Packaging concepts

Fan regulator

Series: From the idea to the chip

Interview: Ludger Krücke

newsletter

newsletter 9/2003

"We are smoothing the way for planned growth"

Dear customer,

Although the market for semiconductor chips has not yet completely recovered from its current crisis, the trend looks set to improve. The demand for special packages is once again increasing particularly in the automotive industry. ELMOS is well-equipped for this as we have, in spite of the past few (admittedly difficult) months not neglected our research and development program: We are on the right way with investments in customer-specific developments. We are therefore focusing on many interesting areas which promise to become new innovative projects for the automotive semiconductor market.

However, pushing new ideas is not just restricted to the development department. All departments co-operate with one another - from the design department and sales department right through to production and the assembly-line with its numerous possibilities of package layouts and package integration.

Therefore we are not just looking at the short-term market situation but we are also equipped for tomorrow's demands. The new possibilities arising from the customer-specific integration of chip, sensor and individual packages alone mean that new markets are opening for us

to take advantage of.

In particular, the possibilities in package-development are creating opportunities previously undreamed of. ELMOS is currently developing and producing solutions for the following applications:

- Mechatronic components for side-collision airbags
- Electro-chromatic-mirror sensor-system
- Low-g-acceleration sensor for inclination angle detection
- Intelligent co-integrated pressure sensor system
- Control circuits for gas-discharge lamps as a chip set

Other products will, of course, follow.

We gain customer projects at ELMOS not only because we act as a team but also because the synergy effects enables us to offer our products very economically. We at ELMOS do not just pay attention to price but ensure at the same time that the customer gets the perfect combination of low costs and the best technical design possible.

The numerous new devices of the past few months can only confirm our modus operandi and this simultaneously consolidates our position with German and European suppliers.

With this strategy, it is also our aim to win over the Japanese market. At the same time we are expanding and strengthening our strategic location in the USA.

We will continue to act as a team and with innovative products, we will expand into the future.

Dr. Peter Thoma

Member of the Board for Sales and Development

Contents

Mechatronic trends for innovative products

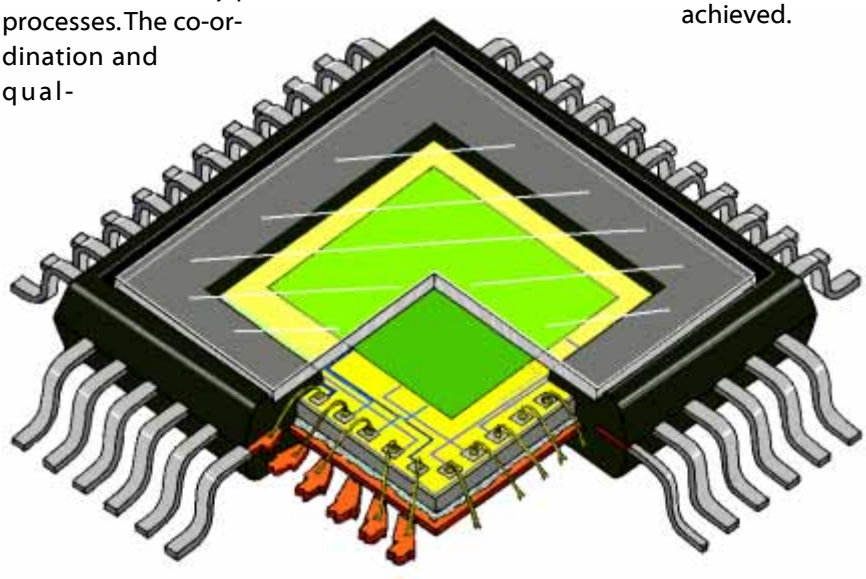
Mechatronics make compact and intelligent systems possible in vehicles. Numerous innovations in the vehicle technology are based on new electronic systems. Intelligent components are replacing additive systems in the area of comfort and safety in vehicles and new measuring and control systems for more efficiency, comfort and safety are being created. ELMOS is one of the forerunners in this field. The ASIC^{plus} work group deals exclusively with the integration of semiconductors and sensors in functional packages. Because of this, new possibilities in vehicle technology are being created.

Up until now, complicated solutions have prevailed. These are both complicated and costly in design as well as in production. This is because passive components, standard semiconductor components, integrated circuits as well as sensors are set up in a module case. This module case is often combined to a system with another component, for example a stepper motor. The design and production of these systems are carried out in many parallel processes. The co-ordination and quality assurance of the processes therefore require numerous technical and logistical interfaces. This means that the time factor and eventually therefore the costs are increased.

