with low energy consumption, which meets the requirements for various new applications in the Internet of Things. IHF is concerned with designing these contactless communication systems, such as sensing, localization, and tracking systems.

The design of individual components and devices is also part of our development work (RFID reader, software-defined reader, design of subsystem chip front ends: RF-DC converter, RF limiter). RFID technology plays a vital role for various companies in the Graz region – about 50% of all RFID chips used worldwide come from this area.

Further information:
www.tugraz.at/institute/ihf/institut/rfid-technologien/



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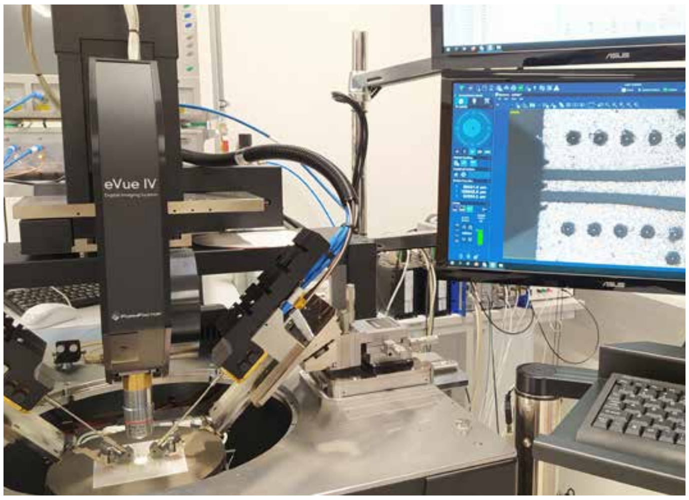
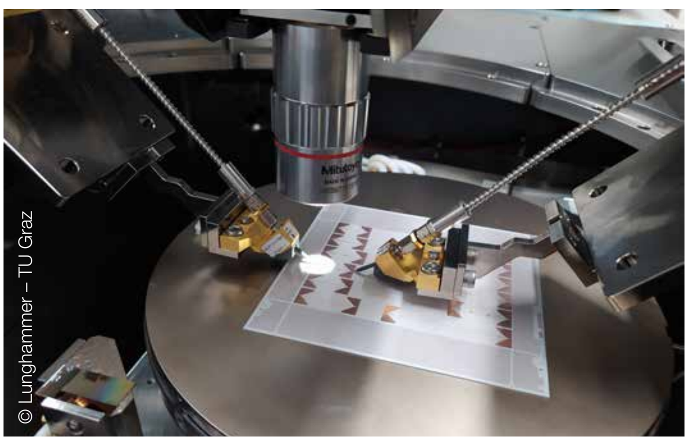
Measurement of RF components

