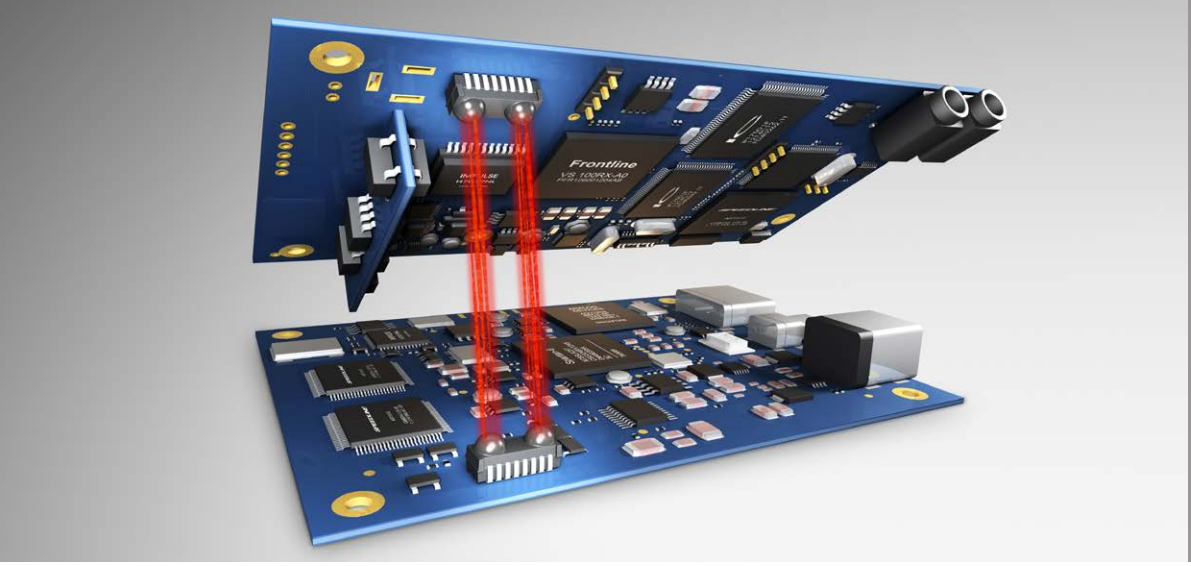
Fraunhofer
IPMS

FRAUNHOFER INSTITUTE FOR PHOTONIC MICROSYSTEMS IPMS

Application Area

Smart Industrial Solutions


Fraunhofer
IPMS
Li-Fi
wireless
high-speed
GigaDock
Hotspot
industrial
real-time
optical
bidirectional



Li-Fi GigaDock technologies facilitate optical wireless board to board communication.

Smart Industrial Solutions

With extensive experience in the development of photonic microsystems and related technologies including nano-electronics and wireless microsystems, Fraunhofer IPMS has released a variety of applications benefiting both industrial customers as well as society as a whole. Innovative products developed at the institute can be found in all markets relevant to the information and communication technology, consumer electronics, automotive, semiconductor and medical industries. We are proud to present some selected examples here.

The current mega-topics of the Internet of Things and Industrie 4.0 are closely linked to great economic opportunities for German industry. In addition to intelligent software, optimally-adapted hardware is also necessary for successful industry digitalization and to ensure future German competitiveness. Fraunhofer IPMS provides exemplary service with a comprehensive spectrum of smart industrial solutions including both photonic as well as non-optical MEMS, RFID solutions together with related software and technology developments for the semiconductor industry.

Key Topics

- Li-Fi: Optical Wireless Communication
- Industrie 4.0
- Indoor Navigation and Localization
- RFID Solutions
- Acoustic Spectroscopy using Ultrasound
- Embedded Non-Volatile Memory (eNVM)
- Screening Services for Micro- and Nano-Technologies
- Lithography

Li-Fi: Optical Wireless Communication

Decentralized manufacturing processes where workflows are continuously monitored by means of machine-to-machine communication are prerequisite for the industrial production of the future. This includes the transmission of large amounts of data which usually still flows through cables. Because wireless communication via WLAN is not efficient enough and too slow, the demand for alternatives with stricter requirements on higher data rates, robustness, energy efficiency, data security and network connectivity is on the rise.