A new approach

The new mechatronic concepts now make an improved system approach possible which is already taking constructive, electric and quality assurance aspects into account even at the development stage. This means that processes in the concept, design and production can be simplified, new technical possibilities can be deployed and synergies can be made use of. This innovative approach offers many advantages:

- The integration of active and passive components in one mechatronic system permits a more compact construction and reduces the complexity.
- The lower complexity of the system reduces the number of electrical and mechanical connections. By using high-quality connection technology, a high level of reliability is achieved.
- The direct electrical connection of sensor, evaluation electronics and actuator enables new functions to be created. For example, physical quantities can now be measured better which, because of the many interference sources in a car, have only been accessible in a limited way up until now.
- An intelligent partitioning of the system enables the simplification of the production processes and quality assurance.
- By making use of synergies in the areas of sensory, electric and mechanical functions, cost



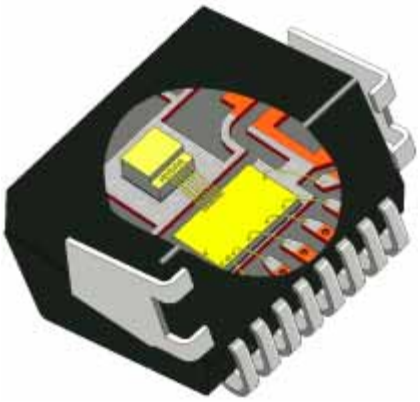
Optical package (PLCC 44) well suited for image sensors (source: eurasem)

Mechatronics

The word "mechatronics" is derived from the terms mechanics, electronics and information technology. Accordingly, mechatronics combines mechanical, electrical and data processing components with each other. Bringing together these individual areas means it is possible to create compact solutions which, by making use of synergies, improve the systems and furthermore, enable new functions to be created.

In vehicles, mechatronic systems are used, for example, in the anti-lock braking system, ESP or motor management. The information sequence in a mechatronic system can flow as follows: A sensor receives signals, the data are processed by a processor and actuators change the mechanical basic system based on the information.

Mechatronic trends ...



Mechatronic packaging approach: Sensor and evaluation circuit on a common leadframe in a standard package.

advantages are created in both the design and production of the complete system.

The semiconductor technology in which these tailor-made silicon chips are manufactured also permits a direct temperature measurement as well as realising visual and magnetic sensors, such as image recording and integrated Hall sensors. Further physical measurands such as pressure and acceleration can be measured and integrated by means of silicon micro mechanics.

Environmental influences are compensated

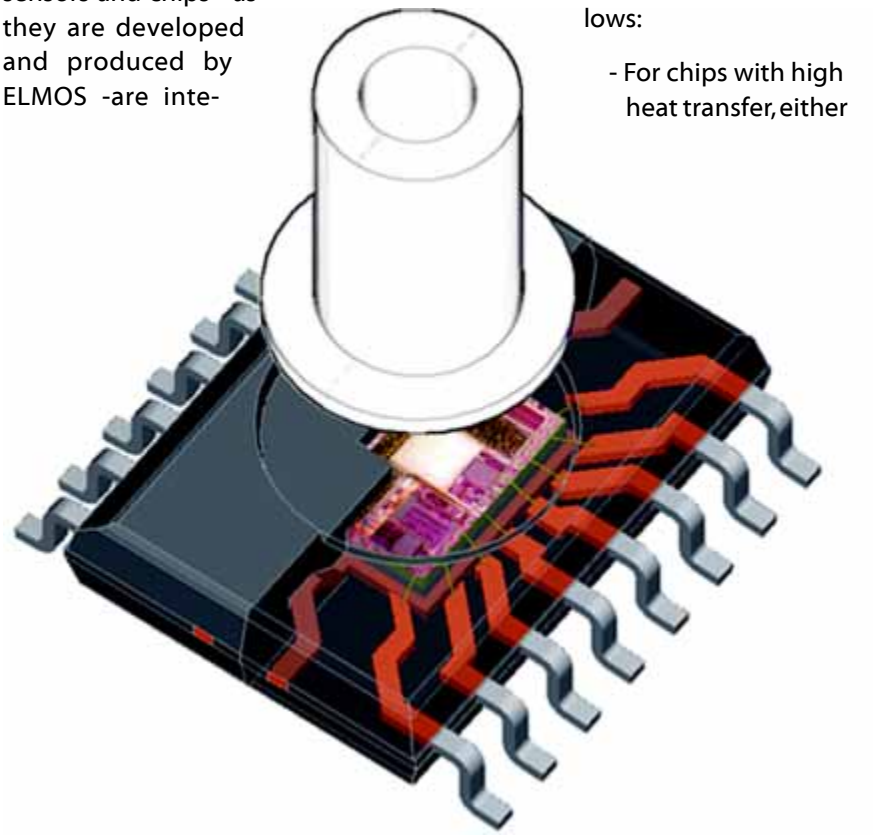
ELMOS has brought the manufacturing processes of CMOS technology and silicon micro mechanics together to one sequential production process. So depending on the need, sensors with integrated evaluation electronics or integrated circuits with a co-integrated sensor function can be realised on one chip.

