Microelectronics - Into the 300mm Future

Microelectronics - Potential, Prospects and Vision

Dr. Helmut Ennen, Udo Klotzbach; Ministry of Economy Affairs and Labous, Saxony

Infineon Technologies Dresden, Clean Room

For decades the state of saxony has been a centre for technological development and innovation. Located in the east German heart of the republic the state has more than one hundred years of tradition in engineering and manufacturing. Here is the birthplace of well known corporations such as Audi. Prior to World War II Saxony was one of the most successful exporters in Germany and is striving to again reach that position.

Throughout the state several excellent tertiary educational institutions provide for a continuous flow of high profile workforce. Among them TU Bergakademie Freiberg the world' sfirst mining university, Leipzig University, one of the oldest in Europe and the prestigious Technische Universität Dresden offering one of the best electrical engineering education in Europe.

Since opening of Siemens Semiconductor (1996) Dresden has become a supreme high tech centre for microelectronics manufacturing (64MB DRAM). In 1999 that company now an off Ð spin called Infineon Technologies had its first million 256 MB chips completed. Siemens semiconductor has also started a joined venture with Motorola to develop 300 mm Wafer in 1998. One year later Adavanced Micro Devices AMD opened its Fab30 to produce Athlon processors on a Aluminium / Copper basis. Currently AMD has about 1000 employees at its Dresden Fab.

Another player, Advanced Micro Devices was awarded a "CeBIT-Oscar" at Hannover CeBIT for the Athlon manufactured at its Fab 30 in Dresden. The lightning fast demonstration CPU utilizes state-of-the-art 0.18 micron copper interconnect technology and an integrated level 2 cache running at full processor speed. AMD's Fab 30 is expected to begin shipping copper-based processors by the end of the second quarter this year.

Resulting from those developments many internationally recognized companies opened branches in the area. Among them are Applied Materials, Canon, Leybold, Sillicon Valley Group, Tokyo Electron and others. But this concentration of microelectronics manufacturing not just attracted well known companies but a significant number of highly innovative young businesses opened offices drawing from the stock of excellent educated highly motivated graduates from the states. tertiary institutions. Currently in Dresden alone about 100 businesses are directly and 400 are more or less involved with microelectronics.

Related industries providing for the substrate bases were established in Freiberg to supply silicon and GaAs semiconductor material to the chip producers. Freiberger Compound Material GmbH has started production in its new Fab in March 2000. Wacker Siltronic GmbH delivers 6' wafers and Bayer Solar is a leading manufacturer of solar elements. Several projects are supported by the state to even foster that development.

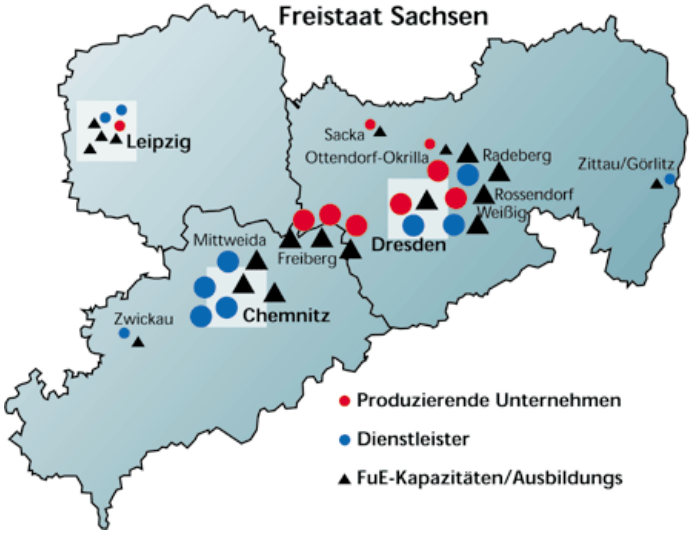
All manufacturers profit from the high concentration of outstanding research facilities in Saxony. The most important institutions are the universities in Dresden and Chemnitz, several Fraunhofer institutes such as Fraunhofer Institut für Integrierte Schaltungen, -Institut für Mikroelektronische Schaltungen und Systeme, -Institut für Werkstoff- und Strahltechnik, Institut für Elektronenstrahl- und Plasmatechnik, Zentrum für Mikrofabrikationstechnik and Zentrum für Mikroelektronik Dresden.

Microelectronics are not the only technological highlight in the state of Saxony. Other branches such as heavy machinery manufacturing (VW, Porsche, Niles etc.), telecommunications (Siemens, Multimedia Software GmbH, BROKAT etc.) and mikrosystems technology (Radeberger Hybridelektronik, DIAS Angewandte Sensorik GmbH, AMTEC, etc) are strong as well. New areas such as nanotechnology and biotechnology are at the center of several research facilities and will supplement Saxony's high tech sector in the near future. The state invests a high amount of money to accelerate F&D in those highly potential technologies.

Despite all the educational, infrastructural, and technological features Saxony offers lifestyle and culture as only few places in the world can. Visitors are always welcome and there are many places and sights to explore. From miles of tracks in the Erzgebirge to unequalled historical sites in Dresden the visitor might choose from a wide variety of activities.

Saxony has much potential as high tech corridor in central Europe and will also provide an ideal hub for serving Eastern Europe. Innovative industries are a major factor in Saxony. s economy and will constitute much of its economic growth in the future. We want you to participate and share our resources to join forces in the development and application of new technologies.

As J. Sanders CEO AMD said:
"It's all about people. People come first, products and profits will follow"



New Investigations - New Products

2000: Year of AMD Fab 30 and the AMD Athlon™ processor:

AMD Fab 30 - First Fab of the New Millennium

During a series of interviews at the recent CeBIT trade show, AMD's Chairman and Chief Executive Officer Jerry Sanders frequently repeated the following statements: "2000 is the year of the AMD Athlon processor" and "The Athlon is why we built Fab 30 in Dresden". These two brief sentences have set this year's strategic goals for AMD in general and for AMD Saxony Manufaturing GmbH in particular.

In line with the high expectations of the mother company, AMD Saxony's new Dresden megafab is now scheduled to ship its first commercial product, the AMD Athlon processor, at the end of Q2 2000. This will be the beginning of a two-year production ramp. More specifically, Fab 30 is already expected to ship significant volume of processors with a clock speed of 1 GigaHertz in the second half of the current year. The Dresden-build processor will be a variation of the initial version of the Athlon, which is currently manufactured at AMD' sother megafab, Fab 25, in Austin, TX. "Thunderbird" is the code name of the Fab 30 processor. It differentiates itself from the original Athlon processor because of an integrated L2 cache, which will further boost the performance of the product.

AMD Fab 30 - Wafer Fab technicians with test wafer

AMD Saxony is confident that it will be able to meet the mother company's and the market's high expectations because of its great achievements of the past year. Recently, Dr. Hans Deppe, Director Operations and Geschäftsführer of AMD Saxony Manufacturing GmbH, summarized last year's accomplishments of the AMD Fab 30 team: "In 1999, our Fab 30 goals have not only have been met, but they have been exceeded considerably. These achievements are the basis for successfully ramping up volume production in 2000."

Indeed, the 1999 results were nothing but astounding. During that year, AMD's European manufacturing facility has implemented three technologies: in January, the first AMD-K6 microprocessors on CS 44 E/7 aluminum technology were produced. In July, the first AMD K-6 microprocessors based on HiP5L copper technology were manufactured. And finally in mid-October, first AMD Athlon processors with copper interconnect, 0.18m technology. "We don' tsee very often the successful introduction of three technologies over the course of just one year. Congratulations to AMD Fab 30", commented an industry analyst.

AMD Fab 30 cleanroom

While AMD Saxony got ready for the ramp up year, AMD Inc successfully launched its new, 7th generation processor in mid 1999. The processor was immediately met with universal acclaim. So far, more than 50 international awards so far have been bestowed upon the AMD Athlon. By the end of 1999, the company had sold more than one million Athlons and returned to profitability in Q4. Market demand remains very high, and until Fab 30 begins shipments, this demand is fully met by Fab 25 in Austin. Here the processors are manufactured on basis of the 0.18m aluminum technology. It clearly shows the strength of the Athlon™ design but also the manufacturing power of Fab 25, that AMD was able to reach an industry milestone much earlier than expected: On March 6, the first GigaHertz processors were shipped by AMD to customers.

In the second half of this year, the Thunderbird Athlon will be available from Dresden. To fully realize the potential of the Fab in 2000, the AMD Dresden team has to grow significantly. With approximately 1050 employees already on board, the number is expected to grow to ca. 1400 by the end of this year and 1800 by the end of next year. The hiring focus will be on Wafer Fab Technicians, but also Manufacturing Engineers and Equipment Engineers will be added to the team. Engineers with backgrounds in engineering sciences, electrical engineering, physics or chemistry are encouraged to submit their applications to AMD Saxony's Employment organization at Wilschdorfer Landstrasse 101 in 01109 Dresden.

At the heart of Saxony's high-tech culture:

Saxony has a long tradition as a location for high-tech industries and first class universities. This sector provides some 15,000 to 20,000 jobs in the Dresden area. The Infineon plant provides this location with an economically successful production facility for integrated circuits using world leading manufacturing technologies.

One of Europe's most advanced chip production facilities - the flagship site for Infineon's global production - state-of-the-art production facilities - progressive environmental standards - finger on Saxony's high-tech pulse

Infineon Technologies Dresden site is one of the most modern chip manufacturing facilities in Europe. Construction of the high-tech plant began on June 6, 1994. The employees at the plant manufacture some of the world's most advanced semiconductor components. The facility produces modern memory chips and high-value logic components, which are marketed by Infineon worldwide. The estimated headcount of 1,450 has since risen to more than 2,800 and together with the 350 staff at SEMICONDUCTOR300, a total of more than 3,100 jobs have been created. 85% of the workforce comes from the region.

Global flagship location

The Infineon Dresden factory is the reference site for the DRAM fab cluster within Infineon's AG international network of production plants - with locations in Europe, Asia and the United States. This concept of a virtual global factory reflects the same high quality standards around the world, enables a reduction in qualification costs and ensures long-term competitiveness via internal benchmarking and a constant exchange of ideas.

First volume production of 256 Mbit chips

The Dresden plant has proven its outstanding technological capabilities on several occasions in the last years. In April 1999, Dresden was one of the first chip factories in the world to start volume production of 256Mbit SDRAM memory chips (synchronous dynamic random access memory). Within just four months the one millionth chip was produced. The 256Mbit component offers four times as much memory capacity as the 64Mbit DRAM, the current memory chip generation for PC and computer use. Only a handful of companies have the technology and the advanced production lines necessary for producing a component of such complexity.

Breakthrough in 300 mm production technology

Dresden has also pioneered production technology based on 300mm wafers, which Infineon developed jointly with Motorola. After the successful start of the pilot line in February 1998, the breakthrough came in September 1999. The first products based on 300mm silicon wafers have already been delivered to customers. The goal is to improve production efficiency. The 300mm process technology can bring about a significant reduction in cost per chip. In comparison with the 200mm technology, about two and a half times more chips can be produced on a wafer. The successful development of production technology in Dresden should give Infineon and Motorola a clear competitive advantage. The development costs for the production technology amount to about EUR 511 Million. Research expenditure for the pilot line has been co-funded by the state of Saxony and the Federal Ministry of Education and

Research as part of a project with 18 partner firms.

Advanced production methods

The 200mm production facility operates around-the-clock. Every week more than nine thousand silicon wafers go through the highly complex production process in the clean rooms. At the same time, hundreds of chips are processed on each wafer in up to 600 different production steps. The state-of-the-art equipment and facility are already geared up for the next generation of products - preparations are underway for the manufacturing of 1Gbit chips.

Environmentally friendly approach to manufacturing

From day one the Dresden factory was conceived to be an exemplary model of environmentally sound semiconductor production. Modern environmental technology was built in as an integral part of the production facility. Advanced waste disposal and recycling, highly efficient cleaning of emissions and waste water are major achievements that demonstrate how seriously the company takes environmentally responsible production. The site has been certified according to the ISO 14401 EC-Environmental Audit program since July 1999.

Wacker Siltronic AG in Saxony:
The Most Modern 150-mm Wafer Plant in the World is Based in Freiberg

Plant Area with the new 200-mm crystal pulling building

History

Wacker's plant in Freiberg already has a 40-year history, dating back to April 1957, when, as VEB Spurenmetalle Freiberg, it was set up to supply the East German economy with germanium and other hyperpure materials. In 1963, it commenced silicon crystal production. From 1970 on, it was able to supply the entire East German electronic components industry with germanium and silicon wafers.
In 1990, the VEB was privatized by the Treuhandanstalt to form the Freiberger Elektronikwerkstoffe Produktions- und Vertriebsgesellschaft mbH. Its efforts to adapt to market conditions led to restructuring: in 1994, the solar silicon division became BAYER Solar GmbH Freiberg and, in 1995, the gallium arsenide division was split off as Freiberger Compound Materials GmbH. August 1995 saw Wacker Siltronic GmbH sign the contract to take over the Freiberg silicon activities.