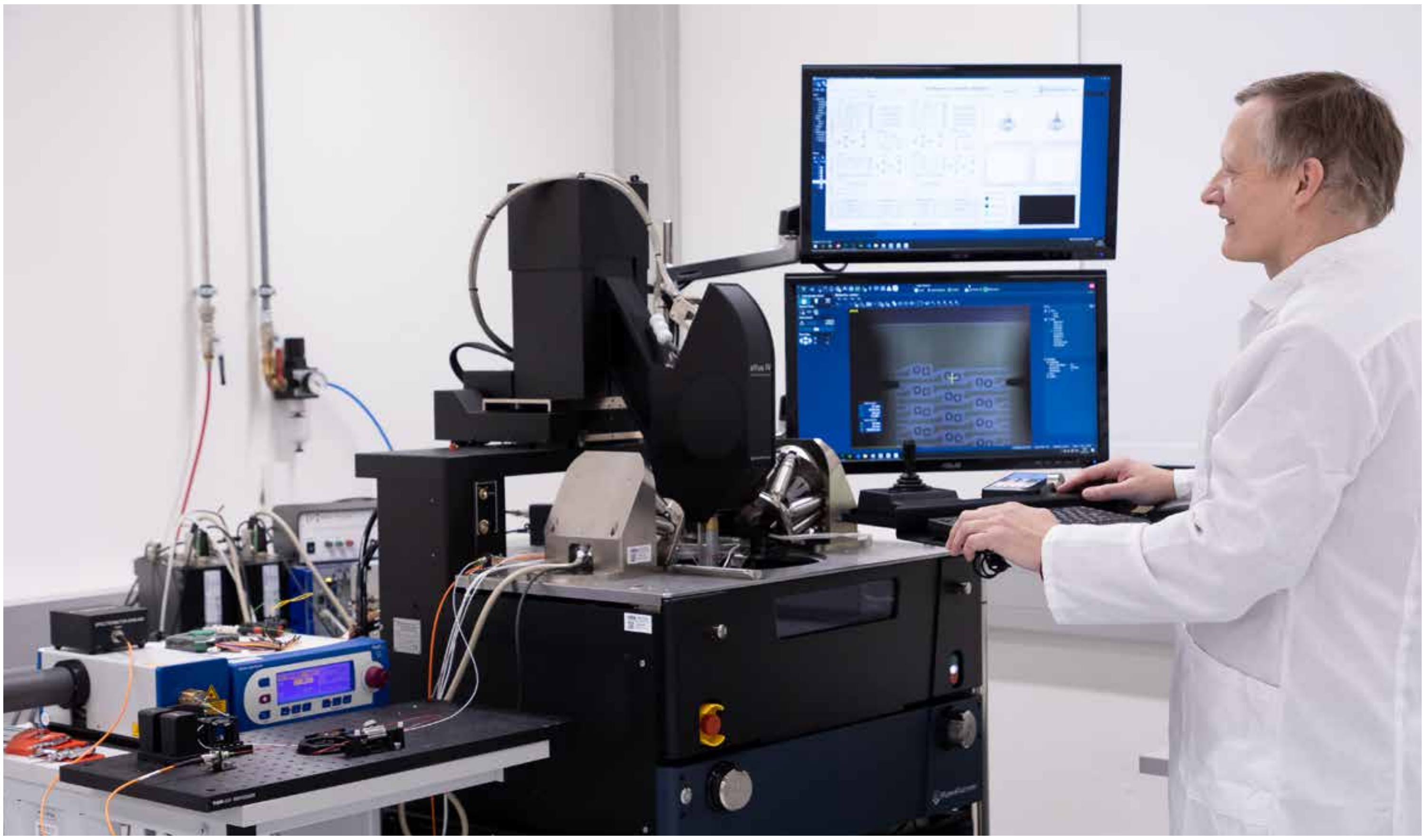


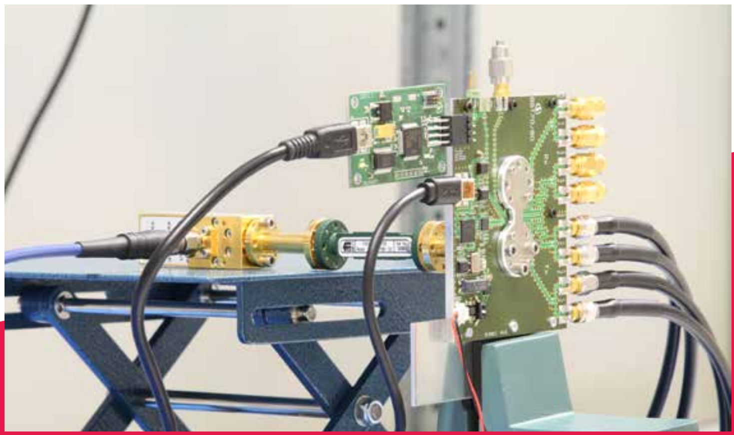
To characterize different types of RF components and systems, our institute operates several measurement laboratories and anechoic chambers that also support over-the-air (OTA) measurements. We conduct emission and immission measurements of electronic circuits and systems. For example, we implement customized transmission measurements of communication and radar systems. In addition, we focus on wideband characterization techniques, which enable us to perform the determination of RF substrates' material properties.