By integrating the two function blocks on one silicon chip, compensating secondary effects, such as the temperature dependence of the sensor signal, is simplified. There are further advantages as well. The spatial proximity of test point and signal processing reduces the influence of external disturbance variables therefore allowing low signal levels to be recorded.

Individual packaging

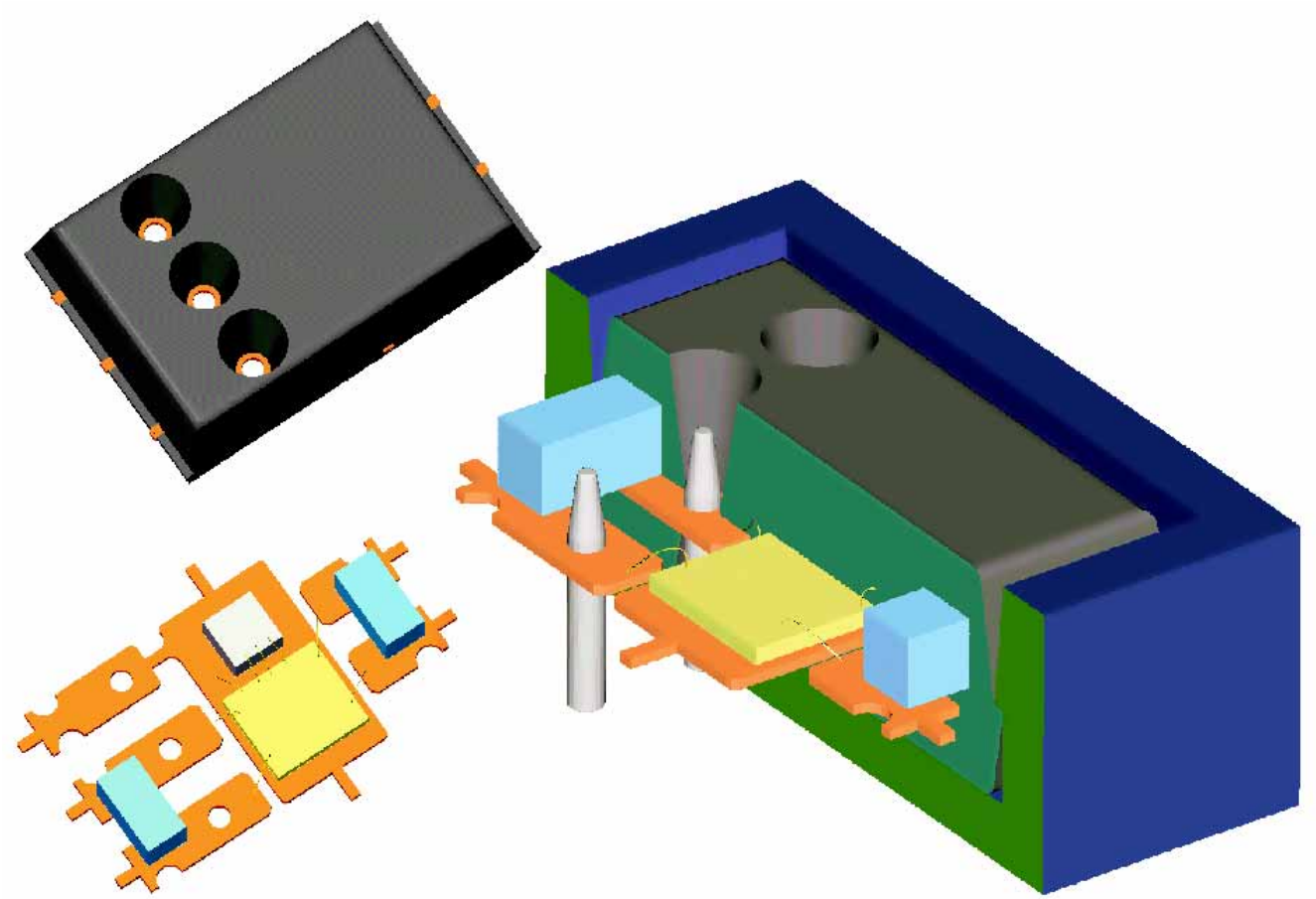
The predominant part of semiconducting ICs manufactured today is encapsulated in standardised plastic packages based on leadframes. These plastic packages form the interface between the semiconducting chips and the sensors of the module. The packages protect the sensitive structures from surrounding influences and mechanical damage. However, there are competing demands, if sensors and chips - as they are developed and produced by ELMOS -are integrated in a common package. This means that the protection function of the package must be partly broken down so that the effect to be measured can work on the sensor element. Therefore, for co-integrated sensors, packages are necessary which are especially adapted to the measuring function. In order to achieve optimal adaptation, the standardised construction is modified to the place of installation and to the surrounding conditions. For this, two aspects are taken into consideration. On the one hand the design of leadframes can easily be changed and on the other hand, moulding tools can easily be adapted. The flexibility of specific package design means it is possible to have additional functions of a mechatronic solution. For this, the package is optimised as follows:

