RESEARCH AND PRODUCTION AT ONE LOCATION

Inertial sensors and ASICs on leadframe and in packages
The Fraunhofer-Institut für Siliziumtechnologie (ISIT) develops and produces microelectronic and microsystem components. The advanced process line based on a 200 mm silicon wafer technology and the expertise built up over decades ensure a world-leading position for ISIT and its customers. Microcomponents for a wide range of applications are developed by the institute. The main areas of application are automotive and transport engineering, consumer goods industry, medical technology, communication systems and automation.

ISIT carries out the design and system simulation of microcomponents for its customers and provides prototypes and pilot production, provision of samples and preparation of series production.

The institute also offers application-specific integrated circuits (ASICs) for the operation of sensors and actuators and deals with all the important tasks involved in system integration, assembly and interconnection technology (packaging) and the reliability and quality of components, modules and systems. Activities are completed by intensive development work on electrical energy storage devices based on Lithium polymer batteries.

**Equipment**

ISIT operates in collaboration with Vishay Siliconix Itzehoe GmbH a semiconductor production line for 200 mm (8”) Si wafers (cleanroom area 2.500 m²). The process line is used for the development of new components and processes as well as for the production of components (PowerMOS, MEMS). Further cleanrooms (650 m²) are available for specific processes, as needed for example in microsystem engineering, and for chemical-mechanical polishing (CMP). In addition to the basic processes of microsystem engineering, highly developed processes are maintained, e.g. for high-precision deep etching (DRIE), deposition of non-IC-compatible materials such as piezoelectrics, thick-layer lithography and electroplating, glass molding and grey-scale lithography. The institute has particular expertise in wafer bonding and wafer-level packaging (WLP), achieving unique levels of quality for various MEMS components (gyroscopes, scanner mirrors, RF-MEMS, etc.). Further laboratory areas (1.500 m²) are equipped for characterization, qualification and assembly and interconnection technology. The scope of activities is widened by laboratories for the development of Lithium polymer batteries, in which a pilot production plant is operated for sample production and evaluation tasks.

To expand the institute’s capacity, a further cleanroom and laboratory building is planned, which is scheduled for completion in mid-2012. The ISIT’s facilities are certified to ISO 9001-2008.

**Range of services**

Fraunhofer ISIT has many years of experience in industrial collaboration. Primarily the concept of technology platforms is pursued, i.e. the definition of process procedures in which the customer-specific solutions take place through the design and packaging. This allows to offer services which, beyond the technical specifications, are attractive in terms of risk, development time, development expense and production cost.

Series production can ultimately be carried out in close cooperation with the locally based MEMS Foundry Itzehoe GmbH (MFI).
IC TECHNOLOGY AND POWER ELECTRONICS

Far left: Waferlevel packaging for power electronics: wafer with balled IGBT devices

Left: 300 mm testwafer in the CMP laboratory

Waferlevel high voltage test equipment for power devices
The power electronics and IC technology group develops and manufactures active integrated circuits as well as discrete passive components.

Among the active components the emphasis lies on power devices such as smart power chips, IGBTs, PowerMOS circuits and diodes. In this context application specific power devices and new device architectures are special R&D areas. The development of new processes for advanced power device assembly on wafer level is a further important research topic. It comprises e.g. adapted chip metallization and novel techniques for backside processing of ultra thin Silicon substrates. Additional support is provided by a number of tools for simulation, design and testing. ISIT also benefits from years of experience in the design and manufacturing of CMOS circuits.

Passive components developed and fabricated at ISIT are primarily chip capacitors, precision resistors and inductors. Development of materials and the integration of new materials and alloys into existing manufacturing processes play an important role in the development process.

ISIT develops individual processes, process modules and complete process flows for diverse applications. The institute also offers processing of customer-specific silicon components in small to medium-sized quantities on the basis of a qualified semiconductor process technology.

In the field of power electronics ISIT coordinates a competence centre which was founded in close cooperation with universities and companies of the federal country Schleswig-Holstein.

A special R&D group with focus on power electronic systems works on application specific topics covering the interface to system end users.

To support the development of new semiconductor production techniques, production equipment of particular interest is selected for testing and optimization by the ISIT staff. This practice provides the institute with specialized expertise related to e.g. etching, deposition, lithography, and planarization methods. Planarization using chemical-mechanical polishing (CMP) in particular is a key technology for manufacturing advanced integrated circuits and microsystems. The intensive work done by ISIT in this area is supported by a corresponding infrastructure. A special emphasis lies in the application of CMP for the manufacturing of MEMS devices and microsystems.

The institute’s CMP application lab is equipped with CMP polishing machines and post-CMP cleaning equipment as well as the corresponding measurement tools for wafer diameters between 100 and 300 mm. The CMP group at ISIT works in close relationship to Peter Wolters AG since many years, as well as with other semiconductor equipment manufacturers, producers of polishing slurries and pads, CMP users and chip and wafer manufacturers.