Characterization and measurement activities:

- RFID, Wireless Power Transfer (WPT);
- On-wafer measurements (RFIC, MMIC, charge pumps, components, …);
- On-wafer transitions;
- On-wafer tuning with lasers;
- Antenna characterization;
- Microwave and mm-wave system characterization;
- Signal integrity measurements (cables, connectors, PCBs, etc.);
- Phased array systems (5G und 6G);
- Broadband signal generation and analysis;
- Intelligent antennas;
- Interference and distortion analysis, coexistence;
- Characterization of material properties (Permeability, losses, etc.);
- RCS calculation and measurements.







Optical channel

The IHF has been involved in a variety of COST projects since the year 2000. COST 270 covers channel characterization for fiber optics and optical wireless links through measurements and laboratory demonstrators. The COST projects aim to develop methods for identifying and improving optical components and devices in modern communication networks and transmission systems.

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Area of Expertise – Integration

The Christian Doppler Laboratory at IHF

In 2020 the CD-Laboratory for "Technology Guided Electronic Component Design and Characterisation (TONI)" was founded and is researching component design and technologies for better control of electromagnetic interactions in intelligent networked devices (e.g., smartphones), especially for 5G and 6G applications.

Only an interdisciplinary approach can resolve the challenges of future communication and sensor systems. Functionalities previously achieved by individual components are innovatively combined in embedded components. The technologies and innovative components must be precisely measured and modeled to guarantee optimum functionality.

The research work is divided into the following four areas:

Filtenna design:
Compact integrated antennas which simultaneously receive and filter signals.

Comprehensive measurement techniques:
Both filtenna and embedded component design rely on measurements of the components or materials involved. Measurement methodologies are being developed to provide highest degree of accuracy.

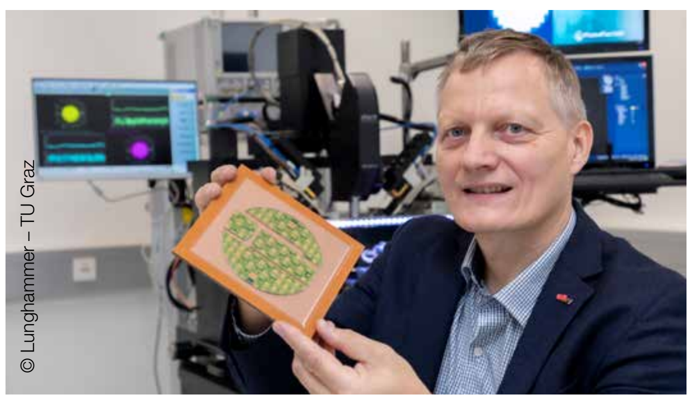
Embedded components:
Electronic components must be embedded in the printed circuit boards to reduce the overall device dimensions and, at the same time, increase their functionality.

Correct models instead of "trial and error":
Passive components in power electronics and the microwave frequency range must be precisely modeled to meet the requirements of modern electronic device design.

Christian Doppler Forschungsgesellschaft

TONI CD-Laboratory for Technology Guided Electronic Component Design And Characterization

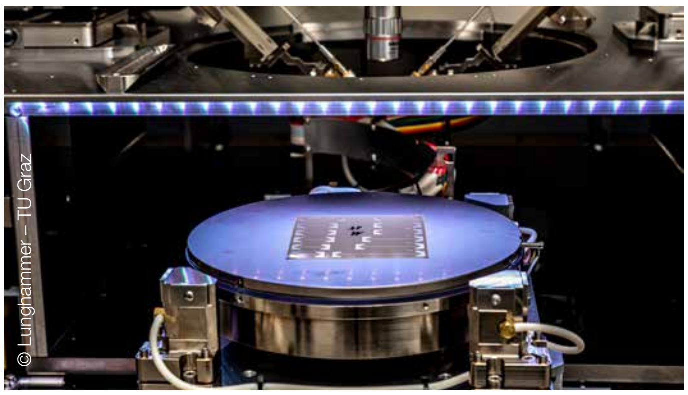
Together with the partner companies Qualcomm, AT&S AG, and Fronius GmbH we focus on embedded electronic components, three-dimensional integration and, at the same time, ensuring a robust and secure multifunctional operation.