- For chips with high heat transfer, either



Application example of a co-integrated pressure sensor: Evaluation electronics and sensor are integrated in one semiconductor chip and surrounded by an individual functional package.

... for innovative products



System in package approach: Active and passive components are placed on one common leadframe (below left) which guarantees the electrical bonding of the complete system with its surroundings (right).

additional thermal conductors in thermally optimised packages with open cooling surfaces, or bonds with electrical and thermal functions are used.

- Several components can be assembled next to each other or on top of one another in one package. In this way, sensors or additional memory chips can be added to an existing chip component. If standard packages are used, the costs can be reduced due to the high quantities produced. At the same time, the costs for a new design are minimised and the development cycle is shortened.
- Assembling additional components such as capacity, resistors or diodes on the leadframe means it is possible to integrate circuits of lower complexity in one package.

In addition, the individual package combined with a special leadframe makes it possible to have a plug function. Plug contacts or plug pins can be formed directly from the leadframe. These integrated plugs simplify the structure of the complete system because they enable a connection to other modules. Moreover, adapting the packages to individual needs presents no problems financially. Mature and cost efficient machines are available for the basic production steps, such as die attach, bonding and moulding with duroplasts.

Altogether, many new possibilities are created by combining these different technologies. Therefore, chips, sensors and packages are always adapted to the individual customer needs and this results in optimal performance.

Parts of this article have been published in the magazine Automobil-Elektronik 3/03 under the title "Mechatronik strafft Prozesse". *(tsp)*

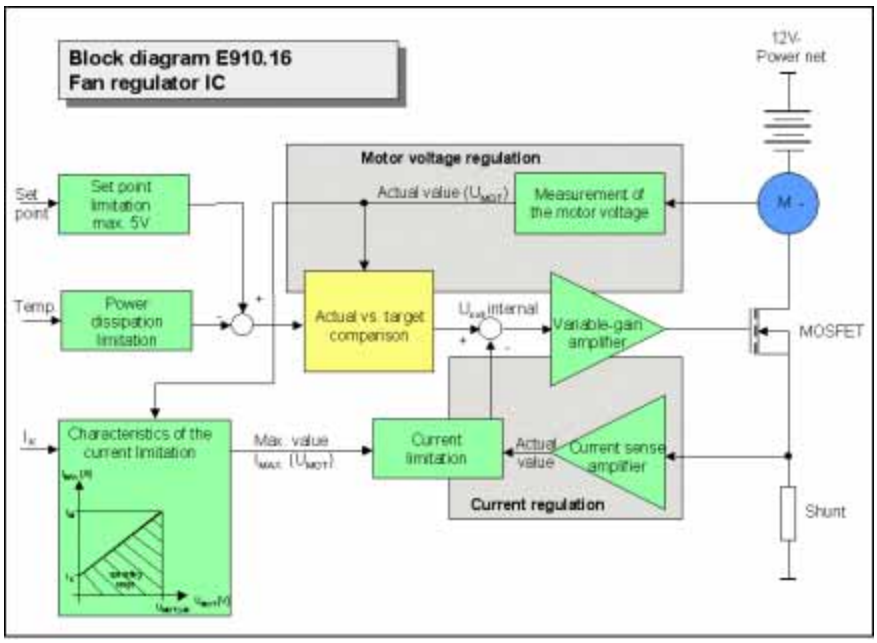
Standard fan regulator IC

The ELMOS IC E910.16 provides a good solution to a fan regulator.

This IC regulates the current of a fan motor linearly, dependent on a predefined control voltage. The ASIC provides the driving voltage for one or two (switched in parallel) external power FETs which adjust the load current as control elements in the motor. When the set values change, adapting the motor speed takes place with a smooth transition.

Both the fan regulator ASIC and the motor are protected from destruction or overloading by a power restriction which is dependent on temperature if the fan motor is sluggish, is jammed or short circuited.

