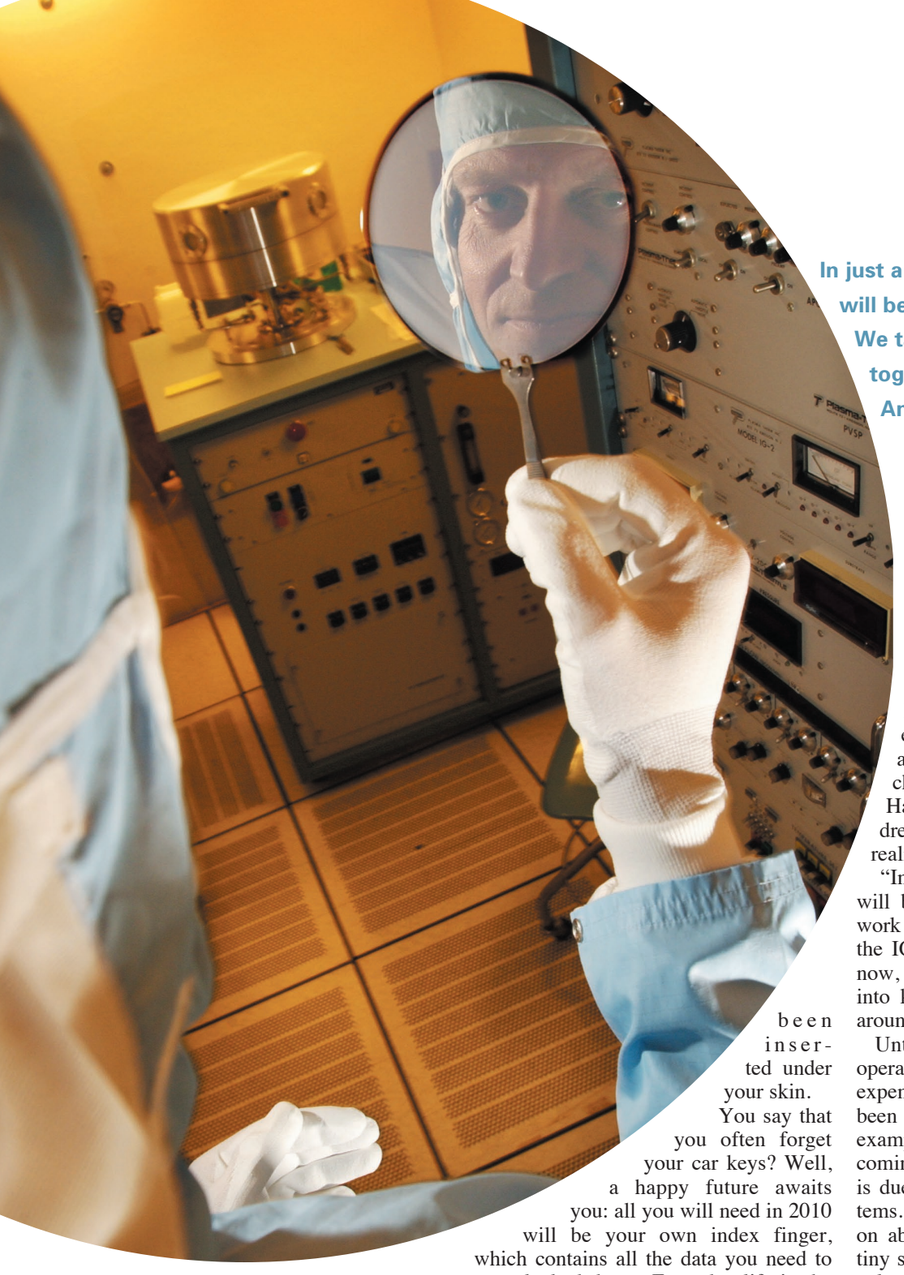
The micros are coming!



In just a few years, microsystems will be part of your everyday life. We take a glimpse into the future together with SINTEF scientist Anders Hanneborg.

By Mari Rian Hanger

Imagine everyday life when all the tools and equipment around you operate themselves. Details that you spend time on today won't be given a thought. Heaters will switch off automatically when you leave the house, your chocolate milk will let you know a couple of days before it turns sour, the medicines you use will dose themselves via a little chip that has been inserted under your skin.