In its research on wireless data transmission technologies of the future, the Fraunhofer IPMS has focused on the use of light. Transmission rates of up to 12.5 gigabit per second over short ranges and up to 1 gigabit per second in distances up to 30 meters are already possible. Wireless systems are particularly advantageous for moving or movable plant components and offer greater reliability and security as compared to expensive solutions based on custom cables prone to wear-and-tear. In addition, wireless systems eliminate supplemental retooling and maintenance costs.

Fraunhofer IPMS has developed several communication modules which can be integrated into existing control systems and machine infrastructures via plug-and-play to use light to transmit data in a fast and secure manner. Modules based on Li-Fi technology replace the wear-and-tear prone high-frequency connectors and allow for improved data communication. High-frequency signals can thus be transmitted between devices faster and more reliably. Modules can easily replace cable and plug connections and are up to ten times faster than currently available radio-based transmitting solutions.

Specific manufacturing environment for Industrie 4.0.

Industrie 4.0

The industrial production of the future will be characterized by a high degree of automation and digitalization. The interplay of machines, manufacturing and services in cyber-physical systems (CPS) will enable decentralized, self-regulating production processes in the Smart Factory. The realization of these concepts calls for novel, easy-to-integrate system solutions for the acquisition and processing of manufacturing data.

With the goal of a one-stop-shop solution, Fraunhofer IPMS develops integrated hard- and software solutions that can be easily and quickly integrated into existing solution via plug-and-play. Acquired data is efficiently processed and analyzed to enable data-driven decisions for the manufacturing process.

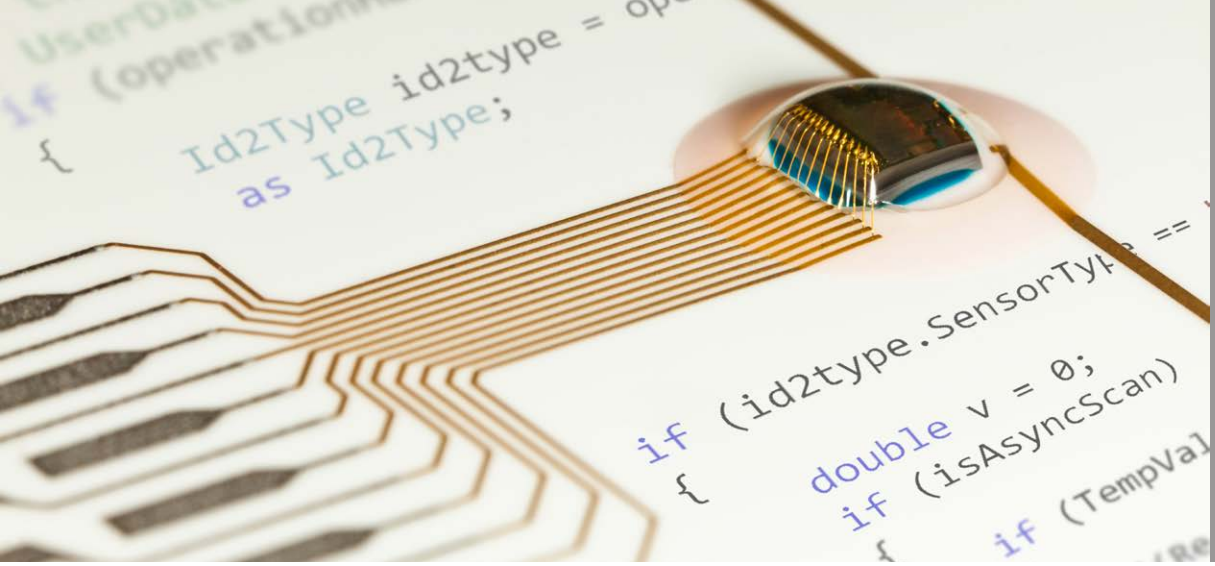
A framework developed at Fraunhofer IPMS enables the easy acquisition of machine data and its analysis in a big data solution. Data analysis is based on methods from the areas of Complex Event Processing, Process Mining and Anomaly Detection. The insights gained from this analysis can be used in further modules, e.g. for predictive maintenance planning and incident detection as well as central or distributed control of manufacturing processing (e.g. based on aspects of energy consumption).