If the control voltage V_{SOLL} falls below a minimum value, the sleep mode is activated and limits the stand-by current consumption to a minimum value. The ELMOS component is produced in the standard SO16 package only according to strict quality and test requirements (AECQ 100) which is for car suppliers of particular importance. It is produced in high quantities and distributed as a fan regulator control and as a motor driver for DC motors. *(tsp)*



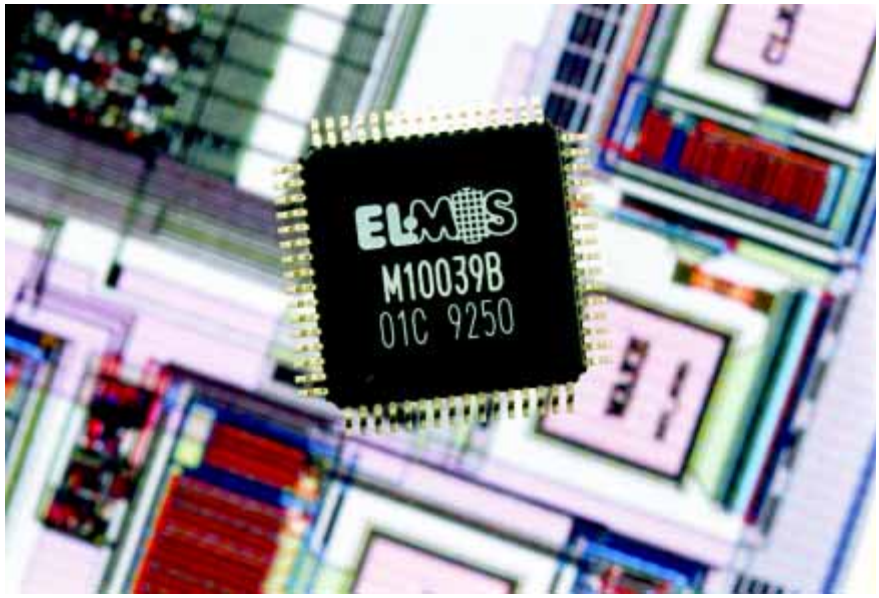
Module with ELMOS chip (reproduced with kind permission from Behr Hella Thermocontrol)

Specification

- Dissipation power reduction by maximum current limitation
- Overload switching off
- Limitation of the stand-by current consumption (power-down mode)
- Operating voltage range of 7.2 V to 17.5 V
- Adjustable minimal current
- EMV-optimised qualities
- Dimensionable excess temperature protection with limitation feature
- Regulating current distribution in parallel switched power FETs
- Control of the power FETs as overload protection
- Operating temperature range of -40° C to 125°
- Standard SO16W package

Part 1: Development of an ASIC

Everybody has heard of the expression "development". But what really lies behind the "design of a semiconductor chip" will be new for most people. The creative design engineers begin the tasks that are needed to construct a new chip very systematically indeed. They are the first people to be involved in the process from the basic idea to the serial chip.



To begin with, the customer has his vision of what he wants. In some cases, this actual idea can already take on a very concrete form. However, it can also be the starting point for comprehensive system consultation. After all, advising the customer is one of the main tasks belonging to the ELMOS sales and design engineers.

The sales and design engineers advise the customer on the optimal technical solution. All those involved fall back on long-standing experience in electronic know-how in all areas of modern vehicle technology. More than 200 individual serial devices form the basis of this expertise at ELMOS.

System integration, which means creating a higher functionality whilst simultaneously reducing the complexity at system level, is no easy task. System knowledge combined with expertise and the optimal choice of possible integration strategies are prerequisites for success.

Customer specifications

The customer specifications form the basis for creating a solution and describe the required functions of the semiconductor chip in detail. These specifications represent a starting point for both the kind and scope of development steps.

The development engineers, also called designers, evaluate these specifications very precisely. An offer, giving the customer a summary of the development costs and production costs for the series ASICs, is calculated on the basis of these specifications. Annual discounts and volume-dependent reductions are already incorporated to keep the costs transparent for all parties concerned.

Here we go: Kick off stage

Once a Development Contract has been completed, the process can then begin. A development project team and a quality planning team work out a Product Detail Specification on the basis of the customer specifications. A detailed time schedule and detailed design documentation complete the quality-relevant documents. From now on, these documents will accompany the development of the semiconductor component which is orientated directly to the product detail specification. The customer can, at any time, gain insight into this documentation from the project leader which therefore keeps him constantly up-to-date.

Part 1: Development ...

Design planning

As a next step, the requirements of the chip must be analysed and divided into single functional units. As a rule, these rough circuit blocks serve as the basis for a structure description which illustrates the requirements on the circuit.

The structure description is systematically checked with regard to possible weak points (FMEA Failure Modes and Effects Analysis) and corrections are carried out. The design outline and the test concept are then developed on the basis of the structure description. If these are accepted by the customer, then this is a big step towards serial chip production.

