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Sensorsystems for Industrial and Automotive Applications

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Whereas in the 1970s microelectronics was one of the dominant strategic research and development goals, in the 1980s materials research and information engineering had priority.
Then in the early 1990s, development work was started mainly in the field of miniaturization and integration of extremely small functional units within a system, in order to open up new technologies of the future, ranging from micro- and nanostructures down to molecular and atomic units, by utilizing also phenomena of quantum physics and quantum chemistry.
Sensors are of essential importance for most products and systems and for their manufacture. To some extent the development of sensors has not been able to keep pace with the tumultuous developments in microelectronic components. For this reason sensorics is in a restructuring phase in the direction of achieving increased miniaturization and integration of sensors and signal processing within a total system. This is giving substantially more importance to technologies that permit low-cost manufacture of both the sensors and the related electronics.

Microtechnologies - Microsystems Engineering

The basic philosophy of microsystems engineering can be described as using the smallest possible space to record data, process it, evaluate it, and translate it into actions. The special feature of this engineering is its combining of a number of miniaturization techniques or basic techniques.
Technical developments in the fields of sensorics, actuators, ASICs, and micromechanics are growing together into a "system". Innovations in the area of field-bus engineering and mathematical tools (computer logic) can improve these systems and optimize communication between them.
Thus a complex technology is available that autonomously processes information and directly translates it into actions in a decentralized fashion in peripheral equipment, without the need for large-scale central data processing.
Microsystems engineering is thus not only an enhancement of microelectronics, it also represents a qualitative innovation.
Microelectronics has entered in nearly all devices in which information is processed or processes are regulated or controlled, from the computer to the automobile and extending to self-sufficient robot systems. Why should not other components and technologies be miniaturized and integrated on a chip and the intelligence of the system be expanded, with a simultaneously greatly reduced energy consumption? The sum total of these future changes brings a large number of new applications having great benefits for society.
The combination of a number of miniaturization techniques presoupposes that the following problem is solved: in the design and realization of systems, a great deal of interdisciplinary knowledge concerning technical possibilities and technologies must come together. In the ideal case, this "knowledge" should come from one entity, because otherwise a high degree of cooperation is required. This can be successful in turn only when the exchange of information and the logistics are good and it must be based on standardization and high quality.

A number of separate technologies have already been developed in recent years: high-frequency circuits, power semiconductors and displays are still part of the field of electronic-elements and they expand the functional scope of the "classical" microelectronics. Microme-chanics, integrated optics, electrooptics, chemosensors, biosensors, polymer sensors, sensors in thin-film and/or thick-film engineering radio-readable passive surface acoustic wave (SAW) sensors are opening up completely new dimensions.
Up to now, these technologies have only been pursued separately from one another and in part they are also based on different materials from silicon, for example, on gallium arsenide, ceramics (eg, Al_2O_3), glass or even monocrystals such as quartz or lithium niobate.
Nevertheless, today microsystems are frequently constructed in hybrid fashion from various different parts, from various technologies, with the goal of miniaturization going along with a simultaneously and enhanced functionality. Therefore, new procedures are aimed at combining chips directly with one another, whether this is a "chip on a chip" or as a "chip within a chip".
Microsystems engineering will provide manufacturing machinery which will enable much finer work than than it is possible today. The door to the submicro world has in any case already been opened. The former magical limits of micrometer dimensions are being considerably lowered by the present-day memory chips and SAW components. Microsystems engineering leads us into nanotechnology and micro-machines will be able to produce systems in molecular and atomic range.
Current research work is aimed first of all at bringing together sensors, actuators and logic components into self-contained units (Fig. 1-1). Here it is not a multitude of elements that is in great demand, but a multiplicity of functions. But to integrate this multiplicity means to bring together different production processes and technologies. Difficulties are necessarily associated with this task, since frequently many processes are "not compatible" with one another

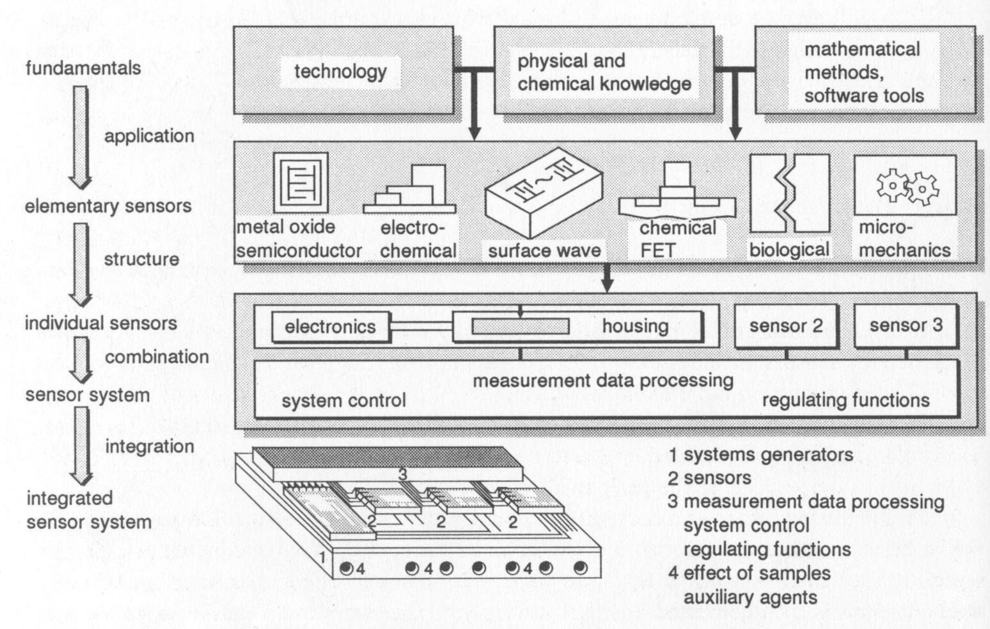

Figure 1-1. Sensors in microsystems engineering: from the elementary sensor to the bus-compatible sensor system.

Fields of application

For greater functionality, modern technical systems require more information. They become available by communication-capabel (reachable, radio-readable) sensors.
The availability of low-cost sensors plays an important role in ensuring that the implementation of these systems will be marketable, especially when large numbers of units are involved. This goal is usually achieved only via "batch-capable" microtechniques. Some of these technologies for miniaturization are already available.

At this point, the great potential of sensors now at the market must also be addressed, because here also the evolution of sensor techniques is going in the direction of miniaturization, multi-functionality, integration, and intelligence.
The fields of application that have a high demand for sensors have already been cited in the Introduction. Here the following fields of application are relevant:

- transportation,
- safety, security
- modern conveniences,
- vehicle-drive management,
- vehicle running gear,
- traffic guidance, traffic engineering,
- intelligent rail systems,
- navigation,
- roadway-route and obstacle recognition,
- health and usage monitoring,
- building engineering
- environment
- production techniques