Indoor Navigation and Localization

In the times of the Internet of Things and Industrie 4.0, the ability to locate electronic objects and movable assets within large buildings, warehouses and production facilities is becoming increasingly important. To determine the actual position of technical equipment, personnel and mobile inventory as well as to direct employees and guests quickly and safely to selected destinations, Fraunhofer IPMS has developed solutions for indoor navigation and localization.

With its systems for wireless tracking of materials, objects, people and tools, Fraunhofer IPMS offers its customers real-time location services (RTLS) for gapless tracking of mobile assets and navigation throughout buildings. RTLS solutions created at Fraunhofer IPMS are designed to be used in restricted areas as well as in various environments such as factories, hospitals and public buildings. Tracking methods are based on an existing WiFi infrastructure and require no additional hardware.

Positions of and distances to inventory being tracked are displayed to the user via an Android app. The app provides users with location-based information enabling interaction with objects or equipment in their environment. The Fraunhofer IPMS solution supports geo-fencing for the marking of specific building areas. Objects entering or leaving these defined areas trigger responsive actions based on underlying rules.



Product-related technologies for passive battery- and maintenance-free sensor nodes in LF, HF, NFC and UHF ranges.

RFID Solutions

RFID technology is increasingly being used in modern production environments to autonomously control logistics or production processes or to perform maintenance-free measurements in hard to reach places or on moving parts and to provide wireless transfer with no internal source of energy. Fraunhofer IPMS develops solutions to facilitate the integration of new RFID components in existing or yet to be established process environments.

Fraunhofer IPMS offers a RFID OPC-UA AutoID (ROAD) Server for Industrie 4.0 environments. This middleware enables the easy integration of RFID readers, tags and sensors into complex production environments regardless of manufacturer. Once implemented on the basis of the OPC-UA interface, applications can continue to be used unaffected even by changes in reader or transponder population.

In the area of RFID sensor nodes, Fraunhofer IPMS offers product-related technologies for passive battery- and maintenance-free sensor nodes used in various applications. These technologies support RFID frequencies LF, HF and UHF and can connect any sensors to passive transponders.