By now, all the specific features of the future component have been established. All details are now binding for the parties concerned, whether they are special features or process steps, the planned production flow, the technologies which are to be used, the package type, or the qualification and time schedule. As of now, conceptional changes will have a direct effect on the time and cost plan.

Cells and blocks - the development phase

The real development phase can now begin. The individual circuit and function blocks are hierarchically divided into further units, and primary interfaces and supply concepts are specified. What remain are the smallest meaningful circuit units, the so-called cells or circuit blocks.

These are functional circuit elements which have been developed on the basis of ELMOS semiconductor technologies and are for the most part available in design archives. These can be either single elements, such as power drivers, diodes or resistors, or complex circuit blocks, such as voltage regulators or analogue-digital converters.

HV-CMOS and Mixed-Signal

As a rule, the operating conditions, the electrical parameters and also the required functions of the chip ensure that not just digital circuit elements are used. Often signals are taken from the surroundings and are directly reprocessed analogously.

Automotive voltage levels and the necessary protection structures mean that the electronics used necessitate a higher dielectric strength, particularly at semiconductor level.

ELMOS, with its high-volt CMOS

Interview with Ludger Krücke

"There aren't any standardised solutions"

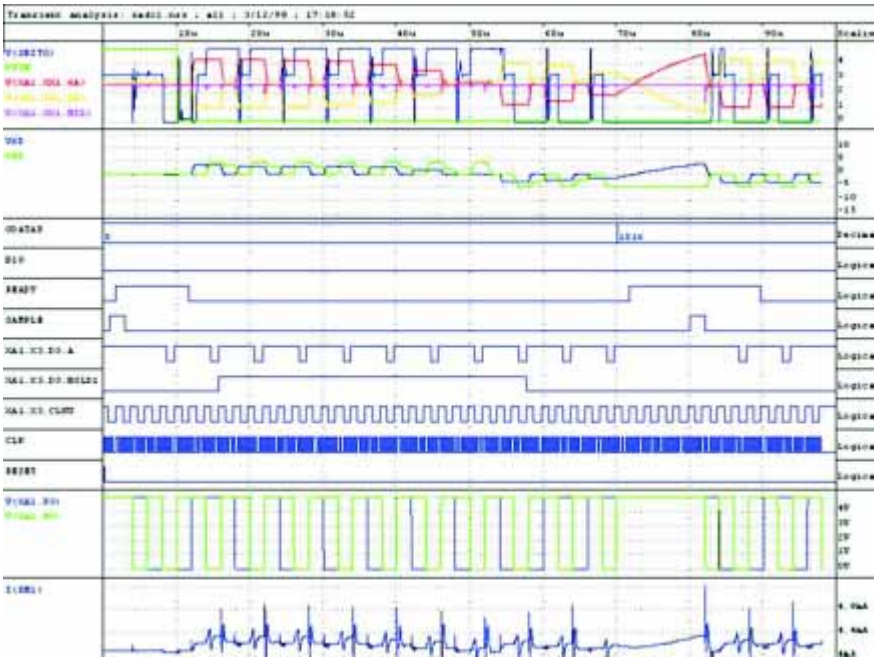
Ludger Krücke (44) is head of the design division at ELMOS. He studied Electrical Engineering at the University of Dortmund and began his career as a development engineer directly after completing his degree. Since 1994 he has been head of ELMOS's design department together with Erhard Müsch. About 60 analogue/mixed-signal designers are employed for the design, the simulation and the test program development of ELMOS products. newsletter talked to him about his daily work and the short-term trends in electrical engineering.

newsletter: Where does your main emphasis lie regarding design?

Krücke: When a customer comes to us, he either has a particular specification or just a rough idea in mind. It is my job to fulfil the needs of the customer optimally within the specification or to put his rough idea into concrete terms and to create a product. In principle, I prefer the

... of an ASIC

technology basis, provides a suitable solution to the demands of automotive electronics. It is now possible to have a dielectric strength of up to 120 volts on the chip with low current consumption. In addition, many analog circuit elements have been optimised and in combination with digital circuit blocks they provide an extensive mixed-signal circuit library.



Simulation - the heart of circuit development

If all functions of the future chip are defined as circuit elements by using cells and blocks, its functionality can be simulated or proved mathematically either totally or partially by taking into consideration the parameter scattering as described in the design manual. In parallel, first test and measuring concepts of the complete circuit are made which later lead to the design of the test program.

The aim is to ensure that the future chip functions fault-free. Therefore, interactions between the different circuit blocks and the various external error sources must be taken into account within the framework of simulation.