You say that you often forget your car keys? Well, a happy future awaits you: all you will need in 2010 will be your own index finger, which contains all the data you need to open locked doors. Everyday life in the future will consist of microscopic, independent aids. No longer will you have to keep an eye on all the electronics around you; equipment will be instrumented to look after itself. And time, which you never had enough of, will be available for intellectual work, creativity, and thought for other people. There will be an end to the obligatory tasks you had to do just to keep the wheels going round. For instance, the new chain-store Straight Home will bring you just the food you need right to your front door, because it knows what is missing from your fridge and what types of food you like to eat.

Little independent systems

Do you think this is going to be expensive? Do you think that these are just dreams that fancy researchers enjoy playing with? Anders Hanneborg has no doubt that such dreams are on the point of becoming reality.

"In the instrumentation society we will be able to programme systems to work for us. This is quite different from the ICT society in which we are living now, where we put a great deal of time into keeping an eye on the electronics around us," says Hanneborg.

Until now, advanced systems that operate by themselves have been very expensive. Control systems have only been used in rockets and aircrafts, for example. The prospect of these now coming within the reach of everyone is due to the development of microsystems. A microsystem fetches information about its surroundings by means of tiny sensors, which transform a physical value such as pressure into an electronic signal. The electronic part of the microsystem interprets this signal. If a physical operation needs to be carried out, a message will be sent to the "executive" element – a chip with an activation function.

"For example, take the airbag in your new Ford car. On the road, the sensor in the airbag is subjected to shock forces which are converted into electronic signals. The signals tell the system how violent these shocks are, and are transmitted to a tiny chip in which they are compared with pre-programmed signals. Was that a collision or just a heavy bump in the road? If the shock is strong enough the sensor sends a signal to the airbag release mechanism," says Hanneborg.

The microelectronics that interpret the signals are not really anything new; they are all around us, in computers, washing machines, TV sets, and mobile phones. What is new is the combination of electronics with sensors and actuators that creates systems which are capable of evaluating situations and performing physical actions quite independently.

Microsystems are becoming so cheap and advanced that they will be within the reach of everyone, in all sorts of variants, in the course of seven to ten years. At present, developments are taking place at a great rate.

Many applications

The automotive industry is one sector in which both manufacturers and users will see the usefulness of microsystems. Manufacturers are happy that the systems they are installing in cars are becoming smaller and cheaper. A tyre that can repair itself eliminates the need for a spare, saving space and costs, while we users want a greater safety margin when we are driving, as well as lower fuel consumption. Microsystems can help in all this. A map that shows us the least congested way into the city centre at any given moment would not be a bad idea; a little more comfort is popular with everyone.

Saving electricity and non-renewable resources will become more important in the future. This does not mean that you will have to think more carefully about your consumption. The microsystems will take care of all that by saving electricity wherever it can be saved.

And what about safety in general? Do you ever think about how exposed you are to hazards in everyday life, and do you take any special precautions? It is likely that the authorities will gradually require safety precautions in more facets of your life.

"Fingerprint sensors will be located everywhere that you used to use codes and identification. CO2 meters in schools will be taken for granted, and there will be no more children coming home with headaches caused by bad indoor climate," says Hanneborg.

Micromedicine

Microsystems will also become a normal feature of the health services. Blood analyses can already be carried out with the aid of microchips, where blood samples are prepared and analysed in a little plastic chip. Analytical systems of this sort are in a state of rapid development, and with the aid of microsystems such analyses will become cheaper than ever, and not least faster. You will no longer have to watch the news every evening for a week to find out whether such and such a herd of cows has got foot and mouth disease.

Medication can be made simpler by implanting a tiny chip under the skin to give you your doses of medicine. In the same way, an implanted sensor can measure blood glucose levels in diabetics and pump out the appropriate dose of insulin on the basis of the results. A prosthetic hand will also function much better with the help of microsystems. Today, for example, such prostheses have difficulty in distinguishing between heavy and light objects.

"Within a few years, "intelligent" skin on prostheses will make sure that the hand tightens its grip when it senses that an object in its grasp is slipping. It is even possible to create connections between the brain and a prosthesis. Nerve impulses are electrical signals. We can allow the nerve endings in an amputated limb to grow into a wireless chip. The chip can then send impulses to the servomotors that are located in every joint of the hand prosthesis, so that the appropriate parts react when the brain sends out signals," says Hanneborg.

Making good use of our time

But will we not become passive when these systems are able to perform so many operations for us? Will we not forget how to think for ourselves? Hanneborg doesn't think so.

"Far from it. All this will give us time for what is important. When I don't have to think about what sort of food I will need to buy for the rest of the week, I will have more time to ask my colleague in the office next door how he is these days. We will have more time to talk!"

