Fraunhofer IZM

FRAUNHOFER INSTITUTE FOR RELIABILITY AND MICROINTEGRATION IZM

DEPARTMENT
RF & SMART SENSOR SYSTEMS

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The Fraunhofer Institute for Reliability and Microintegration IZM is one of 66 Fraunhofer institutes doing research in applied natural sciences and engineering. Working hand-in-hand with industry and government institutions, the institute has many years of experience in developing cutting-edge packaging technology and smart system integration techniques. Its goal is meeting the demand for higher reliability and multifunctionality while reducing manufacturing costs. As a first step in meeting this goal, Fraunhofer IZM uses innovative methods to ensure application requirements are addressed early in the design process, thus ensuring this phase of product development is as efficient as possible.

The institute also cooperates closely with the TU Berlin's Research Center for Microperipheric Techologies. Approximately 220 researchers and 140 interns and students work at the three sites in Berlin, Dresden and Oberpfaffenhofen.

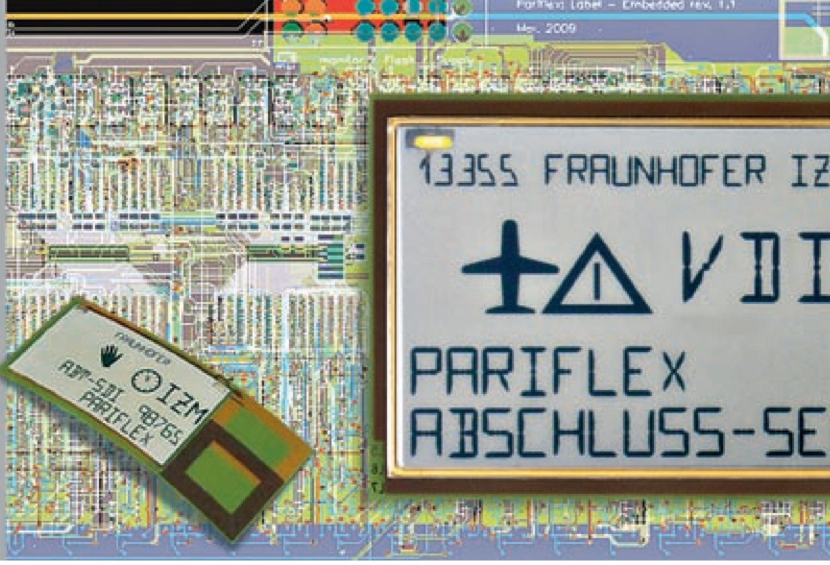
Key technology foci:
- Integration on wafer level
- Integration on substrate level
- Materials, reliability and sustainable development
- Design methodologies and system design

To develop electronic systems using the latest packaging technologies, the design process itself needs to be continually reassessed and optimized to ensure maximum efficiency.

The Department of RF & Smart Sensor Systems develops methods and tools for the targeted, technology-oriented design of electronic systems. By simulating thermal and mechanical coupling and electrical, magnetic, electromagnetic phenomena at all stages of the development process, we can compare the functionality and capacity of different technologies as early as during the concept design phase. Our services include functionality, volume, reliability and cost analyses, which can all be carried out at the earliest stages of the design process.

Using new methods and tools, we develop technology demonstrators and prototypes for electronic assemblies and embedded systems. The most important application areas are:
- Microelectronics and microsystem technology
- RF and high-speed system design
- Micro energy systems

Miniaturized autarkic systems for logistics applications



RFID label with eInk display

MINIATURIZED AUTARKIC SYSTEMS

Autarkic microsystems are an important interdisciplinary technology in many industry branches and make new products and services possible.

Condition monitoring in construction engineering

Autarkic sensor systems can be used to monitor complex machines and equipment during operation. They make condition-oriented maintenance possible by, for example, predicting remaining life time. We develop sensors for this technology that can also be placed in hard-to-access areas of equipment under the harshest operating conditions.

Energy efficiency

Energy industry facilities are decentralized, designed for long lifetimes and have to meet high reliability standards despite fluctuating supplies from regenerative power sources. For this reason, autonomous distributed sensor systems are required that can record state variables at any time and in any part of the overall system. We address these needs by, for example, developing sensor systems suitable for high-voltage systems that can monitor the effects of wind on a conductor cable, such as temperature, sag, conduction current and mechanical oscillation.