Present

The takeover was a turning point: The Freiberg plant, an established producer of basic semiconductor materials, began its journey into the next millennium; and the Wacker Group committed itself actively to Saxony's high-tech region:

Dresden - Freiberg - Chemnitz.

Since 1996, DM 266 million have been spent on adapting Freiberg to the global market conditions. Subsidies granted by the Free State of Saxony for investment and R&D have spurred on progress significantly. Indeed, Freiberg' s customers have confirmed the success of upgrading measures in their audits of the plant.

Upgrading is complemented by a powerful and thoroughly tested management system for **quality, safety and environmental protection**:
Oct. 1995 - DIN ISO 9001 certification
Dec. 1997 - DIN ISO 14001 certification
Sep.1998 - Member of Saxony` s EnvironmentalAlliance
Feb. 1999 - Safety Audit (SCC)

In Saxony, Wacker Siltronic AG is appreciated as a quality supplier for:
125-mm-Wafer - Zentrum für Mikroelektronik Dresden GmbH - ZMD
200-mm-Wafer - Infineon Technologies Dresden
200-mm-Wafer - AMD Saxony Manufacturing GmbH
300-mm-Wafer - Semiconductor 300 GmbH & Co KG
125-mm/150-mm-FZ- and CZ-Wafer - Bayer Solar GmbH (for solar, aircraft or space applications)

On the global front, the Freiberg plant supplies customers based mainly in Japan, Taiwan and the USA.

Besides the comprehensive modernization of the Freiberg plant, progress is being made on its expansion. In 1999, a new production building for ultramodern crucible-pulling facilities for 200-mm-crystals was completed, primarily to supply ingots to the Siltronic's new wafer plant in Singapore.

Polishing area for 6-inch wafer production

Growth by the year 2000

Oct 1995:
- 281 employees
- MDM 45 in sales

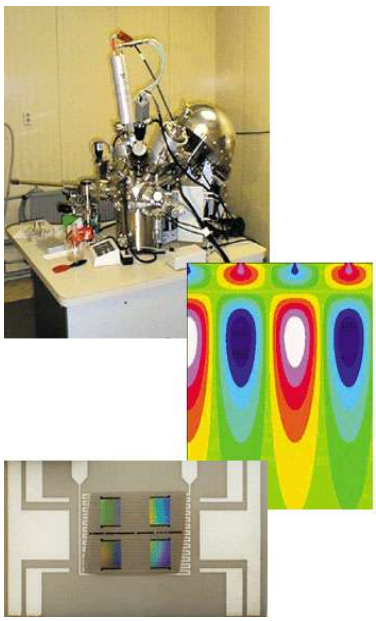
End of 1999
- MDM 266 invested (1996 - 1999)
- 433 employees
- MDM 105 in sales

End of 2000 (forecast)
- MDM 35 invested
- Approx. 550 employees
- approx. MDM 114 in sales

In the future, Freiberg will further strengthen its position as a materials producer for high-tech processes. There are interesting challenges on the horizon and Wacker Siltronic is fully committed to meeting them.

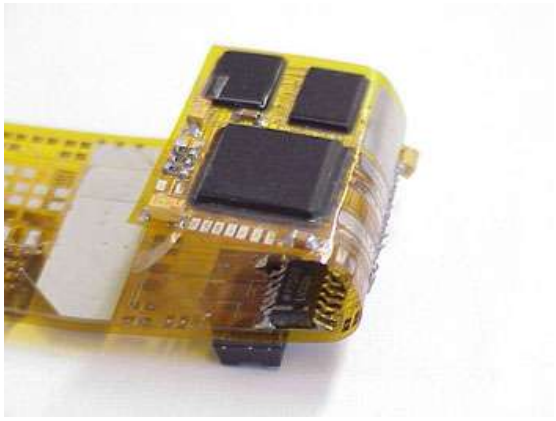
On-line Vibration Diagnosis Microsystem

The chair of microsystem technology is a center of competence for intelligent microsystems, SAW sensors and material research for sensor devices.



Materials / Devices / Systems

Recent developments of semiconductor and microsystem technology allow the miniaturization of complete diagnosis systems in a way that they can be located very close to the technical process or a sensor. This approach leads to a new quality for the electronic system with respect to the mechanical and electromagnetic reliability and, probably the most important aspect, to a notable reduction of the costs.
Rotating or otherwise excited machinery can be diagnosed via vibration analysis. Current diagnostic systems are spatially splitted into sensor and computation components. Within the joint research project "Microsystems for Diagnosis and Control" an on-line vibration diagnosis microsystem was designed and built up in co-operation with the Loher AG, Ruhstorf, the Radeberger Hybridelektronik GmbH (RHE) and the Fraunhofer-Institut IMS Dresden where sensors and the signal processing unit are integrated.
The heart of the electronic system is a 16 Bit Digital Signal Processor (DSP) which is able to perform computations up to 100 MIPS so that all off-line computations can be finished within a few seconds. It transformes the signals of an acceleration sensor into its amplitude spectrum, envelope spectrum and extracts features for the diagnosis. A self-organizing neural network is used for the feature classification.



28 mm flexible substrate with mounted circuits including the 144 pin-DSP, 4 MB SRAM and 8 MB EEPROM in Chip Scale Packages

A large non-volatile memory stores diagnosis results. The long term data get combined with a time information in order to enable event reconstruction. A trend analysis delivers predictions of future values of the machine behaviour. The diagnosis result can be displayed locally and be announced to a host computer via field bus or phone.
The electronic system is built up on a flexible substrate carrying fine interconnection lines as a basis for the surface mount soldering technology (SMT). For the routing two layers are sufficient since the interconnection lines have a width of minimal 40 µm and microvias a diameter of 90 µm.
The folded substrate is stuck in a case and filled with an epoxy to achieve mechanical and environmental reliability and to couple up the sensors to the bearing.

Construction of the diagnostic system

The design of the microsystem and all microanalytic investigations have been performed at the chair of Microsystem Technology, the assembly together with the Microelectronics Packaging Group and RHE.

Stand alone bearing diagnosis at an 355 kW asynchon motor of the Loher AG

Because of its low costs the diagnosis system is suitable for a large variety of vibrating machinery. Companies in the Dresden area prepare the series production of this microsystem.
The Chair of Microsystem Technology supports interested companies in the development and application of similar hybrid or monolithic intelligent microsystems.

Integrating Innovation on a Chip

No doubt - the key to future success of the electronics industry lies in the implementation of single-chip systems. ZMD was one of the first to focus on the market for mixed-signal ICs and so has become a highly valued expert in custom solutions.

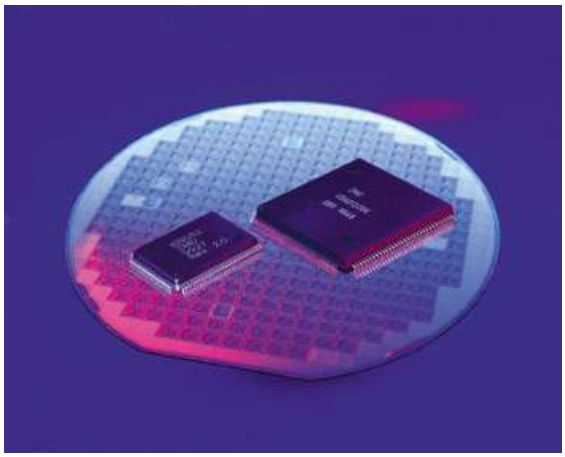
Our many years of experience in ASIC design using analog, digital and special memory techniques enable us to offer customers not only integrated single-chip solutions but also high performance at outstanding quality.

Developing intelligent ideas...

Outstanding custom solutions in mixed-signal products call for excellent partnership and close contact with our customers.
This is exemplified by individual support and service as well as exceptional flexibility. Regional design centres and our subsidiary ZMD - America ensure direct communica-tion and competent local support in finding the optimum technical and commercial ASIC solution.

...based on a modular technology that meets all requirements

Even the most sophisticated system require-ments can be met with the extensive library of analog components available in mixed-signal ASICs from ZMD.
Tailor-made technology enables us to find the optimum technical and commercial solutions specific to requirements.
In cooperation with our subsidiary MPD, we develop application-specific packaging solutions.
The key requirements in the Automotive sector are resistance to extremes of tem-perature and electromagnetic interference, and maximum reliability. We supply customer-specific and standard components for electronic assemblies used in power trains as well as for communications, comfort and safety.



Precise and reproduceable measurement values are called for from small portable battery-powered devices. We supply mixed -signal circuits in our low-voltage technology for Personal Medical applications such as blood-pressure and temperature measurement, hearing aids and medical analysis.

High performance Si(Li)-Detectors from VacuTec Dresden

Energy dispersive X-ray fluorescence analysis is a progressive analytical method in non-destructive material analysis. A diode with high reverse voltage acts as sensor for X-rays. The so called Si(Li)-detector converts X-rays into an electric charge signal proportional to the energy of the photons. The detector is characterized by large area elctrodes, an active intrinsic (lithium compensated) region with a thickness of several mm and bias voltages up to 1000 V.

VacuTec Messtechnik Dresden has experience in developing state-of-the-art Si(Li)-detectors and is an OEM-supplier for well known companies who built XRF-specrometers.

In accordance to different applications the detectors are offered in various geometrical dimensions.

The energy resolution to Mn-Ka radiation (Fe-55) is up to 129 eV.

Bumping for Flip Chip Assembly

KSW microtec has recently expanded their office and production facilities to offer customers more services and higher volumes in mass production. The clean room area has more than tripled and new equipment has been installed.

Using adhesive flip chip technologies, KSW is able to assemble chips on a large range of rigid carriers, like printed circuit board material, glass, ceramics, Si as well as flexible substrates like Dycostrate, PC, PET, ABS and PVC. KSW is also offering substrate technologies like track printing using conductive polymer paste.

As an complete solution provider KSW sells all services necessary for flip chip assembly starting from wafer preparation, dicing to assembly as well as standard and custom products like smart label. There are several kinds of wafer preparation methods available to customers, like the electroless Pd and NiAu bumping/UBM (under bump metallization) as well as polymer bumping. Especially for SnPb solder bumping an UBM of electroless nickel and flash gold is recommended. The electroless NiAu is similar to the electroless Pd process and is carried out using the same plating line. Resulting from processing and evaluating a high number of different wafer types, KSW defined design rules for these processes. The wafers were supplied by various production facilities, research labs and high volume production fabs. KSW microtec is continuously working on improvements of the low cost bumping processes in order to fulfill requirements regarding new wafer materials and assembly technologies.

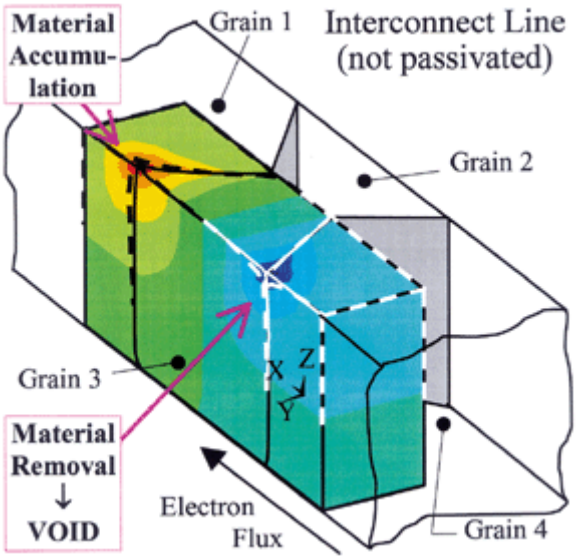
Dr. Thomas Seidowski,
Managing Director

Microjoining, Advanced Technologies and Techniques

Microelectronics Packaging:

The Microelectronics Packaging group at IHM, TU Dresden, combines more than 25 years of experience with the most innovative ideas in the field of chip level interconnect and assembly technologies in offering its comprehensive research, assessment, and consulting services to the microelectronics and the microsystem industries.

