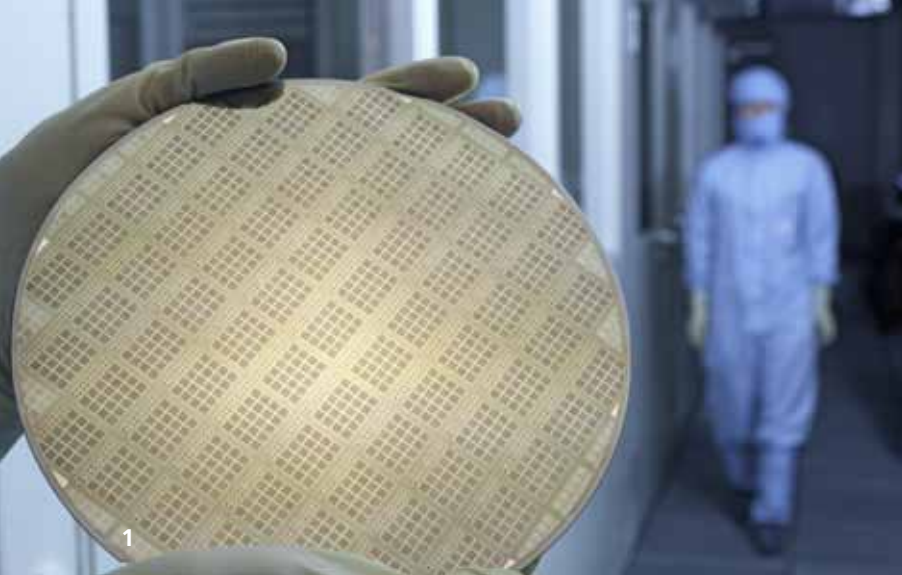


SENSORS AND ACTUATORS FOR PEOPLE AND THE ENVIRONMENT



A word cloud of various microsystems and sensor technologies. The words are arranged in a roughly circular pattern, with some larger than others. The background is a blurred image of a laboratory or factory floor with blue lighting.

Roll-to-Roll
Foil electronics
Microsystems technology
Sensors
CMOS
System design
Silicon technology
Microdosage systems
Sensor textiles
Reliability analysis
MEMS
Nanosensors
Flexible systems
Electrostatic discharge
Sensor materials
Actuators
Flow sensors
Microfluidics
Thin semiconductors
Integrated circuits
Micropumps
3D-Integration
Sensor dyes



**WE BRING
SENSORS AND
ACTUATORS INTO
APPLICATION!**

SENSORS AND ACTUATORS – MARKET WITH POTENTIAL

The fire brigade is automatically called at emission of dangerous gases in the lab. The navigator warns you about traffic jams on your route. The lamp at your home door independently switches on at night fall. All this is made possible by intelligent sensors and sensor systems mostly invisible to us. Yet they have already become an important part of different aspects of our daily lives, and they are bound to gain even more importance in the future. Fraunhofer EMFT is contributing to this future already today.

Whatever we do, wherever we go, we can hardly do without sensors, although we hardly even notice them. At home and in our leisure time they make our lives more comfortable, secure and interesting. In industrial production sensors are used for measuring, controlling, monitoring and automation. Sensors increase the functionality and therefore also the value of several products without significant addition to the production cost. A prime example for this is the mobile phone, which has evolved into an irreplaceable all-round-talent due to integration of various sensors. The end of this development is not yet to be seen.

Visions such as Smart Objects, Pervasive Computing, Internet of Things (IoT) or Industry 4.0 are based on the concept of an internet-based network of physical objects, capable of collecting, analyzing and sharing data autonomously. Such an intelligent network requires innumerable sensors and actuators with new, expanded functionality. These “intelligent aids” will become more and more valuable, specific and robust. Still, their production costs continue to decrease, thanks to modern manufacturing methods. Innovative technologies such as energy harvesting enable additional novel applications, such as energy-independent wireless sensor networks, capable of autonomous monitoring of large areas. Due to these trends, a continuous growth for sensors and actuators can be expected in the next years to come.