Acoustic Spectroscopy using Ultrasound

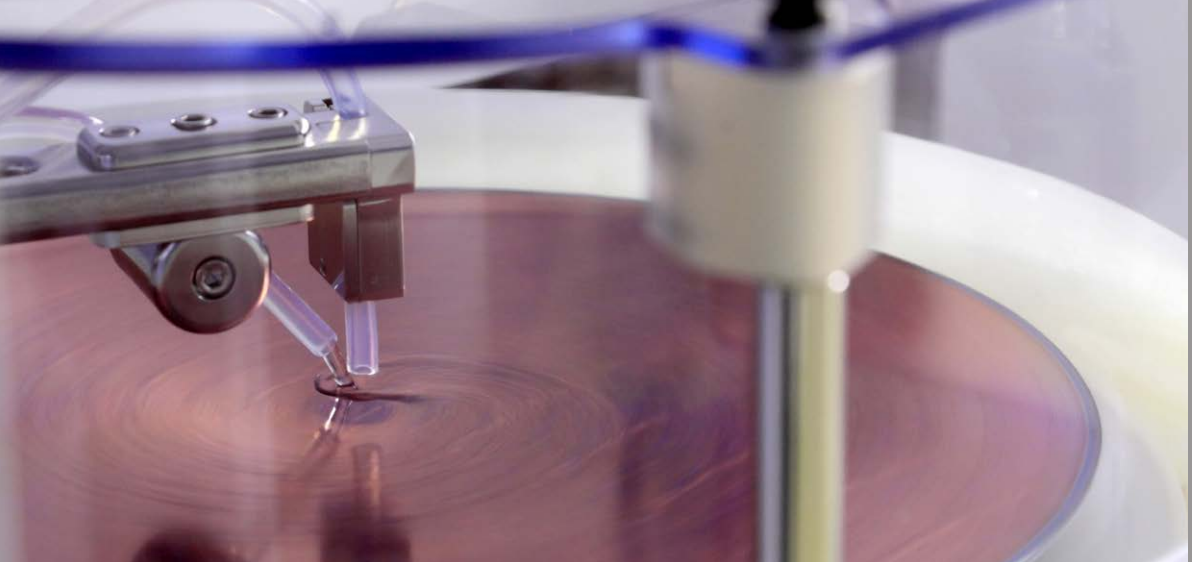
Spectroscopic examination by means of ultrasound provides information about the physical characteristics of materials as well as the chemical analysis of dispersions. By analyzing the frequency-dependent attenuation and speed of sound, quality conclusions and the composition of oils, alcohol-water mixtures or other liquids can be determined, providing an ideal complement to optical spectroscopy.

In this area of application, the use of capacitive micromachined ultrasonic transducers (CMUTs) can lead to new highly-compact environment measurement systems. In contrast to conventional ultrasonic piezoelectric elements, CMUTs are produced through a micromachining manufacturing process and allow for an extremely compact structure. Through a monolithic integration with CMOS circuits, sensors permit the installation of complete analysis systems on one chip. The ability to radiate sound in liquid media with extreme efficiency, provide highly sensitive detection and use a wide frequency bandwidth make CMUTs ideal for acoustic spectroscopy.

Embedded Non-Volatile Memory (eNVM)

Embedded Non-Volatile Memory (eNVM) is increasingly gaining importance and is indispensable as the central component of modern System on Chip (SoC) solutions. Costs and form factors are minimized while energy efficiency and speed are maximized by fusing logic and memory onto a single chip. As a consequence of this fusion, memory cells and their characteristics as well as their compatibility with current technology platforms are of central importance for eNVM solutions.

Due to these specific requirements of embedded memory solutions, Fraunhofer IPMS is focusing on two core areas: First, the research and optimization of novel non-volatile memory cells w.r.t. data storage, degradation minimization and scalability and, second, their integration into current technology platforms such as 22 nm FDSOI, 28 nm HKMG and 1X nm FinFET. This particularly includes the transformation of new materials and processes into a 300 mm fabrication environment. Fraunhofer IPMS and its cooperation partners in science and industry are focusing their research and development efforts on the non-volatile memory concepts FeFET and FLASH (both



Atomic layer deposition (ALD), cleaning, chemical mechanical polishing (CMP) and plating services for supplier and IC manufacturer.

integrated in FEoL) as well as RRAM and MRAM (integrated in BEoL).