The group’s work encompasses the following areas:

- Testing of CMP systems and CMP cleaning equipment
- Development of CMP processes for
  - Dielectrics (SiO₂, TEOS, BPSG, low-k, etc.)
  - Metals (W, Cu, Ni, etc.)
  - Silicon (wafers, poly-Si)
- Testing of slurries and pads for CMP
- Post-CMP cleaning
- CMP-related metrology
- Implementation of customer-specific polishing processes for ICs and micro systems
MICROSYSTEMS TECHNOLOGY (MEMS) AND IC DESIGN
Research in microsystems technology is a core activity of Fraunhofer ISIT in different departments. For more than 25 years ISIT scientists are working on the development of micro electro mechanical systems (MEMS). This covers the complete spectrum starting from simulation and design, technology and component development up to development of endtest strategies and reliability tests. One of the core competences of the ISIT service offer is the development of integration technologies, like cost effective assembly of several chips in a common package, MEMS packaging on waferlevel (WLP) with defined cavity pressure or a system-on-chip approach. MEMS devices can be combined with a suitable ASIC to miniaturized systems with high functionality.

The ISIT cooperation model allows further to offer also a fabrication of prototypes and starting a pilot production. If high volume MEMS production is requested the on-site operating industrial partner MEMS Foundry Itzehoe (MFI) is able to meet this demand.

ISIT is focussed on MEMS applications in three core areas: physical sensors and actuators, devices and technologies for high frequency application (RF-MEMS) as well as passive and active optical microsystems.

In the field of sensor systems strong activities are put on inertial sensors (accelerometer, gyrometer, IMUs) and on flow sensors with integrated electronics (ASICs) respectively. Special technological process modules for sensor development are available, e.g. thick poly silicon as a functional layer or hermetic encapsulation on waferlevel.

High frequency microsystems at ISIT are primarily for application in wireless reconfigurable communication networks, in particular developments for RF-MEMS switches, ohmic switches and waferlevel packaging are running.

In the field of optical MEMS devices ISIT is active in the development of micromirrors for laser projection displays, optical scanning systems and light modulators. Passive optical microsystems are also in the portfolio of ISIT, as there are glass lens arrays or aperture systems for laser beam intensity forming.

At ISIT a large number of single process technologies are available. These have been combined to specific qualified MEMS process modules. They work like a tool kit to realize several applications. Special attention is paid to the PSM-X2 process module, which is based on thick polysilicon layer for the fabrication of accelerometers or gyrometers with automotive qualification AEC Q100.

One of the prerequisites for the development of microsystems and microelectronic components is a highly capable integrated circuit design group. The staff at ISIT are specialists in the design of analog/digital circuits, which enable the electronic analysis of signals from silicon sensors. The designers also model micromechanical and micro optic elements and test their functionality in advance using FEM and behavioral modeling simulation tools.
ISIT is one of the worldwide leaders in the field of electrical biochips. These chips allow the realization of very efficient biosensors and are the basis for fast and cost effective analytical systems.

The electrical biochip technology offers intrinsic advantages over optical biochips because of particle tolerance and mechanical robustness by the direct transduction of biochemical reactions into electrical current.

The use of gold electrode arrays combined with integrated reference and auxiliary electrodes along with sensitive, selective measurement techniques like “Redox-Cycling” enables powerful sensor systems. These arrays are useful for the detection of a variety of analytes within one probe simultaneously. User-friendly operability is realized by integrating the biochips into cartridges. In combination with micro-fluidic components and integrated electronics, these electrical microarrays represent the basis of rapid and cost-effective analysis systems. They can be used to identify and quantify DNA, RNA, proteins and haptens.

Further biosensors enable continuous monitoring, e.g. of metabolites as glucose or lactate. The measurement of these substances is realized by enzymatic conversion and electrochemical detection.

ISIT works closely with the Itzehoe based company AJ eBiochip GmbH (www.aj-ebiochip.com), an ISIT spin-off, to facilitate the marketing of these new technologies.
The “Advanced Packaging” group is specialised in detecting and promoting new trends and technologies in electronics packaging. The industrial challenges of tomorrow are addressed in direct collaboration with suppliers of materials, components, modules and equipment. As an example, the automatic pick-and-place assembly of thin dies on flexible substrates was already developed several years ago. For the encapsulation of MEMS components, the glass frit bonding was developed and later on replaced by the more efficient metallic bonding. ISIT equally participates in development activities on organic electronics and RFID technology.

The Fraunhofer ISIT disposes of all basic technologies for the automatic or manual handling of microchips and microsensors, as well as electrical interconnect methods like wire bonding and flip chip technologies.