At the moment several visionary organizations are predicting a strong growth in the market demand for sensors, from billions in 2016 to trillions within the next ten years. This growth is driven by sensor-based intelligent systems, combining computing, communication and sensors. Several leading companies have recognized this trend to “1 Trillion sensors” and defined sensors as a strategic growth area within their organizations. In addition to the IT business, manufacturers in the areas of medical technology, consumer electronics and mobility are showing strong interest in this topic.

This rapid development brings about new challenges as well, requiring a thorough understanding of the total concept in question. Strong partnerships and open innovation are the key to creation of successful solutions, since they enable combining competences from various fields as well as deployment of synergies.

Fraunhofer EMFT possesses a long-term experience in the development of sensors and actuators for a wide range of applications. The scientists at Fraunhofer EMFT adopt the role of pioneers as well as service providers, combining innovative ideas with concrete benefits for their partners and users. A further strength of Fraunhofer EMFT lies in the interdisciplinary approach, since innovations often evolve, where disciplines and technologies meet. With this mental warehouse, the competence team of Fraunhofer EMFT, together with its customers and partners, is well prepared to turn visions into reality.

1 *Fraunhofer EMFT scientist shows a silicon wafer in a cleanroom environment*

2 *Sensor pigments*

3 *Large-area processing of foil electronics*

4 *Microdosing system for microlubrication of precision bearings in high performance spindles*



BUSINESS AREAS

Fraunhofer EMFT organizes its activities into five business areas, focussing on novel key technologies for providing solutions to the challenges faced by people and the environment worldwide.

“Sensor Materials” developed at Fraunhofer EMFT indicate the presence of analyte molecules by changes in color or fluorescence. The materials are based on indicator dyes and are tailored to the application concerned. They can be integrated in various substrates, such as polymers, foils, microparticles, nanoparticles or even textiles. They can be applied to surfaces by means of coating or printing techniques commonly deployed in the respective field, such as screen printing or web coating. Sensor materials can be used in a wide variety of applications: In protective clothing they increase safety in laboratories, they enable effective measurement and monitoring of hazardous substances in environmental analysis, and special sensor foils integrated in packaging help monitoring the freshness of food.

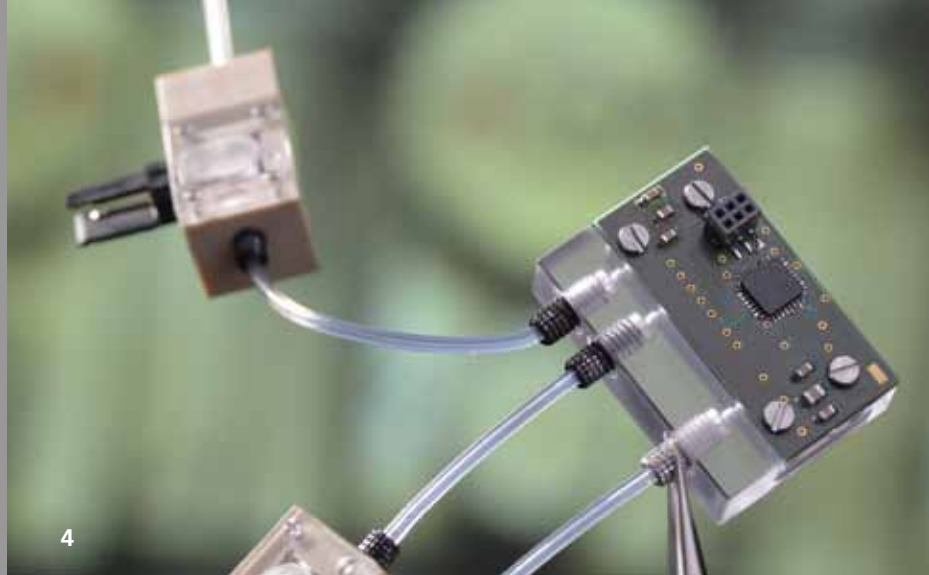
Sensors and actuators are the key focus of the business area **„Silicon Technologies and Devices“**. They are used in several application fields, from life science and medical technology to aerospace. Services provided include process development and small series production of silicon-based sensors as well as the qualification of process media. The close strategic collaboration with companies ultimately benefits the customers: their own staff can use the cleanroom infrastructure as well as draw on the expertise of experienced staff at Fraunhofer EMFT. Small series production at Fraunhofer EMFT makes sense wherever low volumes are not available on the global market. Close collaboration also allows typical customer problems to be solved, such as increasing yield and throughput in small series production.