Screening Services for Micro- and Nano-Technologies

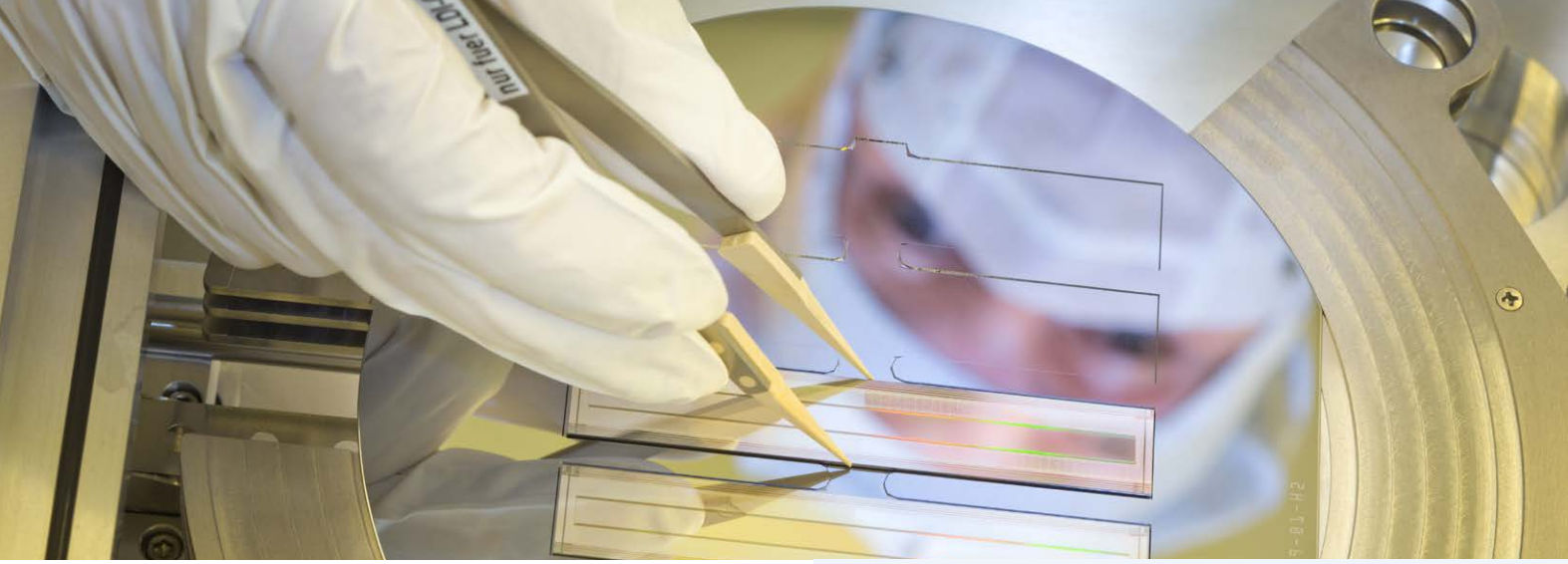
In semiconductor device fabrication, the characteristics of raw materials and equipment are key factors for process performance. Fraunhofer IPMS offers suppliers, materials developers and equipment manufacturers an industrial test environment for 200 mm and 300 mm wafers that facilitates the evaluation and process parameter adaptation of individual products and the immediate re-integration into manufacturer production lines.

In addition to comprehensive analytical instruments, dedicated facilities for the examination and optimization of chemicals, materials and processes are available in the areas of atomic layer deposition (ALD), wafer cleaning, chemical mechanical planarization (CMP) and copper plating. The complete development cycle is supported, from process development over upscaling from lab to mass production, to tests involving specific wafers (2X nm technology nodes). Professional wafer handling and ISO 9001 compliant process management ensure a direct wafer exchange and the risk-free integration of innovations into the production line.

Lithography

With the decreasing size of semiconductor structures, the accuracy requirements on light exposure and the fabrication of light exposure masks are continuously increasing. Other, new lithography requirements have arisen in the back end and packaging areas, such as the 3D integration of chips. Through the use of spatial light modulators, new efficient light exposure devices can be developed for the semiconductor industry.

Spatial light modulators developed by Fraunhofer IPMS are made of micro mirrors arranged on a semiconductor chip (typically < 10 × 10 µm per mirror). The number of micro mirrors can vary, depending on the application, from several hundred to several million. In most cases, an application-specific integrated circuit (ASIC) is used for controlling the orientations of the individual mirrors. In combination with laser light sources, highly-accurate, digitally-controlled exposure systems can be realized, e.g. for semiconductor masks. Other device components are optimized for the maskless, direct writing of lithographic structures (via laser direct imaging and electron beam lithography), e.g. for the fabrication of circuit boards. Spatial light modulators provide a very high data throughput and offer excellent perspectives for high productivity.