Parallel to circuit engineering, a test strategy for later volume production is designed. The aim of this test strategy is to obtain a high functional test coverage of the semiconductor chip in accordance with the requests of the zero fault strategy in as short a time as possible. It might be necessary to integrate suitable process-control monitors into the chip as not all relevant signals are externally attainable later on. Nevertheless all circuit elements can be tested by internal

rough idea because we can then make the most of our experience and creativity.

newsletter : What distinguishes ELMOS's design from those of other companies?

Krücke: Working in the customer-specific field means there aren't any standardised solutions. We want to involve the customer as much as possible regarding design, sales, test and technology. The fact that all these departments are in one company means that we can reduce the interfaces.

newsletter : With which designs have you been mainly involved?

Krücke: I've been involved particularly in the strategic area of safety electronics, i.e. airbags, as well as in alternator controllers. I'm also responsible for a large part of our core competence area which deals with engine and bus systems. At the moment I'm working on new future possibilities with HALIOS.

newsletter : Regarding the future: Where do you think the trends for the next few years lie?

Krücke: Electrical engineering covers a far bigger field than the one that we are currently working on. With the growing number of electronic systems in the car and their interconnection, I foresee a strong growth impulse for our system solutions. Connecting sensors, integrated circuits and mechatronic packaging will create additional possibilities. Furthermore, ELMOS will expand with new ideas into the area of Human Machine interfaces, HMI. *(maku)*

Part 1: ... of an ASIC

test sample generators and evaluation circuits.

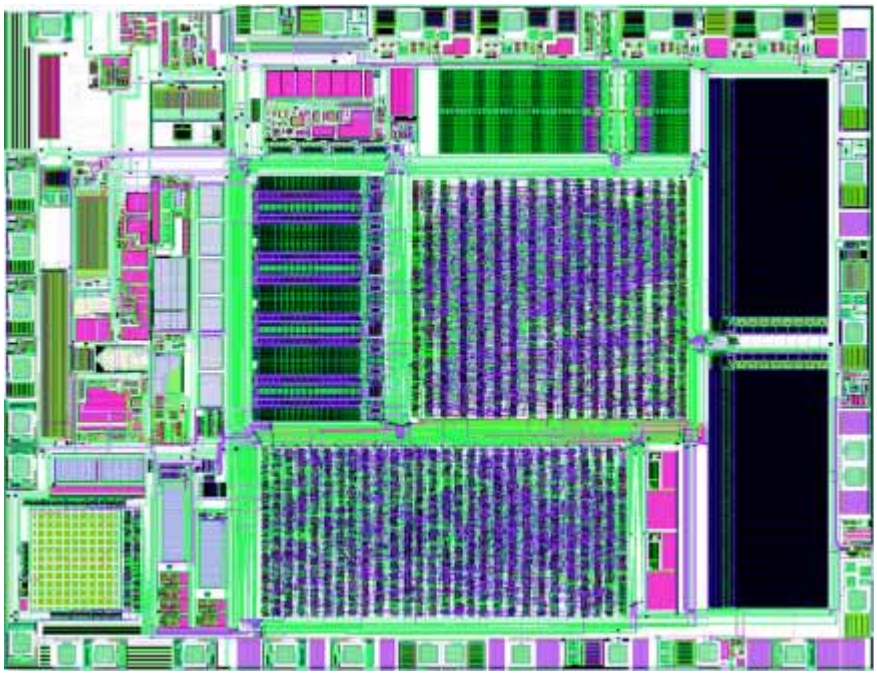
When all the options have been checked and the complete circuit has been further optimised, the next development step can be started.

Net lists and layouts

After the circuit design has been carried out in function blocks, the next step is to generate a net list from the circuit. This net list consists of an alphanumeric enumeration of all circuit elements and their electrical connections. This means that a consistency check of the electrical circuit with the corresponding layout can be carried out later.

With the net list, the circuit reaches a status which makes the transformation into a production-capable form possible. The circuit elements are converted to a layout view which takes the characteristics of the available semiconductor technology into account.

The applied CMOS technology is planar technology. The circuit elements therefore are combined of various stacked thin layers and lateral parts. For the single components of a circuit, various layers are necessary which must be individually produced and structured in the production process. The necessary information is summarised in the so-called layout.



A layout is the topological representation of the single material levels of a semiconductor chip. The later process steps needed for the definition and structure of the single layers are determined by the layout information. Each colour in a layout represents at least one level on the semiconductor chip. The geometric measurements of the layout model determine the later electronic qualities of the circuit.

After a final verification, the tools for semiconductor production can be drawn up from the layout data. For these means a lithography mask (reticle) is generated on the basis of the layout data for each colour level. In chip production, the structure information is exposed in a photoresist layer by these masks.