The **“Micro Dosing Systems”** business area offers its customers individually tailored, sensor-supported micro dosing solutions based on leading edge micropump technologies. The handling and dosage of tiny quantities of liquids or gases is crucial to a wide array of applications nowadays, such as machine lubrication, laboratory technology or even fuel cells. Especially in the field of medical technology the micro dosing systems offer new opportunities for diagnosis and therapy of e.g. cancer, diabetes or diseases of the eye. In addition to exact dosage of tiny volumes the scientists at Fraunhofer EMFT are specialists at overcoming the special challenges of micro dosing systems, such as bubble and particle tolerance, counterpressure or chemical stability.

Increasingly thin semiconductor components is a major trend in microelectronics. Such thin components play an important role e.g. in high performance electronics, micromechanical systems (MEMS) or for RFID labels in logistics applications. In the business area **“Flexible Systems”** the Fraunhofer EMFT scientists integrate thin components such as sensors, solar cells, integrated circuits and displays into entire systems in flexible substrates. In addition to improved performance and easier handling, such flexible systems enable novel applications e.g. for packaging, building or electronics industry. The technological opportunities vary from large-area flexible wiring to three-dimensional packaging and printed circuits and systems.

With its business area **“Circuits & Systems”**, Fraunhofer EMFT offers its customers various services, ranging from design and development of integrated circuits and components through to complete (sub)systems and their multiparametric characterization and reliability assessment. The Fraunhofer EMFT scientists also carry out analysis of functional errors and reliability problems of electronic components and systems, all the way to product authentication. In addition to commercially available equipment also novel technologies developed by Fraunhofer EMFT and adapted to the specific needs of the customers are used.

INDIVIDUAL DEVELOPMENTS FOR YOUR SUCCESS!



COMPETENCES

Complex and specialized Know-how is needed for tackling the technological challenges facing the business areas of Fraunhofer EMFT. Fraunhofer EMFT groups its areas of research and development expertise into five competence areas.

The Fraunhofer EMFT has outstanding expertise in selective synthesis of indicator dyes, and in chemical modification of polymers, in order to create **“Functional Molecules”**. The indicator molecules are either embedded in polymers or immobilized on surfaces as micro- or nanoparticles. The synthesis of sensor pigments allows creation of additional features at wish, such as hydrophily, hydrophobia or polarity. In addition to these indicator molecules the scientists at Fraunhofer EMFT also develop optical measurement modules, adapted to the specific characteristics of the respective sensor materials. Such modules enable analysis of optical signals as well as storage and transmission of the measurement data.