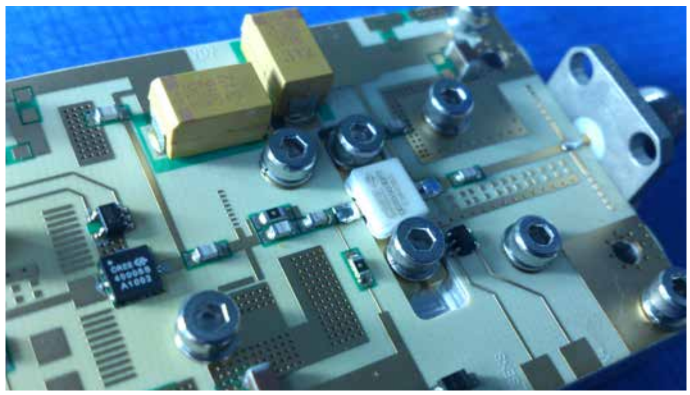


Heterogeneous Integration (Microwave & Photonics)

Current microwave and photonics systems are based on optical fibers and electronic components. Employing heterogeneous integration, we significantly increase energy efficiency, flexibility, and scalability. Thereby we increase the sustainability and cost efficiency of future systems. The aim is to bundle a wide range of different technologies into new high-performance microsystems.

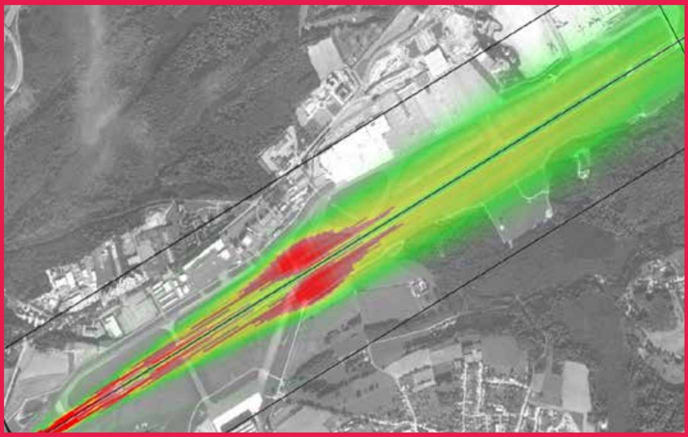
This way, we combine manufacturing technologies, components, and assembly technologies for sensors, electronics, data processing, and wireless communication applications. The optimum combination of different functionalities enables innovative solutions for 5G, 6G, automotive, radar, and space applications.