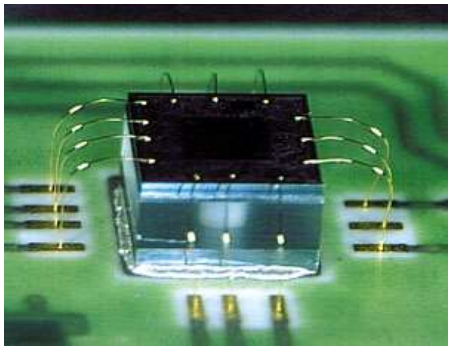
Microelectronics Packaging at TU Dresden that means competence in Inter-connect Technologies and Assembly Processes accompanied by advanced FEA Modeling and Simulation. Today, the field of scientific studies and engineering research starts with the tiny sub-micron copper lines on the wafers, is centered at the chip level packaging processes chip bonding, wire bonding, and Flip Chip techniques, and reaches up to the board level packaging steps known as Chip on Board (COB), Chip Size Packaging (CSP), Ball Grid Array (BGA) assembly, and Surface Mount Technology (SMT).



FEA Analysis: Material Accumulation and Depletion due to Electromigration, Stress Migration, and Surface Diffusion within a 0.25 µm Test Interconnect (Simulation result, dashed line: result without surface diffusion) - A successful new approach to a complex nonlinear multi-physics task.

Starting tiny ...

Semiconductor industry is rapidly shrinking the sized of wafer-level interconnects. The Microelectronics Packaging group contributes to this race studying the Temperature, the Stress, and the Electromigration effects in deep sub-micrometer lines. A unique FEA capability allows pushing the limits of line width down to new records without impairing the reliability of the interconnects. Modeling the complex multi-physics phenomena advances the knowledge of failure mechanisms.
There is no other way leading to performance increase of future ICs like next generation computer processors.

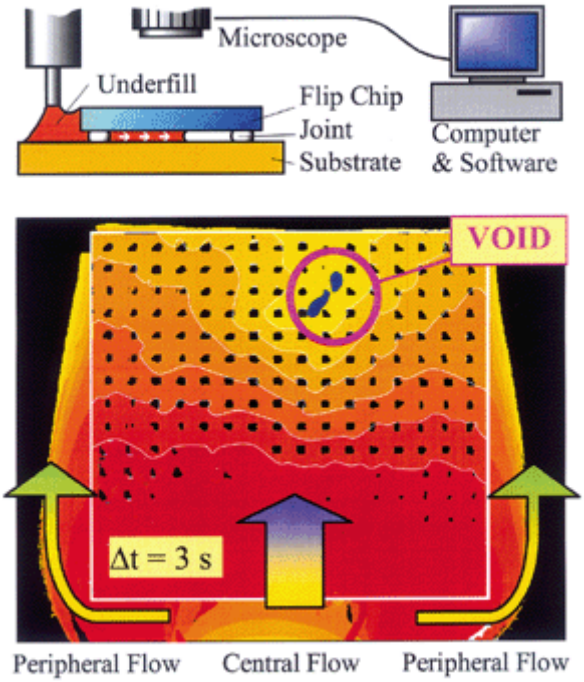


Chip and Wire Bondig: Chip-Level Packaging for Microsystems Devices - A Pressure Sensor is Attached to Thick Film Substrate by Adhesive and Reverse-Bonded by Au Ball/Wedge Bonding. (A service provided to SIEMENS AT, Regensburg

... getting bigger ...

The activities of the Microelectronics Pack-aging group in the field of chip-level pack-aging technologies include

- Chip Bonding
  by adhesive and solders, on all kinds of substrates, for any chip size and thick-ness - fully meeting the needs of tele-communication, automotive, and medical industries
- Wire Bonding
  by gold, copper, aluminum, and alterna-tive wire materials; on rigid and flexible/ inorganic and organic substrates; in finest pitches, for regular mass production - from ribbon bonding/high frequency to thick wire/high power applications



Flip Chip Underfill Process: Assessment of Underfill Materials, Detection of Hidden Defects.
A research cooperation with Infineon Technologies AG, Regensburg

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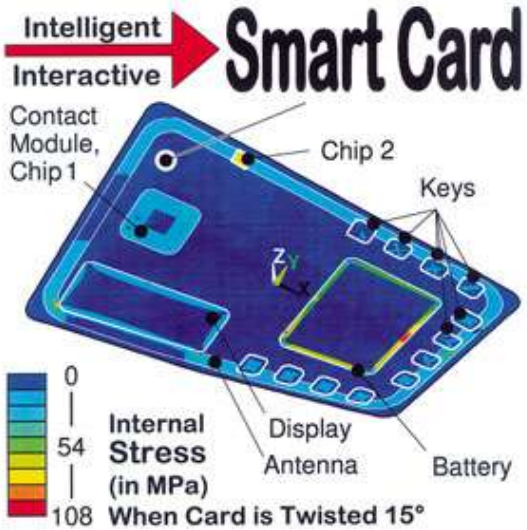
The Universe Between Wafer and Board:

The Microelectronics Packaging group these are 15 specialized engineers and technicians. The group's 300 m^2 laboratory and office space is equipped with the latest bonders, probe stations, and computers. Being an integral part of IHM, the Micro-electronics Packaging group is able to include all relevant process and analyses capabilities of the other groups in their services offered to the industry.

- Flip Chip Techniques
  by solder and adhesives; improving wa-fer-scale and single chip bumping, ap-plying chip placement procedures, studying flux-based and flux-less soldering as well as adhesive joining techniques, assessing underfill material and developing underfill processes
- Design, Assessment, and Testing
  Design of customized test chips and test boards; Material Characterization by FEA-aided micro fatigue tests; Reliabiity assessment of packaging modules based on environmental tests and FEA life-time estimation

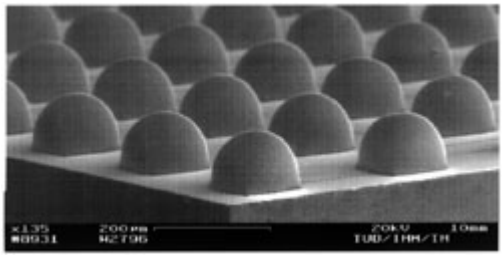


FEA Simulation: Design Optimization after Analyzing the Effects of Typical Mechanical Loads
(A research co-operation with KSWmicrotec GmbH, Dresden)

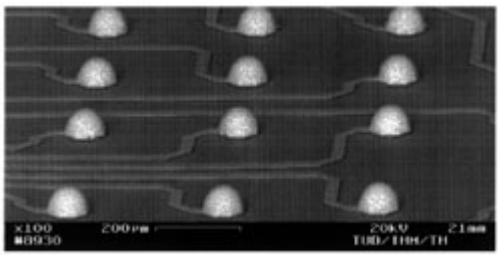
... coming out great!

Board level packaging is driven by the re-duction in feature size, the use of flexible and inexpensive substrates, and the replacement of lead.
The Microelectronics Packaging group is pioneering these trends:

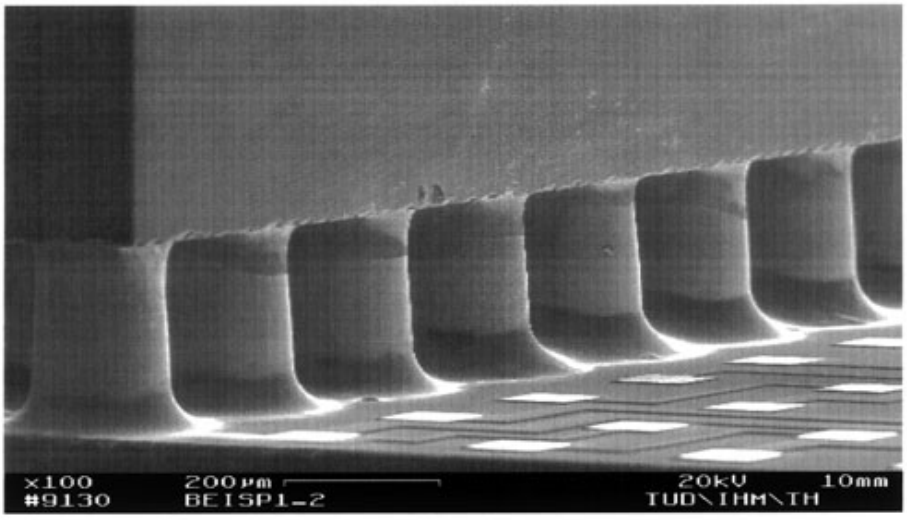
- A new board lithography facility allows patterning features as small as 20 µm on substrates as large as .5 x .5 m^2 in size and up to 3 mm thick
- Interactive Smart Cards and Electronic Labels are currently on the group's probe stations and FEA computers. This way, the design is optimized by finding the best placement of all components (display, battery, chips, antennas etc.)



Chip with Bumps

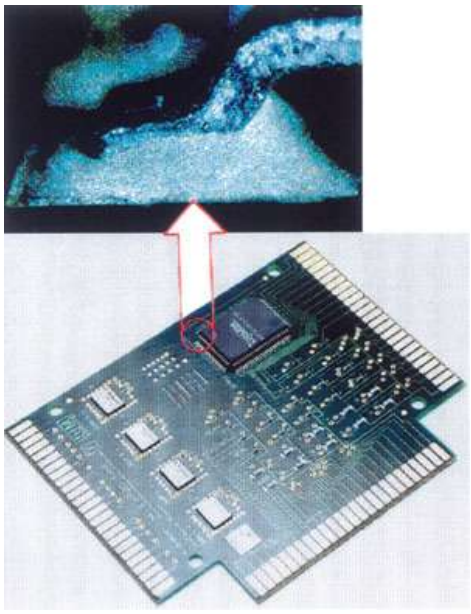


Flexboard with Bumps



Flip Chip Module Before Underfilling

- Alternative solders like SnAg are currently tested mechanically and with respect to their fatigue behavior
- Conductive adhesive joining technolo-gies have been developed by this group for years. Now it can really be seen as a good solder replacement alternative



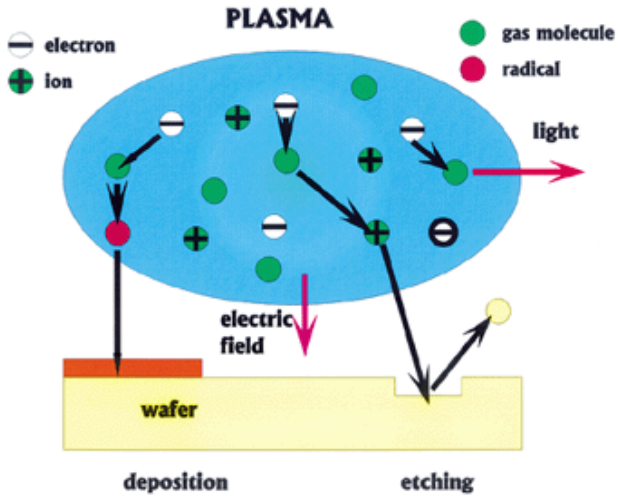
SMT Assembly: Conductive Adhesive Used Instead of Lead Containing Solder (A research co-operation with ZETEX GmbH, Neuhaus, SMT & Hybrid GmbH, Weißog, and Polytec GmbH, Waldbronn)

Plasma Diagnostic in Microelectronics - Process Control investigations at TU Dresden

Plasma Processing became one of the essential technologies in microelectronic manufacturing. Today's products require an extremely close control of the plasma conditions.

Experimental UHV-equipment for testing plasma diagnostic methods

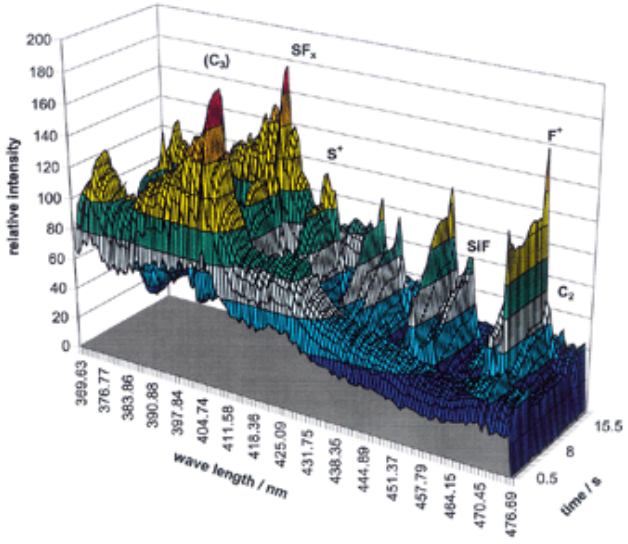
Plasma processing is well established in manufacturing of integrated circuits. With further miniaturization the importance of plasma ("dry") processes is even more increasing. A large variety of deposition and etching processes is necessary to shape the complex structure of a microelectronic device. A substantial part of it will be realized by plasma processing. The removal of photoresits by plasma ashing, the patterning of thin films by Reactive Ion Etching (RIE), the deposition of films by means of plasma enhanced Physical or Chemical Vapor Deposition (PVD, PECVD) and plasma doping or modification of surfaces are common used techniques aided by a plasma.
A plasma is a mixture of neutral and different charged particles: electrons, ions, molecules and radicals. In most cases a low pressure discharge serves as the plasma source. This self-sustaining discharge works far from thermal equilibrium due to the efficient acceleration of the charged particles in electric fields. Therefore, a wide range of physical and chemical processes is possible within the plasma and at the wafer surface. While plasma technology offers unique processing possibilities witch are empirically used in microelectronic manufacturing, there is a growing lack in the fundamental understanding of the plasma properties. The exact determination of plasma parameters and a close control of plasma processes, is urgently required. Essential elementary processes are schematically shown in the following figure.