Find out more in part 2 of the series "From the Idea to the Chip", under the title "Producing a semiconductor chip". *(jgo)*

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VALEO wins award with ELMOS ASIC

VALEO has been honoured by the French society for automotive engineers (SIA) with the EPCOS/ SIA award in the category power transmission.

VALEO has developed together with ELMOS an alternator controller, which is used in the alternator directly and works without any further external components. This is the first alternator regulator world-wide to integrate a microprocessor on an ASIC.

This intelligent one-chip solution is designed to cope with chip temperatures of up to 175°C and communicates directly with the engine management. By connecting the alternator with the engine management the alternator can decide exactly in advance how much current must be provided. As a result the fuel consumption can be reduced and the engine noise during idle running can also be diminished. This solution was first developed for the BMW 3-series and is now also used in other models.

Since 2000, ELMOS as a VALEO-integrated partner has been a member of the Panel 300 making ELMOS an advantage supplier to VALEO. Both companies co-operate closely on the design of new products. The EPCOS/SIA award is the first innovation prize which VALEO has won with one of its VALEO-Integrated Partners.

Dr. Joachim Bergmann, project leader responsible for the ELMOS design is pleased about the EPCOS/SIA award.

For nine years, the EPCOS/SIA prize has been awarded annually to companies and suppliers in the French automotive industry for especially innovative technologies. The jury consists of motor journalists, car manufacturers and technical experts. *(maku)*

News from and about ELMOS

ELMOS achieves environment certification ISO 14001

Environmental protection plays an important role in all departments. Now, ELMOS Semiconductor AG has received the world-wide recognised ISO14001 certificate for its environment management system. This proves that with new developments as well as in serial production a high environmental protection standard is achieved. This concerns all company departments as well as the employees and the general public.

"The certification according to ISO 14001 proves the success of our numerous environment protective measures in the past few years", says Knut Hinrichs, chairman of the management board. At ELMOS, environmental protection is directly subject to the authority of the Board of Management. Even before certification, the Board of Management assessed its environmental policy on an annual basis, adapting it when necessary.

The ISO 14001 establishes environmental protection in management both systematically and permanently. "Our environmental protection measures range from separating rubbish to unsealing areas", says Hinrichs. By improving environmental protection, both a higher level of employee motivation can be achieved and costs are kept down.

ELMOS at JOBfit 2003

On 15th July 2003, ELMOS Semiconductor AG took part at JOBfit 2003, the action day for business juniors sponsored by the Chamber of Industry and Commerce (IHK) Dortmund. At the Dortmund city hall 40 companies from the areas of Dortmund, Unna and Hamm introduced themselves with regard to training programs. 3500 final-year pupils were able to talk to the various companies and inform themselves about possible training opportunities. As well as showing a lot of interest in the opportunities that ELMOS has to offer, the pupils were particularly interested in clean-room technology. ELMOS offers training places for Micro-Technologists and Physics Laboratory Technicians.

ELMOS at SAE congress

Dr. Frank Rottmann, sales manager in Dortmund, found great interest at the SAE World Congress in the USA. His talk dealt with the long-term supply in the different semiconductor markets. "More than 90 per cent of all semiconductors in the world are made for fast markets, for example for the computer industry, telecommunication and consumer-oriented electronics" says Dr. Rottmann. Less than ten per cent are manufactured especially for the automotive industry. Therefore it is the fast market which is driving the semiconductor world forward. As a result, new products are being created according to Moore's law every 18 to 24 months - including those for the automotive market. (www.sae.org)

ELMOS south in new offices

ELMOS Semiconductor AG officially opened its location 'Süd' (South Germany) on Thursday, October 2nd, 2003. The office, managed by Berko Kletzander, is located in Unterschleißheim, only a few kilometres away from Munich. In close proximity to the South German car manufacturers, ELMOS Süd will take on new chip designs and sales tasks.

"This location consolidates our position as a partner of the automotive industry in South Germany", says Knut Hinrichs, executive board chairman of ELMOS Semiconductor AG. "Proximity to the customer is a great advantage for a manufacturer of customer-specific semiconductor solutions."

As well as the headquarters in Dortmund and the Munich office, there are further offices for design and sales in Frankfurt/Oder (GED), Paris and Detroit. ELMOS's subsidiary, Silicon Mircrostructure Inc. (SMI), in California is currently working on the development of micromechanic sensors and also has its own wafer fab. ELMOS's subsidiary in Nijmegen/Netherlands is responsible for the custom-designed packaging of the chips.

Topic preview of the next newsletter:

- Cover report: Pressure sensors
- Overview: Tire pressure sensor systems
- Series "From the Idea to the Chip": "Producing a semiconducting chip"
- Interview with Volker Gruber, Vice President of Frontend Production