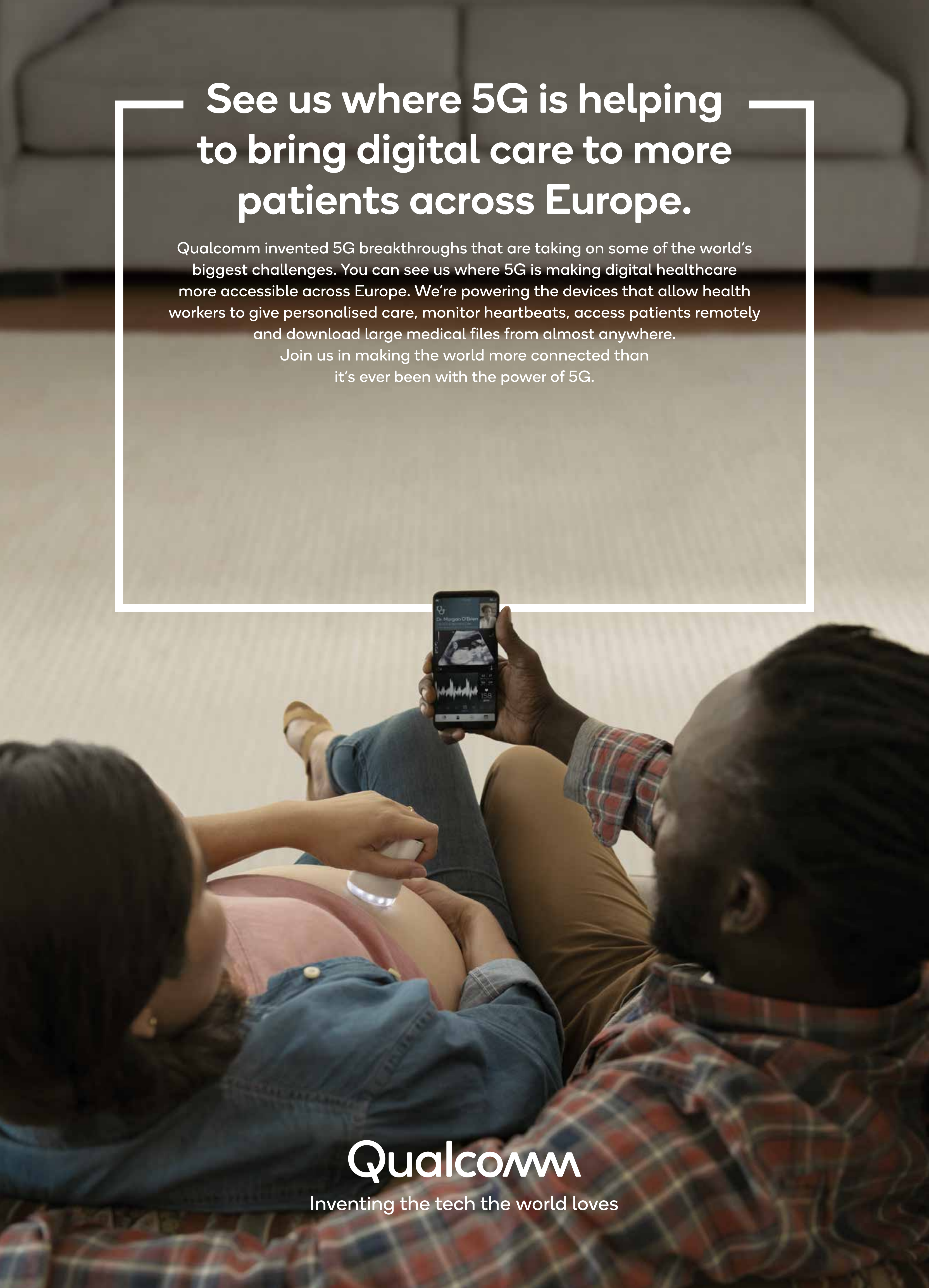
Coexistence of systems

This competence area focuses on the coexistence and compatibility of future electronic communication and radar systems. In this context, IHF is concerned with measurements of wireless power transfer (WPT) systems, near field communication systems (NFC), and generic measurements of electromagnetic exposure at microwave frequencies. Simulations of interference to radar systems, instrument landing systems (ILS), and other radio systems caused by, e. g., wind turbines, photovoltaic systems, buildings, etc., are also carried out.



The Institute of Microwave and Photonic Engineering says – thank you!

Our long-standing partners significantly contribute to the institute's research and development activities based on their competence and loyalty. At this point, we like to express our gratitude for the excellent cooperation!