Plasma processing - basic excitations and interactions between plasma and substrat

Plasma design and control require in particular the knowledge of the kind and number of particles and their spatial and energetic distribution. Different methods are used to characterize the plasma state.

Mass spectrometry is a powerful tool for an analysis of the chemical processes in the reaction chamber, the residual gas and contamination. In combination with an energy analyzer information about the energy distribution of positive and negative ions might be obtained. The basic plasma parameters - electron density and electron temperature - can be determined with a usual "Langmuir" probe. Alternatively a new method, the so-called Self Excited Electron Resonance Spectroscopy (SEERS), yields these information's in a more suitable way for production control.
Any plasma emits light with specific wavelengths witch are characteristic for the excited species. Therefor Optical Emission Spectroscopy (OES) is also a widely used method to control plasma chemistry and to determine plasma parameters.



Time dependent optical emission spectrum of a plasma etch process

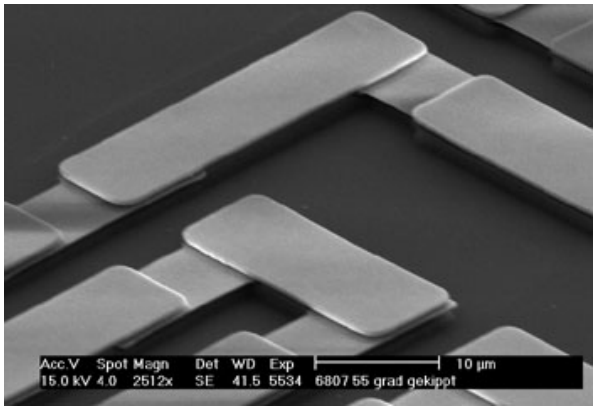
The department of Semiconductor Technology (HLT) at the Institute of Semiconductor-Technology and Microsystems (IHM) at the Dresden University of Technology is dealing with all of the above sketched methods in order to characterize and to optimize plasma processes used in production tools (e.g. RIE tools) and to improve the measuring techniques themselves. A multiplication effect is expected regarding accuracy and clearness of the evaluated plasma parameters due to a combination of the measuring methods. Concerning SEERS a tight collaboration with Infineon Technologies and the Adolf Slaby Institute GmbH Berlin is established.

Chemical Mechanical Polishing in Microelectronic Manufacturing Studied at TUD

CMP is becoming a key technology in microelectronic manufacturing. The processing behavior of different materials and consumables is studied at TUD's IHM.

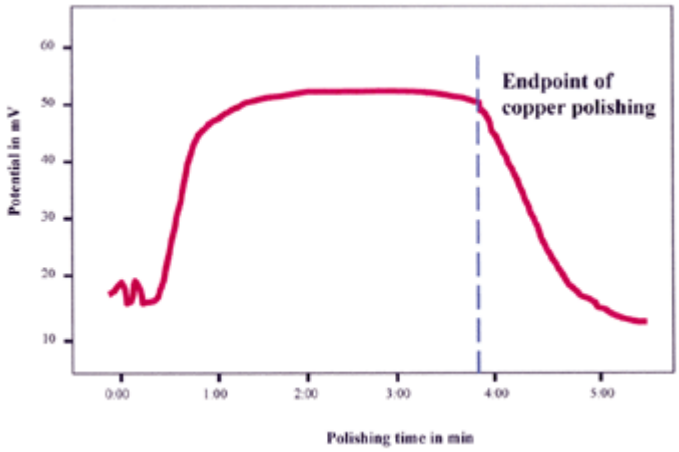
Professional CMP system for R&D at the IHM Clean Room Facility

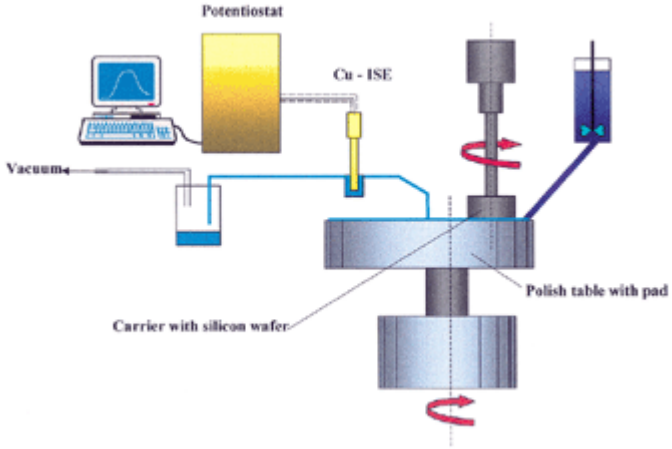
Since the very first days of integrated circuits manufacturing in the 60` th,metal conductor lines were made out of Aluminum. Initially the microstructures were created by lift off technology, however until today metal lines are made by subtractive etching. Approaching linewidth. s down to 1 µm, anisotropic resp. Reactive Ion Etching (RIE) became necessary. The growing degree of integration required more and more narrow lines to connect the devices on a chip. A further complication in the manufacturing process emerged from the fact that, due to the raising complexity of the chips, several layers of conductor lines became necessary to create the interconnects on the device.
> These two development trends became limited by the following implications: 1. Caused by the miniaturization, the resistance of the interconnect lines increased in such a way, that the signal propagation time limits the operation speed of the IC. 2. Caused by the growing number of interconnect layers the surface of the chip became more and more corrugated, making it increasingly difficult to create a sharp photo pattern on the corresponding top layer.
Currently we observe a revolutionary change in microelectronics manufacturing that solves both of these limitations. It is the introduction of a generally novel way of making micrometer- and sub micrometer structures. Key to this method is the wafer processing by Chemical Mechanical Polishing (CMP), enabling copper instead of aluminum as conductor material.



Three layer copper damascene structure manufactured at IHM. The interlayer dielectric has been removed partially

Copper has not been considered as suited for interconnect wires because there was no RIE process available to etch Cu anisotropically. The availability of CMP offered a generally new way of making metal wires on a chip, named damascene technique.
Instead of etching the metal layer, leaving the conductor lines left, here first the insulating material or interlevel dielectric is etched anisotropically, creating groves which are filled by a metal deposition step covering the whole surface. Deposition conditions and thickness is chosen such that the grooves are completely filled. The excess metal on top of the dielectric material is then removed by CMP, resulting in an ideal case in a perfectly planarized surface.
One significant advantage of CMP is, that the method can be adapted to several materials like Siliconoxide, Tungsten, Poly-Silicon, polymer materials and copper. However the process conditions, the polish pad and the polish slurry must be adapted individually. The correct detection of the polish endpoint is inevitable.

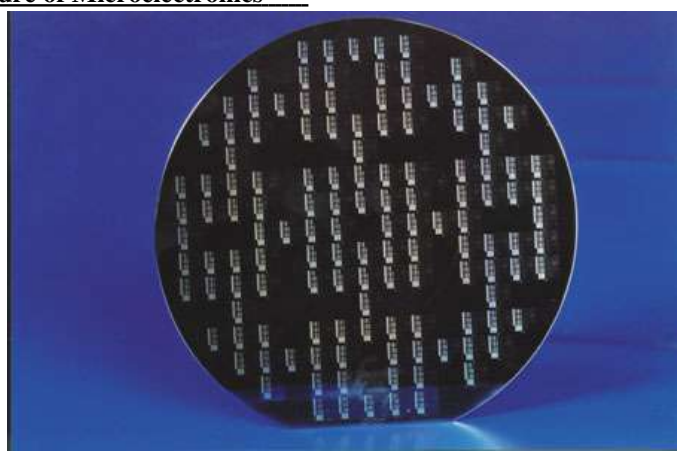




Performance of a Cu CMP with a selective endpoint detection, patended by IHM.
The transition of copper layer to barrier was detected with an ion selective eletrode

The department of Semiconductor Technology (HLT) at the Research Center of Semiconductor- and Microsystems Technology (IHM) at the Dresden University has started 6 years ago fundamental research in CMP. Two professional CMP tools by PRESI (now STEAG) and an automated brush clean system offer to study complex two step processes. The planarisation of silicondioxide and polymers as well as the structuring of several metals including barrier materials has been investigated so far.

Nanotechnology - The Future of Microelectronics



6"-Si wafer coated with thin films of chromium and oxide (source Center of Microtechnologies, University of Chemnitz)

Nanotechnology is going to become one of the key technologies of the 21st century. Despite the fact that nanotechnology is still in its infancy numerous examples of products already exist. Prominent examples are hard discs and read heads in the field of magnetic data storage, which are coated with protective films only a few nanometers thick in order to achieve high recording densities. Scanning probe microscopy has opened up new and exciting insights into the world of atoms and molecules and allow for the manipulation of single atoms. X-ray mirrors formed by multilayers of ultrathin films are increasingly used as beam forming elements in x-ray analytics. In microelectronics the precise deposition of very thin layers and the generation of nanometer structures are prerequisites for a further increase of clock frequency and integration density.

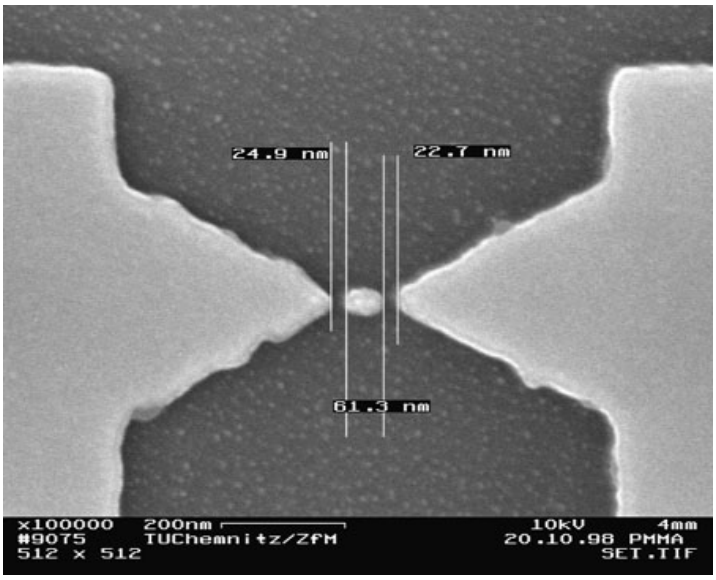
Due to the interdisciplinary nature of nanotechnology new kinds of transdisciplinary and multi-institutional cooperation are needed in order to fully exploit its potential. Therefore, in Germany the federal ministry of education and research has initiated the formation of six national centers of excellence with each of them adressing a specific field in nanotechnology. Saxony and especially the region Dresden/Chemnitz offer a superb infrastructure of universities and research institutes and has become a center of attraction for microelectronics companies as well as equipment manufacturers. This led to the formation of a network of competent partners being recognized as a national center of excellence for ultrathin functional films and funded by the federal government. The network consists of 38 companies, 14 university institutes, 19 research institutes as well as six professional societies and is coordinated by the Fraunhofer Institute for Material and Beam Technology. Common activities are focused on the following topics:

- Advanced CMOS
- New devices
- Biomolecular layers
- Protective layers
- Ultrathin films for optics and photonics
- Nanoscaled sensors and actors.

Microelectronics which will transform to nanoelectronics in the future is a major topic of the center of excellence. Examples of current R&D activities deal with the investigation of ultrathin barriers or copper as a favourable alternative interconnect material. Long-term research on EUV-lithography, magnetoelectronics and the study of single electron transistors are further topics of common activities between academe and private industry. Close cooperation of the partners within the center of excellence guarantees for an efficient use of available resources and allows for a rapid technological and economic progress.