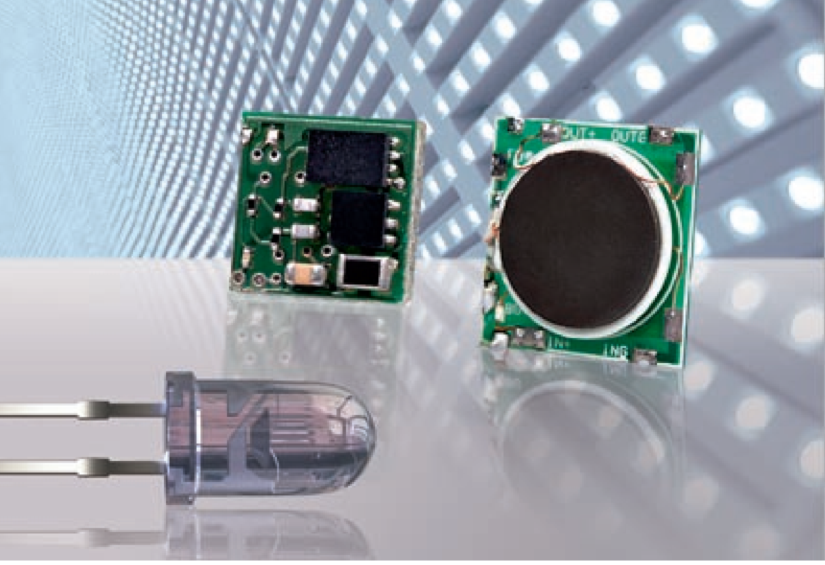
Logistics

Information about the handling, current position and environmental conditions of a shipment improves services and makes new ones possible. Consequently, logistics was one of the first areas to take up and extend the use of autarkic data loggers and display systems. We have developed semi-active and active sensor tags and modules for this area, including some with position finding and innovative display systems.

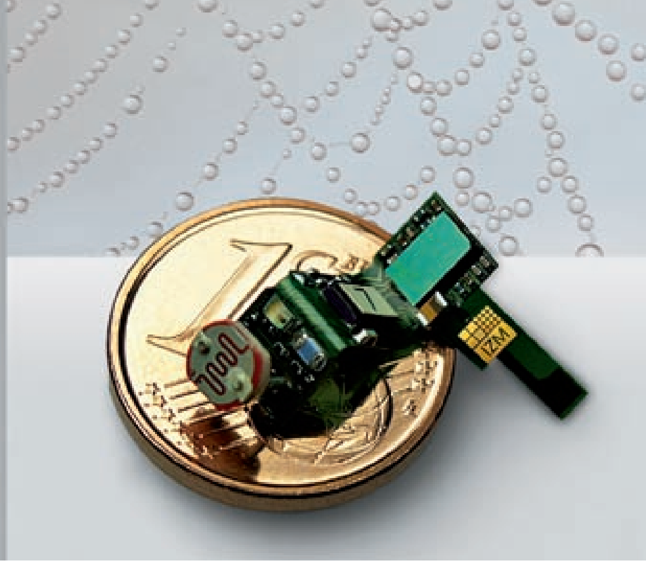
Design and development

Once a niche idea, autarkic sensor systems are fast becoming a measure of innovation in many new products from a variety application areas. We specialize in the targeted adaptation of all components in such system to the requirements of the application:

- The processor is the core of an autarkic sensor system, and precisely configuring its computing performance and power consumption is crucial, which is why we work with a wide range of systems, from simple processors to co-processing systems.
- The type of memory required, for example long duration data loggers or digital data processing and transmission in real time, strongly depends on the system's degree of networking.
- Especially energy efficient measurement principles are used to select the sensor elements for systems that include high-resolution components.
- A current development focus is the integration of optical sensors for color recognition and spectral analysis.
- Properly applying configured transmission and receiving frequencies is a key task in designing efficient communication and position finding technology.
- Using storyboards detailing the system's operating conditions, we develop autarkic sensor systems right through to the casing design, which generally includes integrated sensor elements. Apart from the protective function of the casing, display and operating elements are also directly integrated where necessary in ways that do not hamper later assembly.



Miniaturized piezoelectric converter



World's smallest sensor node

ENERGY SUPPLY OF MICROSYSTEMS

AUTARKIC ENERGY

As the miniaturization of distributed electronic systems progresses, so do the challenges to providing adequate energy supplies. We model and parameterize the entire energy conversion chain – from the source, like a primary cell or an energy harvester, to a suitable processing technique and intermediate storage element, right through to variable loads. This allows us to assess how individual components affect the behavior of the overall system during the design stage and to optimize these according to set criteria.

Energy management

A key focus of our work is energy management and the adaptive adjustment of dynamic loads in energy autarkic systems that communicate wirelessly. This includes communication interfaces and components for condition monitoring whose energy requirements necessitate a wide range of load profiles.

Recharging

We are also extending the range of applications for such systems by developing new concepts for the wireless recharging of batteries used by miniaturized systems.