Through the close relationship between MEMS technology and packaging in ISIT’s premises, the institute has become a leading R&D service provider in the domain of waferlevel-packaging. A cross-disciplinary technology portfolio is now available that allows to reduce cost and volume of a system. Even more, the packaging itself can become a functional part of the microsystem in many cases, e.g. by integrating optical elements or directly interconnecting MEMS and ASIC dies. Outstanding success was achieved in the vacuum encapsulation of micromechanical sensors by eutectic wafer bonding, which paved the way towards the industrialisation of a gyro sensor product family for automotive applications.

ISIT continuously expands their assortment of test chips and -substrates that facilitate the ramp up and calibration of production lines for securing quality on a high level.
Quality evaluation – in particular for the soldering work done in pre-production, pilot and main series lots – represents a continuous challenge for ISIT, as for example whenever new technologies such as lead-free soldering are introduced, or when increased error rates are discovered, or if a customer desires to achieve competitive advantages through continual product improvement. To reveal potential weak points, ISIT employs both destructive and non-destructive analysis methods, such as X-ray transmission radiography and scanning acoustic microscopy. Working from a requirements matrix, ISIT scientists also evaluate long-term behavior of lead-free and lead-containing assemblies alike. They then formulate prognoses on the basis of model calculations, environmental and time-lapse load tests, and failure analysis.

In anticipation of a conversion to lead-free electronics manufacturing, Fraunhofer ISIT is undertaking design, material selection and process modification projects for industrial partners. To effect a further optimization of manufacturing processes, the institute applies process models and produces samples on industry-compatible equipment. The group also addresses issues related to thermal management and reliability for customer-specific power modules.

In addition to these technological activities, the group regularly holds training sessions, including multi-day classes, at the institute or at company site.
Secondary Lithium batteries as a powerful storage medium for electrical energy are rapidly capturing new fields of application outside of the market of portable electronic equipment.

These new fields include automobiles, medical devices, stationary electric storage units, aerospace, etc. Therefore, this type of rechargeable batteries has to meet a variety of new requirements. This covers not only electrical performance but also design and safety features. The Lithium polymer technology developed at ISIT is characterized by an extensive adaptability to specific application profiles like extended temperature range, high power rating, long shelf and/or cycle life, extended safety requirements, etc. Also included is the development of application-specific housings.

In the Lithium polymer technology all components of the cell from electrodes to housing are made from tapes. At ISIT the complete process chain starting with the slurry preparation over the tape casting process and the assembly and packaging of complete cells in customized designs is available including also the electrical and thermo-mechanical characterization. This allows access to all relevant parameters necessary for an optimization process. The electrode and the electrolyte composition up to the cell design can be modified.

In addition to the development of prototypes, limited-lot manufacturing of optimized cells on a pilot production line at ISIT with storage capacities of up to several ampere-hours is possible.

Specific consideration in process development is addressed to the transferability of development results in a subsequent industrial production.

ISIT offers a wide portfolio of services in the field of secondary Lithium batteries:
- Manufacturing and characterization of battery raw materials by half cell as well as full cell testing
- Selection of appropriate combinations of materials and design of cells to fulfil customer requirements
- Application driven housing development
- Test panel
- Prototyping and limited-lot manufacturing of cells

Additional services are:
- Preparation of studies
- Failure analysis
- Testing (electrical, mechanical, reliability etc.)
- Technical consultation

Folks for electrodes, current collectors and the housing are the basic materials of Lithium polymer rechargeable batteries.
ISIT-COOPERATIONSPARTNERS AT HIGH TECH ITZEHOE

Vishay Siliconix Itzehoe GmbH
Fraunhoferstr. 1, 25524 Itzehoe
Phone +49 (0) 4821 / 17-4702
www.vishay.com

SensorDynamics AG
Fraunhoferstr. 1, 25524 Itzehoe
Phone +49 (0) 4821 / 17-4106
ovl@sensordynamics.cc
www.sensordynamics.at

AJ eBIOCHIP
AJ eBiochip Systems GmbH
Fraunhoferstr. 1, 25524 Itzehoe
Phone +49 (0) 4821 / 17-4333
info@aj-ebiochip.de
www.aj-ebiochip.de

Peter Wolters AG
Fraunhoferstr. 1, 25524 Itzehoe
Phone +49 (0) 4821 / 17-4303
g.moersch@peter-wolters.com
www.peter-wolters.com

Plan Optik AG
Fraunhoferstr. 1, 25524 Itzehoe
Phone +49 (0) 4821 / 17-4227
t.hoefmann@planoptik.com
www.planoptik.com

MEMS Foundry Itzehoe GmbH
Fraunhoferstraße 1
D-25524 Itzehoe
Phone +49 (0) 4821 / 17-4221
peter.merz@memsfoundry.de
www.memsfoundry.de

ISIT is located about 40 km north of Hamburg in Schleswig-Holstein directly at the highway "Autobahn 23" in sight of the exit “Itzehoe Nord”