The overall aim of the center is to support the creation of new products and qualified jobs in the fast growing field of nanotechnology. Therefore, besides transdisciplinary cooperation other objectives of the center are to support nanotechnology startups / spin-offs and to encourage new types of educational opportunities to train students.

Similar to the successful story of Silicon Valley the long-term vision is to turn Saxony into a "Nano Valley"



Test structure of a single electron transistor (source: University of Chemnitz)

R & D Services for Microelectronics and Microsystems Technology

The field of micro- and nanotechnology is one of the most important industrial resources at the beginning of the new millennium. The down scaling in microelectronics combined with the use of ultra thin films and advanced materials like copper and low k dielectrics for the interconnect systems is a main challenge for the semiconductor industry. On the other hand, Si-micromachining has been developed to become a key technology in the field of microelectromechanical systems (MEMS). Both of these technologies are mainly based on silicon wafers and can benefit from each other. Thus, our vision at the Center of Microtechnologies (ZfM) of the Chemnitz University of Technology is to offer new developments and ideas in the field of MEMS, new materials and processes for ULSI interconnect technologies and Si-nanotechnology.

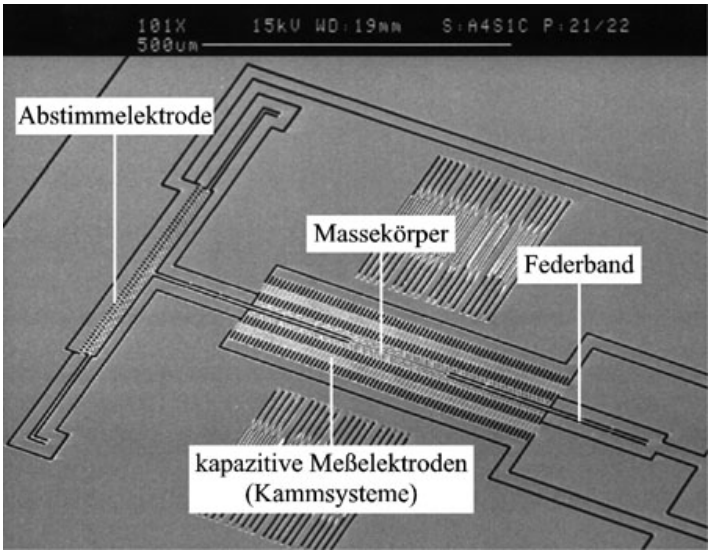
The basic facility of the ZfM is a clean room with an area of about 900 m2 (410 m2 clean rooms of class 10 to 100, remainder of class 1000 - US-FS 209e) including mask and wafer processing equipment. A lithography with a minimum feature size of 0.2 µm is also available. Additionally, there are several systems for design, simulation, testing, and analyses of microsystems and microelectronics. About 50 employees are working at the ZfM: a key staff of 5 scientists, a supporting team of 15 technicians and laboratory assistants, and about 30 project-bounded scientists. The applicable silicon wafer size is 100 mm and 150 mm, respectively.

The research and service fields of the ZfM are:

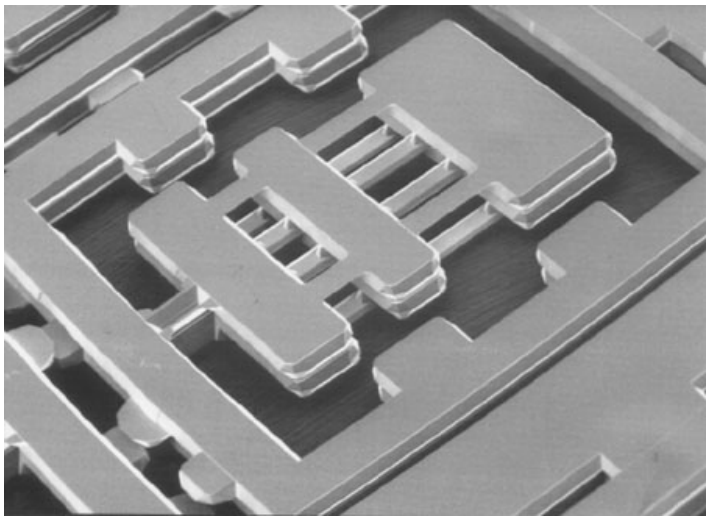
- Design and fabrication of microelectronic and micromechanical devices

- ULSI metallization: copper, copper alloys, barriers and patterning
- Low k dielectrics: nanoporous materials, plasmapolymer films
- Metallization for high temperature applications
- Bulk, surface and near-surface micromachining
- High aspect ratio silicon (HARS) MEMS
- Metal oxide gas sensors for high temperature applications
- Characterisation of micromechanical components
- Experimental analysis of microsystems

Two types of MEMS fabricated within the ZfM cleanrooms:



Near-surface micromachined resonator


Angular rate sensor

All these developments are carried out by interdisciplinary collaboration of different scientists within the ZfM, industry and other institutes. Lately, one of them is jointly working with the ZfM nearby its cleanrooms in Chemnitz. This is the "Micro devices and equipment" branch lab, which was founded in 1998 as part of the Fraunhofer Institute for Microintegration and Reliability in Berlin (FhG-IZM) and has now been integrated into the Microfabrication Center of Saxony, part of the Fraunhofer Institute for Machine Tools and Forming Technology in Chemnitz.

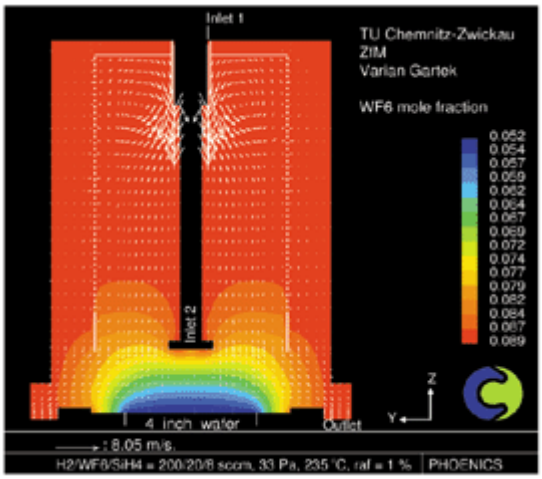
The FhG department's basic research fields are the development of MEMS and of microtechnology equipment, respectively. The research activities are focussed on new assembling technologies, the combination of silicon micromechanics with down scaled traditional precision mechanics and equipment development. A further main emphasis is the process and equipment simulation of CVD, PVD and etching.

The following services are offered:

- Development of MEMS, for example sensors (kinetic, pressure, force, chemical) and actuators (scanner) and their integration to systems

- Development of advanced technologies (3D-patterning - deep silicon etching, chip and wafer bonding including low temperature bonding and combination of new materials)
- Process and equipment simulation. The goal is the improvement of deposition and etch rates, uniformity and fill behavior of vias and trenches by optimizing process conditions and reactor design.

- CVD - metals, semiconductors and dielectrics in batch and single wafer systems
- PVD - metals and semiconductors



Example of CVD process/ chamber simulation: WF6 mole fraction distribution in y- and z-direction

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Deep UV makes it all visible

The Next Generation Imaging: Deep-UV Technology for Wafer-Inspection

Semiconductor components such as microprocessors and memory elements have to meet more and more critical demands. Enhanced performance is accompanied by an increase in the packing density of chip structures and smaller getting geometric structures. The expectations for which optical microscopes being made on inspection, metrology and quality control are correspondingly high. With the minimum dimensions shrinking below 0.18 µm optical microscopy is being challenged to come up with new technologies to provide fast and easy high-resolution images.

Standard microscope techniques in visible light make it possible to recognize and resolve features down to approx. 0.25 µm. Confocal scanning microscopy (CSM) increases contrast and resolution even more due to the fact of spatial filtering with resolution limit shifted to structure sizes down to 0.18 µm. To visualize the shrinking features of 0.15, 0.13 and 0.10 µm chip generations the resolution of microscopes operating with visible spectrum is not sufficient anymore.

The solution is single-wavelength Deep-UV Imaging. Carl Zeiss developed a new, high-quality product line of fully automated 200 and 300 mm wafer inspection & review systems with microscopes equipped with quartz optics and dedicated high-performance UV-objectives. The systems can be used both with standard imaging techniques using visible light and binoculars as well as i-line (365 nm) and Deep-UV (248 nm) illumination for high resolution imaging.

Simply a look at Abbe' sresolution formula, d = lambda / (2 x N.A.) makes it clear that the resolution is dependent on the wavelength used (lambda) and on the numerical aperture (N.A.) of the working objective. To improve resolution, the numerical aperture of the objective can be increased to as high a value as possible, or the object can be illuminated and imaged with increasingly shorter wavelengths. For contamination-free wafer control dry objectives are used. Their numerical aperture is always close to but less than one and the upper resolution limit is reached very quickly.

Therefore only shortening of the wavelength from visible light to Deep-UV (248 nm) gives the needed resolving power and allows to explore and again visualize the next generation linewidths. To have maximum benefit in resolution and contrast in respect of the optical material's properties all of the new Carl Zeiss' systems can be operated at two shorter wavelengths, i-line (365 nm) or deep-UV (248 nm), to achieve the resolution down to 0.1 µm. The use of light of shorter wavelengths makes new technological demands on the microscope lenses. Although glass still transmits at 365 nm, it no longer does so at 248 nm. Synthetic Quartz optics have therefore been used in all of the systems. Of course, observation with the eye is now impossible. A special UV-sensitive CCD camera is used instead with or without software enhancement. As necessary for use in production environment not only high resolution imaging is given, but

also high throughput rates for very fast inspection. The user just switches with very few key strikes between overviewing and different UV modes back and forth.

At i-line limits in resolving power are already shifted further beyond. In the newly developed CSM-UV mode the operator can observe at first with visible CSM observation mode several layers simultaneously and then switch without leaving the CSM mode to i-line high-resolution imaging and to discriminate the layer of interest.

For the development of new electronic components and memory media, UV and especially the Deep-UV technology opens up a promising future for further easy and simple microscopy use in quality assurance, inspection and metrology.

author: **Dr. Axel Zibold, Product Manager**

Another World First from SUSS

Karl SUSS Dresden, number one in designing, manufacturing and selling manual and automatic probe systems to the semiconductor industry, has continued its innovative path by introducing the first ever analytical probe system to probe structures 0.2 µm.

Since Karl Suss Dresden was started in 1990 as an independent sister of the Karl Suss Group, its turnover has continuously increased to DM 35 Mill. last year. Nearly 80% of this comes from export. Among other products, SUSS is renowned for its analytical probe systems.

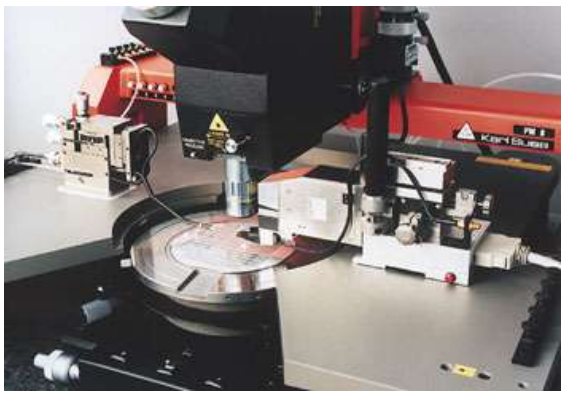
SUSS' complete probing solutions meet virtually any analytical testing requirements in either R&D or production situations: from measurements on wafers or substrates to measurements on flat panel displays, multi chip modules and packaged devices. They meet advanced requirements in the field of failure analysis, parameter extraction & test, device characterization and wafer level reliability.

Analytical probers are mechanical high-resolution precision instruments. Together with electrical measuring devices, testers and a large range of high-tech accessories, they are used for:

- Characterisation of newly developed integrated microelectronic circuits,
- Localisation of problem areas and analysis,
- Optimisation of technology and production control
- Reliability tests on structured completed silicon wafers.

Always at the forefront of innovation, Karl Suss Dresden' s experts work with the industry, technical universities, and renowned research bodies such as the Fraunhofer Institute to ensure that, innovative ideas rapidly become reality.

One of the most recent innovations is the worlds first analytical AFM probing system, the SUSS MFI Probe.



BU: The SUSS MFI Probe

With the increasing complexity of IC devices, current probing technologies are reaching their limit. The SUSS MFI Probe System is a brand new tool specifically designed for Failure Analysis and IC Design Engineers. Capable of seeing and accurately probing features down to 0.18 microns (the thickness of a thousandth of a human hair), the SUSS MFI Probe System utilizes Atomic Force Microscopy (AFM) technology to meet the new challenges of the FA industry for probing in the submicron range.