See us where 5G is helping to bring digital care to more patients across Europe.
Qualcomm invented 5G breakthroughs that are taking on some of the world's biggest challenges. You can see us where 5G is making digital healthcare more accessible across Europe. We're powering the devices that allow health workers to give personalised care, monitor heartbeats, access patients remotely and download large medical files from almost anywhere.
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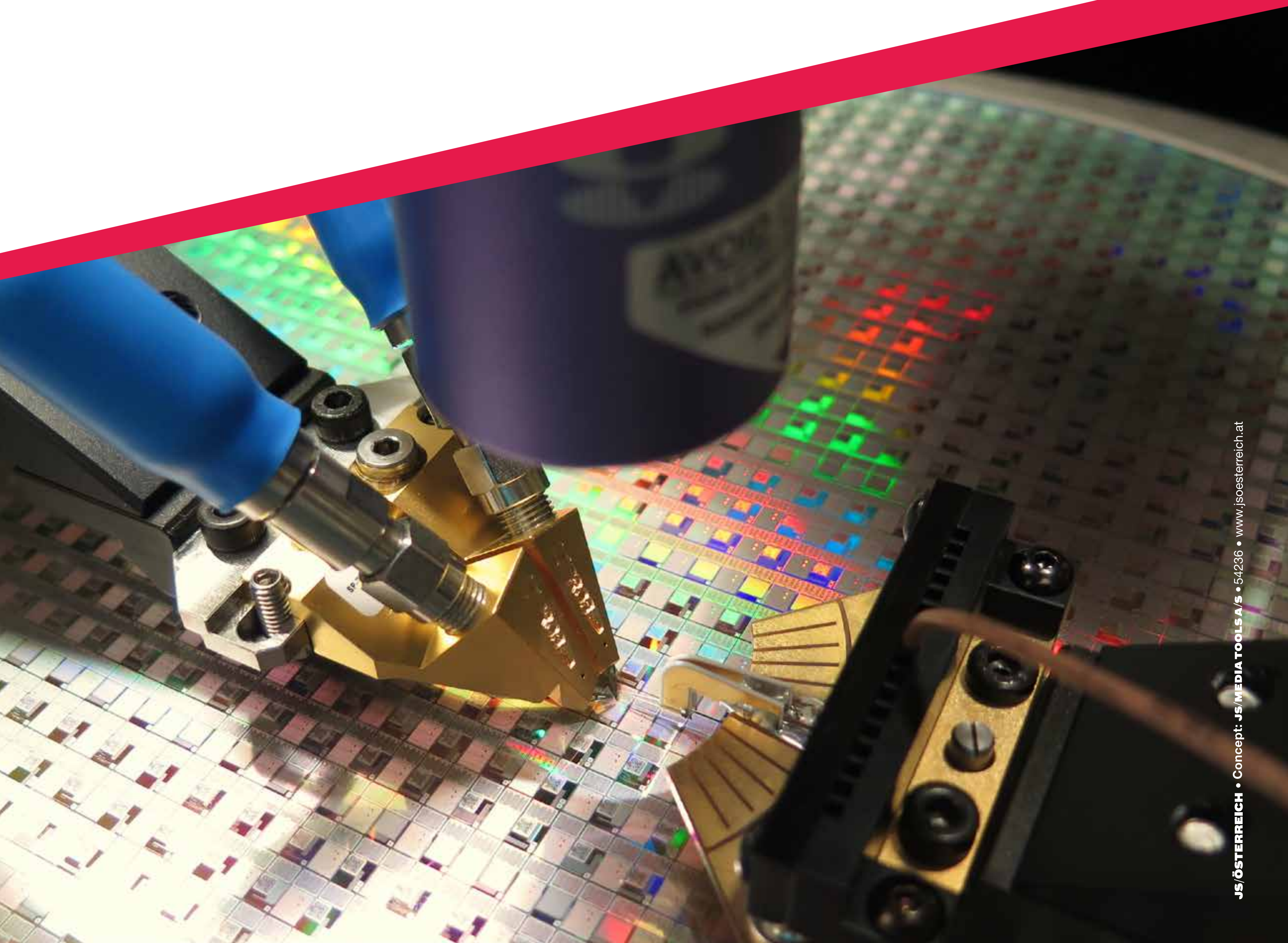

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