PIEZOELECTRIC CONVERTERS

Piezoelectric converters are expected to appear in a wide range of applications in power supplies, actuators and as power sources. Increasingly, they will drive the technology required to miniaturize and efficiently design the power supplies of LEDs, notebooks and monitors.

Power supplies

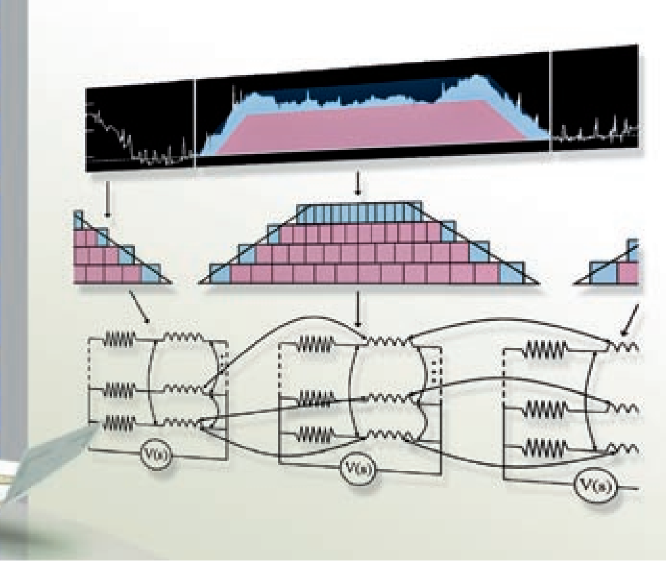
Fraunhofer IZM is a world leader in the design and optimization of piezo power supplies. We have particularly extensive experience in the design of extremely planar high-voltage generators for controlling cutting-edge actuators, such as electrorheological, piezo and elastomer actuators. The patent portfolio we have assembled over recent years in this area secures our project partners entry into the market.

Application-specific IC design

We also have comprehensive knowhow in the design of integrated circuits for piezo and resonance converters, as well as for energy harvesting units with extremely low power dissipation, autarkic systems, sensor technology and RF design.

Our many years of experience in the optimization of systems (evolutionary methods, heuristic energy-based processes) allow us to provide services in the design and optimization of customer-oriented systems, from prototype manufacturing, to characterization and measurement analysis, right through to short time-to-market.

Antenna characterization in Fraunhofer IZM's ASE lab



Numerical techniques for conductor loss modelling

RF SYSTEM DESIGN & INTEGRATION

To meet increasing demands for miniaturized electronic products, integration density is continually increasing on all levels - on the chip, in the package and on the substrate. More and more products also include a variety of wireless communication interfaces. These high integration densities combined with working frequencies of more than 1 GHz are increasingly impairing electromagnetic reliability, resulting in degraded signal and power integrity and electromagnetic interference.

M3 Approach – methods, models and measures

Our research focuses on the application of electromagnetic field and network theory for the development of efficient and accurate electrical modelling, simulations and measurement techniques. We design reliable models using these techniques, which can then be used to analyze and characterize electronic chip packages (e.g. SiP, SoP, CSP, WLP), circuit boards and antennas. Our methods and models apply at up to more than 100 GHz and have been validated using measurements for frequencies up to 110 GHz. Finally, we derive design measures and rules from these models and apply them to develop cost-efficient RF & high-speed components, modules and systems. Furthermore, this approach allows us to optimize the systems' functionality and electromagnetic reliability. We call this comprehensive and systematic technique the M3 approach, as methods, models and measures are developed and coordinated.

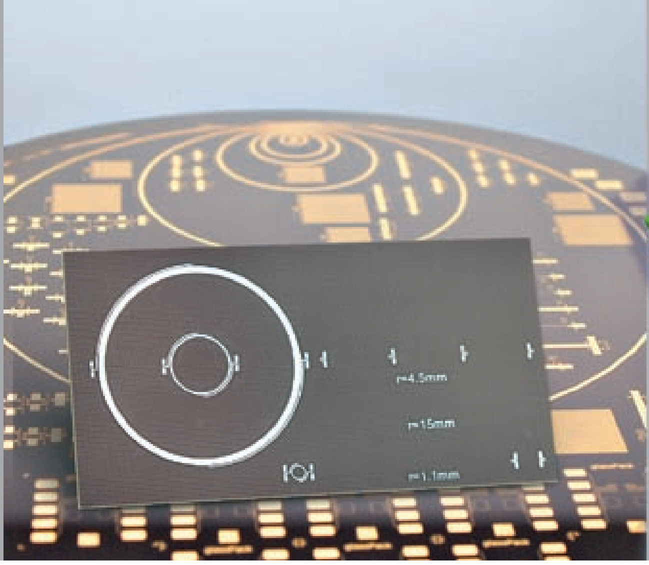
We have used the M3 approach to systematically design components such as flip chip bumps and wirebonds, transmission lines, power distribution networks, integrated waveguides and through connects in silicon (so-called through silicon vias, TSVs) and insulating substrates (e.g. FR4, ceramic, glass) for chip packages and circuit boards.