Capable of quickly debugging submicron devices, this new tool:

- Improves test & measurement performance
- Provides an ideal solution for supporting passive RF, active RF and DC probe tips
- Keeps pace with continuing technological advances.

With an image resolution of 50nm within an imaging area of 40 microns by 40 microns, and a computer controlled placement capability of 180 nm - the SUSS MFI Probe System is a tool which is supporting the semiconductor industry in developing the next but one generation of devices now.

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1. Advanced Equipment Control / Advanced Process Control (AEC/APC) Workshop Europe Dresden, March 30-31, 2000

The first Advanced Equipment Control/ Advanced Process Control (AEC/APC) Workshop Europe will launch an annual European AEC/APC Symposium. The model for this workshop is the very successful yearly AEC/APC - Conference in the USA, which is organized by International Sematech.

New in-situ and integrated measuring techniques, sensors, data acquisition (equipment - level data transfer / host communication) and methods for data analysis are the major issues to be discussed during this two day event. Carefully selected presentations and posters, sufficient time for discussion, and the pleasant atmosphere of a brand - new congress center near the historical part of Dresden will provide an excellent framework in which to learn about the latest achievements of AEC/APC and to discuss future developments and requirements.
The workshop will also include supplier exhibitions and practical demonstrations.
AGENDA:

- **Sensors and Measurements Tools**
  In-Situ Sensors for Copper CMP, Particle, Interferometrie, Ellipsometrie, Ion-flux; Integrated Thickness Measurement; Electrical and Optical Plasma Process Diagnostics and Simulation
- **Equipment & Control**
  Furnace Control, Plasma Control, Implementation of Control Tools, Data Collection
- **Manufacturing** Characterization and Control of 200 and 300 mm Manufacturing Tools, Run-to-Run Control
- **Control Methods and Software** Data Mining, Run-to-Run Control, Data Compression, Fault Detection, Pattern Recognition, Software Solution, Fab Monotoring

WORKSHOP PROCEEDINGS:
A compact disc containing all presentations, posters and supplementary information can be ordered at the given address.

SILICON SAXONY - Open Space for microelectronic research, development and production

The gateway to the Saxony Network - An Initiative by TechnologieZentrumDresden

Since 1992 many internationally firms in the field of microelectronics located in Saxony, Research and Development Organisations und Universitys were able to become world class centers of Excellence.
The TechnologieZentrumDresden has organized for the first time a cooperative fair stand on Semicon Europa in this year. It presents the network of regional partnership in semiconductor industries Ð the SME`s and R&D-partners of Saxony, specialized and oriented to equipment to semiconductor industries, R&D for new 300 mm wafer-generation, clean-room, measurement, factory and process automation, software, waste gas abatetment, industrial services and support.

Promoters:

- AMD Saxony Manufacturing GmbH,
- Infineon Technologies AG,
- SEMICONDUCTOR300

Exhibitors:

- ABAKUS Software GmbH,
- ROTTER Reinstraumservice,
- DERU Planungsgesellschaft,
- LOEMAT Industrievertretung,
- ZMD Zentrum Mikroelektronik Dresden,
- TechnologieZentrumDresden,
- TU Dresden/Institute for Semiconductor Technologies and Microsystems,
- TU Chemnitz/ Center of Microtechnologies and Fraunhofer Institute Reliability & Microintegration ,
- XENON Automatisierungstechnik GmbH,

Manufacturing, Testing and Equipment

The new Automatic Tape Remover ATR 2, prepared for 300 mm

The new Automatic Tape Remover ATR 2 is a further developed Backend Equipment for the automatic removing of foils from re-usable frames, used in Semiconductor Manufacturing to carry wafers.

The first ATR (for 200 / 150 mm wafers manufacturing) has been running for years with good results in performance, function and reliability.

Now the new Tape Remover is ready for operation. It has become smaller than the old type by integrating the control box into the base of the machine. Therefor the footprint of the machine has been reduced noticeably.
There are two variants of the ATR 2, one for 150 and 200 mm wafers (convertible), the other for 300 mm wafers (under development). With their optimized characteristics they are both thoroughly up to date for the most modern semiconductor production plants.

Specific Solutions for handling of Masks and Wafers within Semiconductor Manufacturing

History and Capabilities

HSEB was founded in 1991 based on staff and know how of the former Carl Zeiss Jena Development Centre Dresden.

Until 1996 HSEB emphasised design work in contract of larger companies only. After this time HSEB started to offer complete specific components and handling systems according customer requirements. The company's philosophy is not quantity but short time from specification to delivery including very high flexibility to fit late changes of requirements too. Quality of design, integration and test are supported by an ISO 9000 quality management system. Manufacturing of mechanical parts using actual technologies is done by experienced manufacturer.
The design work is based on a high performance 3D- CAD system (Pro Engineer). Most of the employs have university / college education.
To improve the technical / technological base (clean room capacity , integration and test area) HSEB will remove into an own facility near Infineon / SC 300.

Atmospheric Mask Handling

A specific mask handling device to be used within a e-beam writer system was designed and manufactured for Leica Microsystems Lithography Jena. Masks (5"- 9") have to be transported with high accuracy of placement (mask Prealigner used) from a modified FOUP to a specific mask carrier (customer). The mechanisms of this carrier have to be operated from the handling service station for loading / unloading the mask.
The carrier interface to be operated includes an electrical interface for measurement of contact resistance too.
The mask carrier is handled to / from the vacuum lock of the system by a high payload Robot. To process different mask sizes there is integrated a mask carrier store.

Vacuum- Handling of masks and wafers

By contract of Leica Microsystems Lithography Jena HSEB has designed specific handling systems to handle objects into vacuum environment with high accuracy of placement and are parts of a Process Development Tool for future "Ion Projection Lithography IPL (MEDEA project) which will provide structures less than 100 nm. The very specific "Stencil Mask" (thin silicon membrane with frame) has to be moved in vertical position from an vacuum lock to a interface inside the vacuum system. The "cluster" concept uses a vacuum robot operated in unusual "hanging" position to provide the required interfaces and free envelops.

The IPL- wafer handling requires a specific tempering cassette (6", 8") inside the vacuum lock to provide a high stable wafer temperature (accuracy \< 0,1 K). The tempering cassette consist of an monolithic body from Al to provide high

mechanical accuracy and good thermal conditions and is fitted into an external tempering water loop. The wafer shall not touch the cassette surface during tempering (clearance of about 0,05 mm). The handling consisting of the external standard wafer cassette, the 2 link arm Robot, a Prealigner and the vacuum lock including tempering cassette must provide a mechanical repeatability within the tempering cassette of \< 0,2 mm.

Expertise / Business Areas:

- Specific Front End Tools for masks / wafer handling used within e- Beam- Technology
- Specific Front End Tools for masks / wafer handling used within Ion- Projection- Lithography (vac. Envir.)
- Macro Inspection Systems (Bright Light Inspection, 200 / 300 mm wafers) including specific illumination subsystems (lamp houses) and Filter Fan Units (FFU)
- Specific optical systems (scientific use)
- Modification of devices / components according specific system requirements (customising)
- Short term technical service by contract of the EFEM / Tool manufacturer

Co-operation / Customer:

- Leica Microsystems Lithography Jena
- Leica Microsystems Wetzlar
- Carl Zeiss Jena
- Brooks Automation Jena
- Kayser Threde GmbH Munich
- Clean Room Logistics System Dresden (c.l.s.)
- Infineon Dresden
- Semiconductor-300 Dresden

Handle with care - HAP solutions make it possible___

The company HAP was founded in 1991. Our fields of business are handling and transporting systems, automation and process-control, precision technology, microscopic inspection and testing systems.

HAP offers solutions for semiconductor manufacturing and PCB-production.

HAP's experience is based on a long standing work at Carl Zeiss Jena.

HAP-solutions are designed to achieve a more efficient production and higher yields.

The Conveyor System at Infineon Technologies Dresden is a fully automated transporting system for wafer cassettes. It works very effective because it goes without any additional carrier.

The Conveyor System is arranged below the ceiling of the production hall, in close proximity to filter fan units.

Conveyor System at Infineon Dresden

Elevators are employed to transport the wafer cassettes to different stages along the production chain.

HAP developed a new elevator to fit into the existing Conveyor System without any problems.

Here are some of the essential advantages of the HAP-elevator:

- It is suitable for clean room class 1.
- Its features fully meet the requirements of Infineon semiconductor manufacturing.
- An internal SIEMENS-PLC makes it easy to prepare the HAP-elevator for similary applications.
- It takes up mimimum floor space to reduce integration costs.
- The elevators construction complies with the highest safety standards.
- Although the HAP-elevator was developed for 200 mm wafer cassettes, its modular structure allows modification for 300 mm FOUPs.

The HAP-elevator is an innovation in wafer handling and was successfully tested at Infineon Technologies Dresden. It illustrates the HAP know how and experience.

HAP offers:

- complete service from development and design through production of tailormade equipment
- solutions for microelectronic- and microsystem-wafers and for PCBs
- handling and robotics
- microscopic inspection
- solutions for production support
- customer specific equipment

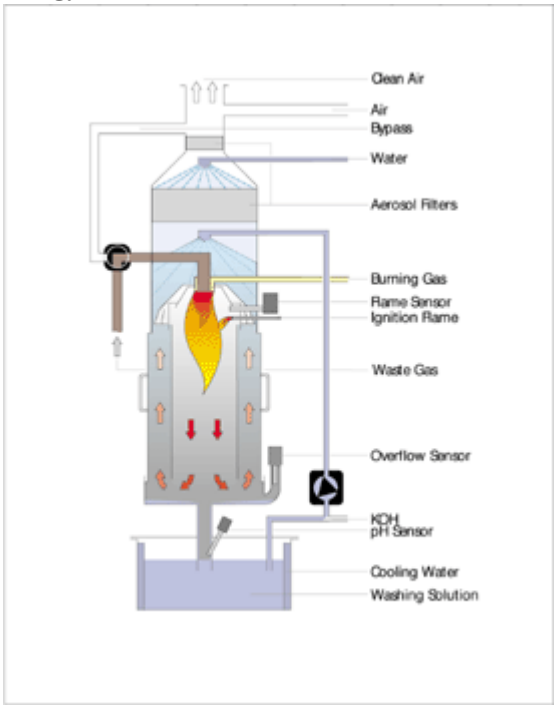
HAP services:

- production of parts
- assembly
- final assembly
- lab and final testing
- on site service
- production of individual items
- series production

HAP serves companies producing equipment for semiconductor manufacturing and for PCB production as well as the semiconductor industry itself.

HAP-elevator

High-Tech Equipment and Technology



FLAWAMAT

High efficient and cost effective system for environmental protection

Thermal processes are cornerstones of the semiconductor industry. Here is the core competency of centrotherm. Wherever thermal processes run - we provide the components and the systems. Own achievements in Research & Development as well as intensive cooperations with research institutes keep the technological know-how of centrotherm on a distinctive level. Centrotherm manufactures high-quality equipment: precise, solid and in compliance with international standards. The modular architecture offers flexibility at low costs. The advantage is obvious: high productivity at low Cost of Ownership. The in-house manufacturing gives us a high degree of flexibility in order to react on customer's requests in an optimal way.

Service is an elementary segment of the partnership with our customers: a separate capacity to accomplish the value of centrotherm products.

The evolution of our customers is the strict guideline to us. Therefor centrotherm has evolved from "equipment vendor" to "partner for innovation". The intensive communication with customers makes us aware of their problems. Our know-how widens perspectives in order to open the way for solutions.

E.g. for solutions to protect the nature from being polluted by industrial processes. During the production of semiconductors a number of toxic, corrosive, inflammable or otherwise harmful substances emerge. Thermal processes lead to universal solutions.

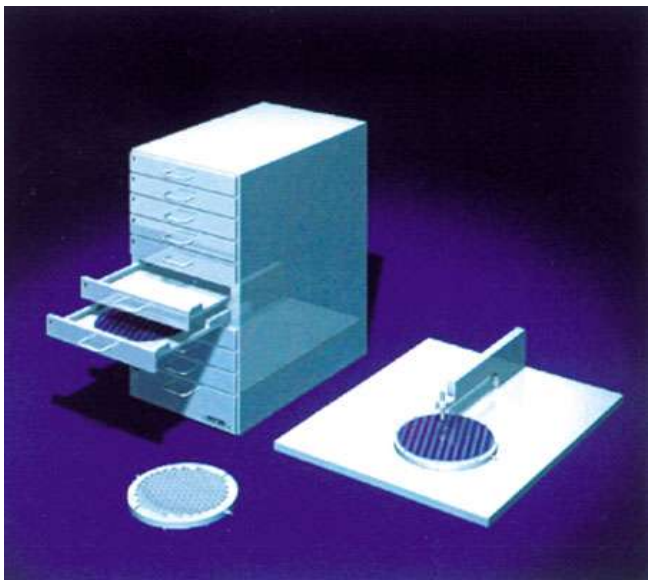
The concept "Flawamat" offers a solution that can be directly integrated into the production process. By combination of combustion/thermal decomposition, washing and holding back of aerosols the system can be deployed in a very flexible manner. The direct control of the "Flawamat" system by the production installation minimises the costs of operation. The degrees of purification reach up to 99.9% and indicate the high effectiveness.