Services

The Fraunhofer IPMS offers various cooperation possibilities along the entire value chain to its customers. Feasibility studies are the first step if it is unclear at the beginning of a cooperation whether – and if so by what means – a customer request can be realized. For the basic proof of the functionality of a device or system demonstrators are realized within a development project. Especially in wafer-based processes, new technologies might be required which could be then developed in parallel. In the second step, the demonstrator turns into a prototype that fulfills all customer specifications. Fraunhofer IPMS offers qualified pilot fabrication in its clean room for MEMS and other microsystem devices.

Fraunhofer IPMS participates in the high-performance center "Functional Integration for Micro-/ Nanoelectronics". Together with multiple other Saxon Fraunhofer institutes, Dresden University of Technology, Chemnitz University of Technology and the University of Applied Sciences Dresden, Fraunhofer IPMS is working on developing application-oriented products based on the results of basic research to strengthen the economy. The whole project is coordinated by the Fraunhofer IPMS. On the basis of roadmaps we jointly identify possible opportunities for cooperation in talks with industrial customers. If the need arises, the center of excellence's topics can be extended accordingly.

Research Topics

The applications realized in close cooperation with our customers make use of the following results of our R&D activities:

- **SPATIAL LIGHT MODULATORS**
  Arrays of micromirrors on semiconductor chips
- **MEMS SCANNERS**
  Resonant and quasi-static MEMS mirrors for light deflection
- **WIRELESS MICROSYSTEMS**
  Devices and systems for RFID and optical communication
- **ENVIRONMENTAL SENSING**
  Sensor devices and systems for photonic and chemical sensing
- **NANOELECTRONIC TECHNOLOGIES**
  Semiconductor device development and screening of processes and materials on 300 mm wafers
- **MESOSCOPIC ACTUATORS AND SYSTEMS**
  Electrostatic bending actuators with very large stroke
- **CAPACITIVE MICROMACHINED ULTRASOUND TRANSDUCERS**
  Ultrasonic devices manufactured with microelectronic technologies
- **SMART MICRO-OPTICS**
  Liquid crystal wave guides, tunable micro lenses and energy harvesting solutions
- **MEMS SENSORS**
  Product oriented development and pilot fabrication of diverse physical and chemical sensors

Short profile

Based in Dresden, Fraunhofer IPMS is your research and service partner in the fields of optical sensors and actuators, integrated circuits, microsystems (MEMS/MOEMS) and nanoelectronics. As one of the currently 67 independent institutes making up the Fraunhofer-Gesellschaft for the Promotion of Applied Research, the leading European organization for near-industrial research, our approximately 280 scientists work together with both private industrial and service companies as well as the public sector in projects to directly benefit business and society. To meet the high standards of our customers, Fraunhofer IPMS is certified by DEKRA in accordance with DIN EN 9001:2008 for the research, development and manufacturing of microsystems, respective semi-conductor and microsystems processes as well as integrated actuators/sensors.

Regarding micromechanical and photonic microsystems we offer complete solutions: From conception to component right up to complete systems. This includes sample and pilot production in our 1500 m² (15,000 ft²) clean room (ISO 14644-1 class 4) with qualified processes. Additionally, our business unit Center Nanoelectronic Technologies CNT provides services in the field of nano and microelectronics with functional electronic materials, processes and systems, device and integration, maskless lithography and analytics. Another 800 m² of clean room space (ISO 14644-1 class 6) is available for this purpose, along with analysis and metrology processes with atomic resolution and high sensitivity.

Smart Industrial Solutions

Quality of Life

Medical and Health

Fraunhofer IPMS

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