Integrated antennas

Robust communication via wireless interfaces are becoming very important in many applications. Reliable integration of the antenna is a crucial aspect in the development of such systems. Here too, we use the M3 approach to create a reliable design and integrate planar, conformal and 3D antennas for RFID, GPS, WLAN / WPAN, radars and mobile radio applications from kHz to 100 GHz.

Model-based system design

We provide electrical modeling, simulation, design and measurement services for the pre- and post-layout phase of product design. In the pre-layout phase, we apply the M3 approach. In the post-layout stage, we employ our state-of-the-art simulation tools and our well-equipped laboratory to perform thorough electrical analysis, characterization and optimization.



Ring resonator to determine dielectric constants

Design tool for 3D hetero system integration

ELECTRICAL CHARACTERIZATION

The electrical capability and reliability of many components used for RF, high-speed and sensor systems depend on the applicable dielectric or carrier substrate and the casing or encapsulant. The dielectric properties depend on the frequency and environmental conditions such as temperature and moisture. For this reason, in-depth characterization of the materials for the intended frequency range based on realistic environmental conditions is essential.

RF properties depending on moisture and temperature

Our research aims to extract the relative dielectric constants and the dielectric loss factor depending on frequency, temperature and moisture content for a multitude of dielectric materials based on a combination of measurement methods, and analytic and numerical models. We develop special test structures to experimentally validate these models.

Our services also include determining the electrical parameters of dielectric materials using test structures and split-cylinder measurements, and measuring breakdown voltages. We have already used our methods to characterize organic substrates, glass and silicon for applications up to and including the milimeter wave range.

SYSTEM DESIGN METHODOLOGY

More complex microsystems comprise a multitude of materials joined using different techniques. Using the most important integration technologies and their degrees of freedom, we develop models to efficiently solve the challenges of electromagnetic reliability, system miniaturization and cost optimization. This results in design rules, component arrays and optimization measures. Instead of considering individual components in a rigid design workflow as is conventionally the case, we prefer a flexible, model-based design approach.

Increasing design efficiency

The individual design steps are identified during the development process by weighting the individual design decisions according to the target sizes, such as the system volume or the interference resistance. This increases design efficiency significantly. We develop and validate specific design tools for various system classes to make this possible.

System design tools

After detailed validation, the design tools are developed further into universally applicable tools using concrete design tasks. These tools can then be integrated and applied by our project partners in the design process. The capability of the developed design methods have already been demonstrated in collaborations with research partners and customers from industry. For example, we have developed extremely cost-efficient tire imprint sensors and the world's smallest sensor nodes for adhoc wireless networks.

SERVICE & CONTACT

LABORATORY FACILITIES

ADVANCED SYSTEM ENGINEERING LAB

In our newly designed, excellently equipped Advanced System Engineering laboratory, we offer our customers multifaceted services for targeted, efficient design and fast prototyping of sophisticated electrical systems.

Comprehensive measurement technology is available to our customers for smaller measurement tasks as well as for long-term research projects.

Key features include:

- RF characterization up to 110 GHz of microelectronic technologies and components
- Antenna measurement and characterization
- Power conversion for energy storage and piezoelectric components
- Micro energy systems
- Rapid prototyping: PCBs, 3D replication, mechatronic tests

ELECTRONICS CONDITION MONITORING LAB

- Condition monitoring and online failure detection for electronic systems
- Combined lifetime tests: vibration, temperature, moisture

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SERVICES

Our services cover the entire electronic system design process – from feasibility studies through to prototype manufacturing.

- Support during all phases of development
- Development and realization of demonstrators and prototypes
- Simultaneous design support (pre- and post-layout)
- System verification testing
- Derivation of parametric models for efficient system simulation
- Technical and organizational support during the transfer into series manufacture

CONTACT

Fraunhofer IZM
Head: Prof. Dr. Klaus-Dieter Lang
Gustav-Meyer-Allee 25
13355 Berlin
Phone: +49 30 46403 153
Fax: +49 30 46403 123
Email: info@izm.fraunhofer.de
URL: www.izm.fraunhofer.de

Head of Department RF & Smart Sensor Systems
Dr. Ivan Ndip
Phone: +49 30 46403 679
Email: ivan.ndip@izm.fraunhofer.de

Harald Pötter
Phone: +49 30 46403 742
Email: harald.poetter@izm.fraunhofer.de

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