Customer-specific Products and Special Equipment for Clean Rooms by ROTTER

Work in clean and ultraclean rooms characterizes the microelectronic industry, scientific and industrial laboratories, and medical facilities as well. In these areas production too reguires modern, individual solutions for development, fabrication, and packaging, which a serial vendor can deliver only with great difficulty, if at all.

Single-Source, Complete Solutions

ROTTER`s range of service includes the development, fabrication, delivery, and installation of components for the outfitting of and production in clean rooms. The complete train of events from the ideas leading to solution of the construction tasks through the design, statics, mechanics, electrical wiring, programming, and packaging is viewed as a complete management project and is realized together with partners from within the firm`s network.



EXOLAB made by K E K___

EXOLAB series is a modular industrial outfitting system for clean room and laboratory areas required to be kept in accordance with high standards of cleanliness. Out of the standardized individual elements in their building-block system, configurations for the most varied uses can be assembled. In ist first phase the system consists of the shelving, transport wagon, cabinet, and work bench.

In the second phase peripheral componentes required for processing techniques in clean room areas can be addded easily using the modular, selfcarrying features of the basic framework as an axternal skeleton. In this way the product palette can be systematically expanded, depending on customer needs. The electrically conductive stainless framework has an almost completely closed outer surface in the vertical colimn areas and, therefore, optimal properties with respect to transportation, cleaning, and provision for laminar flow. The constructive characteristics and materials of the outfitting system offer the customer an excellent price-performance relationship. The combination of these advantages into a continuous designer line makes EXOLAB a perfect union of function and aesthetics.

Leybold Systems + Service GmbH

You' ve g the idea for innovative R&D...

The company Leybold Systems + Service GmbH was started in 1990 with service for Leybold pumping and measurement devices. Since 1995 we manufact special designed PVD-deposition systems for R&D and production.

In cooperation with partners in Saxonia we develop new devices and technologies for surface treatment and thin film deposition technology.

Systems:

PVD deposition systems:

- box coater of the LAB-series (LAB500 to LAB 1200)
- cluster tools
- horizontal and vertical inline systems
- special designed systems

Further offers:

- automation and visualization of systems
- advisory of customers finding a solution for their problems and art of design
- retrofit of old systems

MAXI: Inline deposition system for coating metallic plates and stripes

Service:
Service for Leybold pumping technics

- world-wide service for cryo pumps
- repair of turbo molecular pumps
- repair of fine vacuum pumps
- de-contamination

Service for Leybold components

- repair and service of mass spectrometer, leak indicators and total pressure measurements devices
- repair and service of thin film measurement devices

A700V: Modular inline sputter system for coating of glass plates

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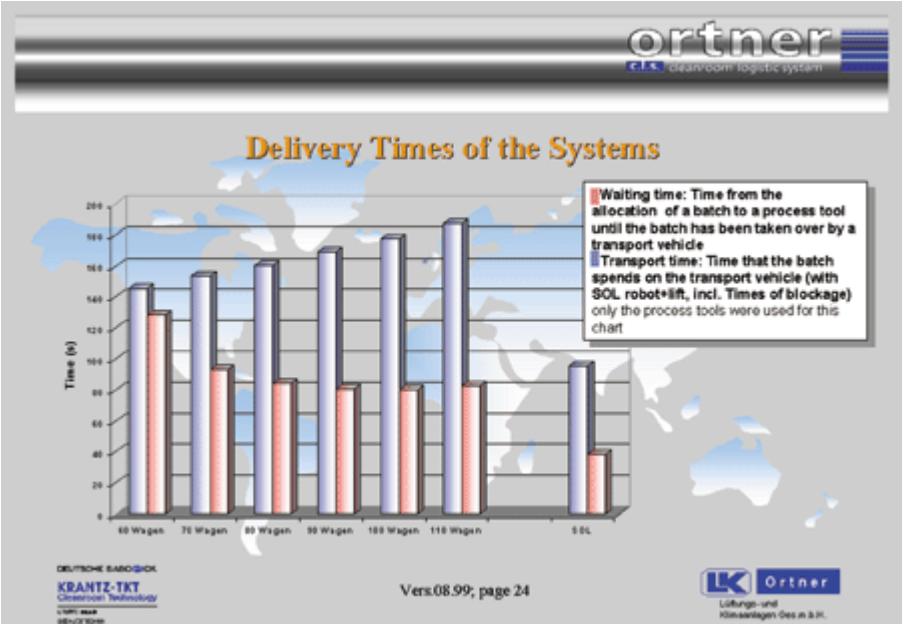
Sea of Lots

In connection with the introduction of the SMIF and FOUP minienvironment technology and in furtherance of the goal of reducing the investment and general operating costs of a semiconductor factory, a new transportation system concept has been developed, which will be the base of the system introduced by the firm Ortner as "Sea of Lots".

The system's main goal is to use the available area, which is also necessary for operating a semiconductor factory, more effectively, thus saving valuable clean room area. The plenum above the clean room area proved to suit ideally for the purpose of transporting and storing wafer batches. Additional use of this space will lead to the goal of saving clean room area. When the plenum is used as a storage and transportation area, the areas of the clean room necessary for stockers and WIP racks become redundant. The area becoming available this way, which makes up to 10 % of the whole clean room, can then be used for additional processing machines or can be saved generally. This is the most

important advantage of the Sea of Lots system.
Simply structured hardware and software as well as the use of industrially proved components for the batch transportation lead to a significant reduction of the investment costs compared to the transportation systems that are conventionally used in the semiconductor production.
This way, productivity rises and the costs of ownership are reduced.



The following text describes the Sea of Lots transportation system in more detail:

A six-axle joint-arm robot travelling on a linear axis is placed directly above an intrabay, i. e. a processing aisle. The robot' s reach allows for placing lots in three lines on each side of this linear axis. The linear axis' length corresponds with the intrabay's length or is 32 m at its maximum. Therefore, more than 300 lots per bay can be stored.
The connection between the individual robots is realized by the Interbay Conveyer System (ICS). This way, complete automation should be ensured. The transfer into the clean room is realized by the Vertical Transfer Unit (VTU), a vertical lift. This lift is operated by the robots.
The lift was designed to enable an integrated sluice system with its own FFU to clean the lots before they enter the clean room. The sluice ensures, in any operating mode, spatial separation of plenum and clean room.
Transportation itself is controlled by the Material Control System (MCS) which is directly connected with the Manufacturing Execution System (MES), the actual processing software. MCS administers any transportation orders as well as the storage coordination.

An a-site of this transportation system was for the first time presented to the world public at the Semicon Europe fair, Munich in April, 1999. After the fair, the a-site was subject to several tests, in order to receive data necessary for further development. These tests concerned its clean room suitability, vibration behaviour and noise release. In addition, reliability, reproducibility and the mechanical state of the individual components were tested.
Further more aim was, besides the optimization of the speed and acceleration parameters, to learn about and/or work out new mechanical transportation principles as well as new requirements regarding the controlling unit.
Within the framework of these tests, time measurements were carried out which were the base for the first real running simulation of the Sea of Lots system.
Therefore, two simulation tools of different function principles were used. The first simulation results were based on a fictitious factory. For the second simulation, the a-site was based on the really measured times of the movements.
Both simulation models confirmed independently that the time necessary for transporting one lot after the operator's request is only less than one minute, that a low operating rate of the components themselves is required and that only one robot per intrabay has to be used. Further advantages can be shown by directly comparing the Sea of Lots system with a monorail system on the basis of the simulation results. Their results can be simply presented in the following graph. Fig. 1 reflects the transportation times concerning the monorail and the Sea of Lots system.

FHR Anlagenbau GmbH - Company Profile

State of the art sputtering equipment and processing is actually the main field of activity FHR. Today FHR is

satisfying customers around the world.

FHR Anlagenbau GmbH was founded in 1991 as a private company with the aim of offering complete solutions in the field of thin film and plasma technologies. After an impressive growth in the recent years FHR is working actually with 45 employees and moved with the beginning of the year 2000 in brand new 3000 sqm (30000 sqft) facilities in Ottendorf - Okrilla near Dresden. This investment was necessary in order to ensure further growth of the company based upon continuous innovation.

Today FHR is one the leading German companies offering full service for sputtering processing based upon modular components for cluster tools and in-line equipment with excellent industrial references like SIEMENS and EPKOS. More than 60 percent of total turnover are realised by export of FHR products mainly to Europe, Asia and North America. The advantage of FHR is the ability to offer customised equipment backed by an experienced staff of design and process engineers and a laboratory facilities equipped with industrial scale sputtering equipment.

Sputtering technologies and also etching technologies together with hard- and software of the equipment are representing the latest state of the art. In close cooperation with leading research institutes and industrial partners FHR is actually working for further development of thin film processing.

In-line Sputtering Machine S750-DKS3

Products and Services

- Cluster tools for sputtering and etching for R&D and small scale production
- Batch type sputtering equipment
- High productive industrial in-line sputtering equipment
- Magnetron sputtering sources in various dimensions for all modes and applications
- Process control equipment
- Sputtering targets of all materials and dimensions including bonding service

Modular Sputtering System MS150x4

Double Ring Magnetron DRM 250

European / German Representative of

- DME Danish Micro Engineering A/S, Denmark - Scanning Probe Microscopes
- Flowlink, France - ultra pure gas components
- JIPELEC, France - RTP/RTCVD equipment
- TYSTAR, USA - horizontal furnaces for annealing, diffusion and CVD

Software, Industrial Service

R & D Services for Microelectronics and Microsystems Technology

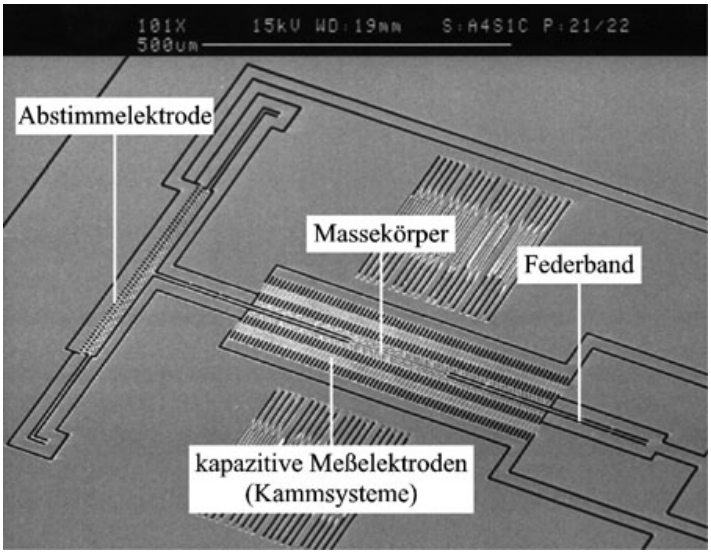
The field of micro- and nanotechnology is one of the most important industrial resources at the beginning of the new millennium. The down scaling in microelectronics combined with the use of ultra thin films and advanced materials like copper and low k dielectrics for the interconnect systems is a main challenge for the semiconductor industry. On the other hand, Si-micromachining has been developed to become a key technology in the field of microelectromechanical systems (MEMS). Both of these technologies are mainly based on silicon wafers and can benefit from each other. Thus, our vision at the Center of Microtechnologies (ZfM) of the Chemnitz University of Technology is to offer new developments and ideas in the field of MEMS, new materials and processes for ULSI interconnect technologies and Si-nanotechnology.

The basic facility of the ZfM is a clean room with an area of about 900 m2 (410 m2 clean rooms of class 10 to 100, remainder of class 1000 - US-FS 209e) including mask and wafer processing equipment. A lithography with a minimum feature size of 0.2 µm is also available. Additionally, there are several systems for design, simulation, testing, and analyses of microsystems and microelectronics. About 50 employees are working at the ZfM: a key staff of 5 scientists, a supporting team of 15 technicians and laboratory assistants, and about 30 project-bounded scientists. The applicable silicon wafer size is 100 mm and 150 mm, respectively.