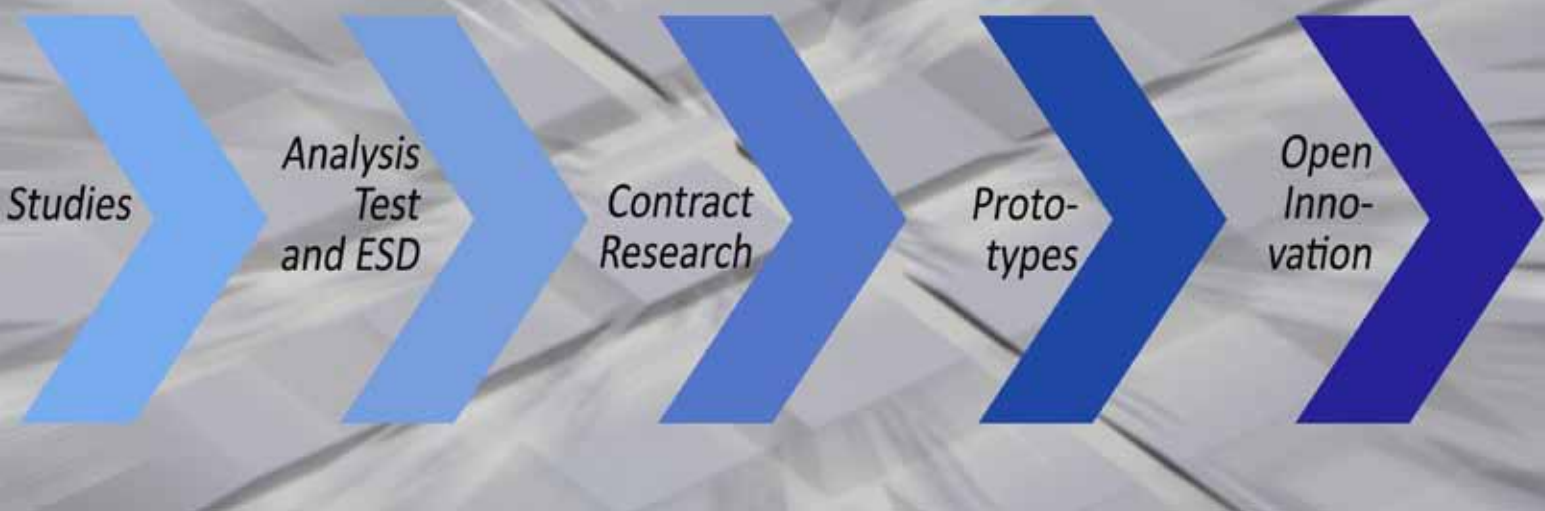
The scientists at Fraunhofer EMFT are specialists in the field of **“Silicon Technologies, Devices and 3D Integration”**. In addition to CMOS technology this competence area breaks down into the areas 3D integration, MEMS technology, thin wafer technology and epitaxy. A key feature of 3D integration by means of through-platings through the silicon of a circuit (through silicon vias, TSV) is the combination of tungsten vias with the structuring of subsystems based on intermetallic connections made of copper and tin. Technologies for the production of thin wafers are directly linked to 3D integration. The “Dicing-by-thinning” technology, developed and patented by Fraunhofer EMFT, allows for production and processing of thin, flexible silicon chips only 10 µm thin. Other focus areas include silicon epitaxy for high-impedance, intrinsic layers and SiGE epitaxy for selectively strained layers or sacrificial layers. The combination of standard and special processes offers a wide range of technological possibilities. These vary from small batch wafer processing to development of new components for flexible customer solutions in the field of microsystem technology.

Fraunhofer EMFT scientists also have special know-how in piezoelectrically powered **“Micropumps”**. They are at the heart of micro dosing systems. However, the technology requirements such as dosing precision, counter-pressure resistance, small size, low energy consumption, particle resistance, bubble tolerance and free

flow protection require a series of technical solutions. The Fraunhofer EMFT team has longstanding experience in this area and has extensive practical knowledge in the design of micropumps. Given the combination of design expertise and technology platforms (silicon, metal, plastic), there is currently no other development team in the world that is able to offer industry clients this breadth of solutions for micro dosing systems. The competence also includes a good IP portfolio with broad and central key patents.