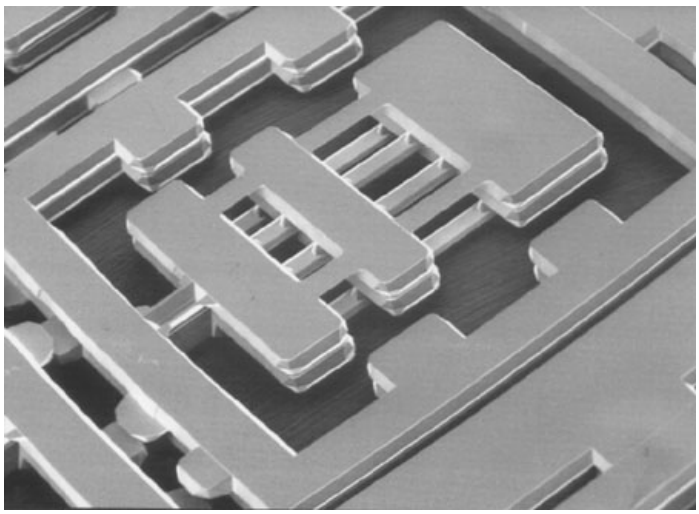
The research and service fields of the ZfM are:

- Design and fabrication of microelectronic and micromechanical devices
- ULSI metallization: copper, copper alloys, barriers and patterning
- Low k dielectrics: nanoporous materials, plasmapolymer films
- Metallization for high temperature applications
- Bulk, surface and near-surface micromachining
- High aspect ratio silicon (HARS) MEMS
- Metal oxide gas sensors for high temperature applications
- Characterisation of micromechanical components
- Experimental analysis of microsystems

Two types of MEMS fabricated within the ZfM cleanrooms:



Near-surface micromachined resonator



Angular rate sensor

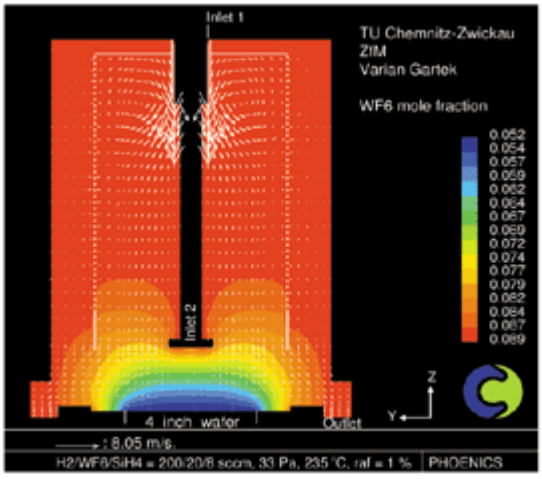
All these developments are carried out by interdisciplinary collaboration of different scientists within the ZfM, industry and other institutes. Lately, one of them is jointly working with the ZfM nearby its cleanrooms in Chemnitz. This is the "Micro devices and equipment" branch lab, which was founded in 1998 as part of the Fraunhofer Institute for Microintegration and Reliability in Berlin (FhG-IZM) and has now been integrated into the Microfabrication Center of Saxony, part of the Fraunhofer Institute for Machine Tools and Forming Technology in Chemnitz.

The FhG department's basic research fields are the development of MEMS and of microtechnology equipment, respectively. The research activities are focussed on new assembling technologies, the combination of silicon micromechanics with down scaled traditional precision mechanics and equipment development. A further main emphasis is the process and equipment simulation of CVD, PVD and etching.

The following services are offered:

- Development of MEMS, for example sensors (kinetic, pressure, force, chemical) and actuators (scanner) and their integration to systems
- Development of advanced technologies (3D-patterning - deep silicon etching, chip and wafer bonding including low temperature bonding and combination of new materials)
- Process and equipment simulation. The goal is the improvement of deposition and etch rates, uniformity and fill behavior of vias and trenches by optimizing process conditions and reactor design.

- CVD - metals, semiconductors and dielectrics in batch and single wafer systems
- PVD - metals and semiconductors



Example of CVD process/ chamber simulation: WF6 mole fraction distribution in y- and z-direction

Analytical service for semiconductor industry

Compared to the microelectronics industry, no section of the economy is more characterized by innovation and progress. The continuous reduction of the integrated structures in logic and memory circuits determines the technology development. Use of alternative materials and new production techniques is imperative. Furthermore, the number of applications using micromachining and microfabrication techniques is increasing.
The requirements of quality and reliability are extremely important issues in all fields of production.
A powerful material analysis is necessary for an efficient failure analysis and reliability testing. To manufacture cost-effectively requires closer collaboration between all engineering disciplines - including analytic service.

The Institute Fresenius offers service and cooperation in the fields of:

- Research,
- Technology development,
- Production control,
- Failure analysis,
- Quality guaranty.

For this purpose we provide a wide range of analysis techniques:

- Materialography, Light microscopy,
- Scanning electron microscopy (SEM),
- Atomic force microscopy (AFM),
- (Analytical) Transmission electron microscopy (TEM),
- X-ray diffraction (XRD), X-ray topography,
- Electron probe micro analysis (EPMA) using EDX and WDX,
- Auger electron spectroscopy (AES),
- X-ray photoelectron spectroscopy (XPS),
- Secondary ion mass spectrometry (SIMS),
- Spreading resistance profiling,
- Infrared spectroscopy (IR, FTIR)

Additionally, we use various analysis techniques provided by our partners.

System of the Future for the Factory of the Future

PRIAMOS - Facility Management System with Totally Integrated Database

The company ZEUS Facility Management Systems is a medium-sized business headquartered in Neutraubling near Regensburg (Bavaria) with branch offices in Munich and Dresden.

One of the main business partners is Infineon Technologies who successfully employs the control system PRIAMOS.

The company ZEUS Facility Management Systems introduced one of the first building and process control systems which is based on data base technology to the market. PRIAMOS does not only manage a database just by the way, it really generates itself in contents and functions from the dynamic and logic design force of a ORACLE database.
Developing a database centred control system working with the principle of the Totally Integrated Database, the engineering team of ZEUS created a system that remains unparalleled on the market for building and process control technology regarding efficiency and extendibility.
Even 100 000 data points and participation of 100 Clients does no longer cause any problems for the Process Information and Monitoring System (PRIAMOS) which works according to the Client-/Server-principle.

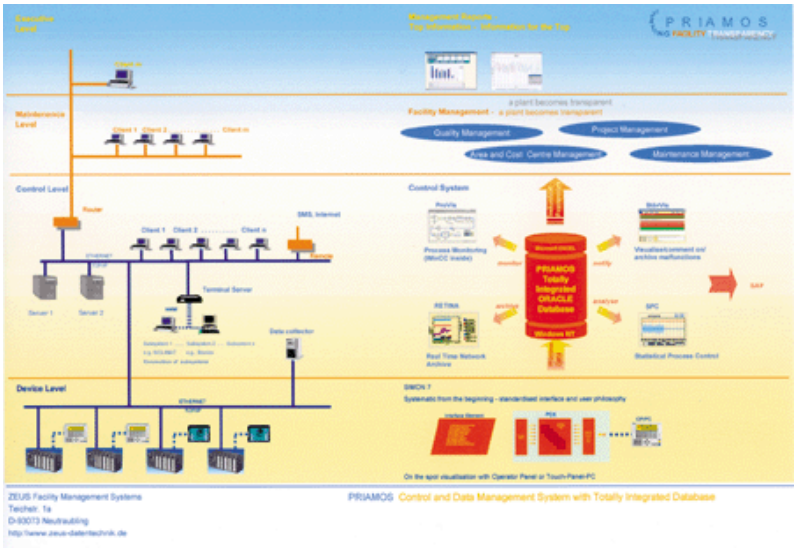
Data collectors that are integrated in the ETHERNET network are responsible for acquiring data from the technological environment. Data extraction from the nearly inexhaustible capacity of the ORACLE database is implemented by logically rationally sophisticated database queries. These queries create and supply - user-friendly as they are - the Front-Ends in such a way that users get an insight and overview on what happens on the plant, which is so clear and depictive, that there is nothing left to be desired. And all this with a performance that a traditional system working ãlinearlyÒ could never accomplish handling such an amount of data.

This is the novelty achieved by the database centred system: the principle of networking regarding the structures of data

management and data connection.

New horizons open up in the field of industrial process-near data and information processing. It seems that modern technological times are dawning in the field of building and process control technology. Modern times that are to conquer the world of facility management in near future as well.

Intelligent connection between consumption measurement data and data on the infrastructure for instance allows implementation of area and cost centre management. Interaction of various modules generates a combination of technological functions including handling of administrational tasks. The whole new world that opens up for a control and database management system is full of abundance of varieties of database technology applications.
In near future, the user will also have the system interface available in the Intranet and Internet. SINTBAD© (Solutions by Internet Based Access on Data) allows you to move the plant's control station to any location desired.



Technical Data for PRIAMOS:

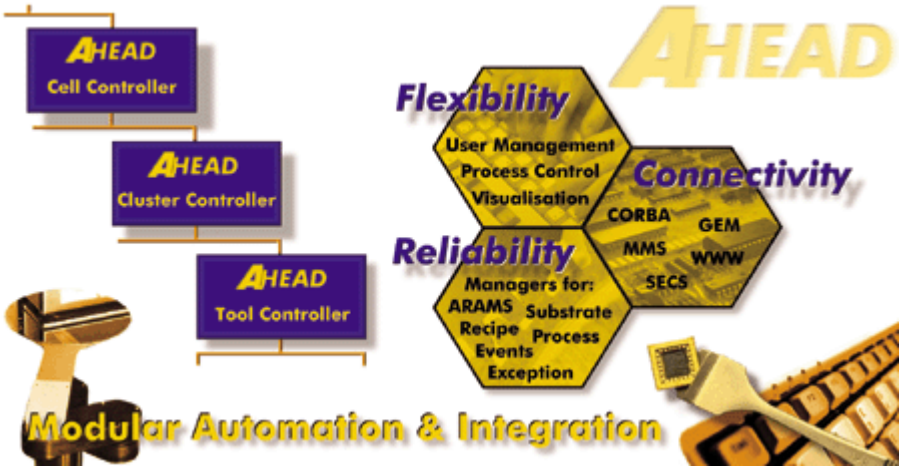
- Based on DBMS ORACLE
- Operation System WindowsNT
- Client-/Server systematic (e.g. 100 clients)
- Communication via ETHERNET and TCP/IP
- Components: Process monitoring, visualisation of malfunction, long-term archive, Statistical Process Control (SPC)
- Facility management functions
- Online data within the database
- Parameterisation of new master data during online operation
- Reporting with EXCEL and ACCESS
- Intranet/Internet connection

Modular Factory and Process Automation

ABAKUS Software GmbH has helped customers around the world gain competitive ad-vantage through state-of-the-art process control, communication and visualisation within their production environments.

ABAKUS offers two flagship products:

- **AHEAD suite, the modular solution for manufacturing and process automation.**
- **SCI, a comprehensive soft-ware application to simulate, integrate and test SECS and GEM communications com-pliant to SEMI standards.**



ABAKUS has been a driving force in the field of software solutions for the semiconductor industry since its establishment in 1995. Headquartered in the centre of the "Eastern-Silicon-Valley" in Dresden, ABAKUS is situated in one of Germany's fastest growing high technology regions. From the very beginning we directed our talents and resources toward what we expected to be the future requirement of the semiconductor industry: flexible, modular systems both standard compliant and extendable - nowadays this trend is vast accelerating.

ABAKUS professional services are based on the expertise and knowledge gained from implementing advanced automation solutions for some of the world«s largest semiconductor and electronics companies. To realise the strategic goals of lower costs, highest product quality and optimal equipment utilisation ABAKUS developed AHEAD suite. This modular control and automation solution consists of one basic package already equipped with compre-hensive functionality and numerous additional modules:

- Real-time scheduling
- Real-time visualisation of scheduling
- Modular recipe architecture
- Recipe change ãon the flyÒ
- Single wafer batch with individual recipe
- Parallel/separate flows within equipment
- Control of material transport
- Processing/engineering state simul-taneous within equipment
- Custom specific user management.

Due to its standard compliant interfaces it can plug in other factory applications easily. AHEAD controls and monitors equipment to ensure smooth operation. In case of problems or errors AHEAD will notify the engineers, reschedule the process flow and move the material to alternate equipment and processes.

SCI - the SECS Communication Interface is a complete software package to simulate, implement and test SECS interfaces.
SCI provides:

- Drivers for SECS-I and HSMS
- SECS-II libraries
- GEM compliant interface
- SML¨ Compiler
- Versatile SCI Toolkit.

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