The Fraunhofer EMFT possess excellent competencies in the area of **“Foil Technologies”**. The combination of various technological areas enables new efficient solutions for manufacturing of components and systems, as well as integration of systems on flexible substrates. The merging of distinct technological worlds paves the way for new, effective solutions for producing components and systems as well as integrating systems in flexible substrates. With its laboratory facilities and reel-to-reel manufacturing capabilities for foil technology and flexible electronics, Fraunhofer EMFT has at its disposal a unique technology platform for cost-effective development of multifunctional electronic systems. This makes near-product prototypes and small batch production possible, also in combination with the classic areas of semiconductor technology.

The interdisciplinary approach in system development and integration are the basis of the competence area **“Design, System Integration and Test”**. The competence fields include hardware, software, electronics, mechanics as well as optics. The offering in system development comprises first concepts and feasibility demonstrators as well as prototypes and complete systems. In addition to customized components developed at Fraunhofer EMFT, standard components can be deployed, according to the individual needs of the customer. Microcontrollers or PCs are used for controlling the systems. Analysis of complex errors and reliability problems is another focus area of this competence, offering a basis for successful robustness validation as established e.g. in the automotive industry.



YOUR DEVELOPMENT PARTNER FRAUNHOFER EMFT

The Fraunhofer EMFT research and development services extend from strategic preliminary research over bilateral industry projects to coordination of industrial project consortia. Practical, customer-oriented solutions always stand in the main focus of the cooperation.

Studies

- Technology analysis
- Feasibility studies
- Assessments in the case of damage claims

Modeling & Simulation

- Whole process
- FEM simulation
- System response

Customer-specific development

- Advance development
- Single process modules and overall process
- Chip design
- Components and systems

Prototypes and small series production

- System design
- Layout
- Device design and construction

Analysis & Test

- Risk and problem analysis
- Development of test methods and equipment

Professional development

- Seminars and training programs
- Special conferences

R&D as part of publicly funded projects

- Joint publicly funded projects or by industry, e.g. BMBF, German states, the EU
- Coordination of industrial project consortia
- Consultancy for national and EU research applications

Start-Ups & Joint Ventures

- Spin-offs for the commoditization of products and systems
- Participation of industrial partners via joint ventures



**Fraunhofer Research Institution for
Microsystems and Solid State
Technologies EMFT**

Hansastraße 27 d
80686 München
Telefon: +49 89 54 75 90
Fax: +49 89 54 75 95 50

www.emft.fraunhofer.de

CONTACT



Director Fraunhofer EMFT:
Prof. Dr. Christoph Kutter
Phone: +49 89 54 75 95 00
Christoph.Kutter
@emft.fraunhofer.de



Sensor Materials:
Dr. Sabine Trupp
Phone: +49 89 54 75 95 61
Sabine.Trupp
@emft.fraunhofer.de



Marketing and Public Relations:
Pirjo Larima-Bellinghoven
Phone: +49 89 54 75 95 42
Pirjo.Larima-Bellinghoven
@emft.fraunhofer.de



Micro Dosing Systems:
Dr. Martin Richter
Phone: +49 89 54 75 94 55
Martin.Richter
@emft.fraunhofer.de



Business Development:
Prof. Dr. Peter Kuecher
Phone: +49 89 54 75 92 41
Peter.Kuecher
@emft.fraunhofer.de



Circuits & Systems:
Prof. Dr. Linus Maurer
Phone: +49 89 54 75 93 20
Linus.Maurer
@emft.fraunhofer.de



Silicon Technologies and Devices:
Prof. Dr. Ignaz Eisele
Phone: +49 89 54 75 91 89
Ignaz.Eisele
@emft.fraunhofer.de



Flexible Systems:
Christof Landesberger
Phone: +49 89 54 75 92 95
Christof.Landesberger
@emft.fraunhofer.de



Prof. Dr. Marc Tornow
Phone: +49 89 54 755 51
Marc.Tornow
@emft.fraunhofer.de