So when you are stressed up and irritated about the keys you are always forgetting, the empty fridge, the car-engine heater you forgot to plug in, or the corner shop that is out of chocolate spread, just be patient for a little longer. We will soon be surrounded by intelligent microhelpers that will take care of all the boring bits of everyday life. Then we shall, if we can, remember what all that extra time was to be used for.

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WHAT IS A MICROSYSTEM?

A microsystem consists of three parts:
- A sensor, which acquires information about specific aspects of the environment and transforms this information into electronic signals
- An electronics part; i.e. a tiny chip that picks up these signals and decides whether a particular physical operation should be carried out. If so, it sends a message to:
- An actuator, which performs the physical operation.

NORWEGIAN MICROTECHNOLOGY CENTRE TAKES SHAPE IN OSLO

SINTEF is investing NOK 75 million of its own funds, while the Research Council of Norway is contributing a further NOK 65 million to the construction of the Norwegian Microtechnology Centre in Oslo. The official opening of the centre will take place spring 2003, and this will be the first building in Norway to have been specifically designed for research and development in micro- and nanotechnology. This type of research requires advanced instrumentation, and the rooms in which it is carried out therefore need to be of extremely high standard. For this reason, some parts of the new building will be laid on air cushions in order to eliminate vibrations from Oslo's trams, which pass close to the building every quarter of an hour. The Centre will cost a total of NOK 230 million and will be used by SINTEF and the University of Oslo. Courses given in connection with the work of the laboratory will provide Norwegian companies with a large number of highly qualified staff in an exciting branch of industry in the future.

Continued on next page

Tiny life-saver

Studies have shown that the most frequent type of fatal accident on the roads today is a rollover, where a car hits an obstacle and rolls on its side, often turning over several times. In such cases, an airbag that inflates in front of your is of little help.

A new microsystem developed by SensoNor inflates airbags on your right- and left-hand sides when your car rolls over. SensoNor has developed the sensor chip (photo) for this system in close cooperation with SINTEF. The sensor determines the angular velocity, i.e. how fast the car is turning over, by measuring the number of degrees per second by which the vehicle's ground reference plane changes.

When the car leaves the ground the reference plane changes very rapidly; a tenth of a second can cost lives. The sensor needs to have reacted before the first two wheels become airborne if the airbag is to have time to protect the passengers.

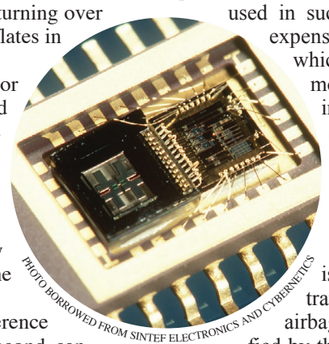

PHOTO BORROWED FROM SINTEF ELECTRONICS AND CYBERNETICS

The type of sensor used in this system is cheap. It is already possible to inflate airbags during rollovers, but the sensors used in such systems are from ten to thirty times as expensive as the microsystems from SensoNor, which has meant that only manufacturers of the most expensive cars have been able to afford to install them. This cheaper system opens up the prospect of a larger market.

The complete microsystem measures 11 x 8 x 4 mm. The mechanical part consists of two plates that are mounted and vibrate on three springs. The vibration changes when the angular velocity changes, a change that is instantly picked up by the sensor, which transmits an electronic instruction to inflate the airbag. The new product is currently being qualified by the system manufacturer, which aims to sell it on to vehicle manufacturers.

Contact Geir Uri Jensen, SINTEF Electronics and Cybernetics

Pocket doctor

PHOTO: KAI PAULSEN

In collaboration with SINTEF, NorChip is developing a microsystem that is capable of analysing biological samples. The microsystem is about the size of a credit card, and with the help of a blood sample, for instance, it can determine whether a particular virus or bacterium is present. This tiny laboratory will be used in the first instance to reveal the presence of dangerous bacteria and viruses, as well as the risk of developing various types of cancer.

A prototype system is now ready for use. A sample is placed into a little chip that contains 25 reaction cells, each of which already contains one or two RNA sequences which are unique to the type of bacterium or virus that we are looking for. The nucleic acid RNA is very like DNA, but unlike DNA, there are many types of RNA in each cell. If the RNA in the sample matches one or more of the RNA sequences already in the chip, a biological reaction will take place in one or more of the cells. This enables us to see rapidly and simply whether any of the bacteria or viruses we are testing for are present in the blood.

In the first place, the chip has been envisaged as an instrument for use in doctors' surgeries and hospitals. The method is rapid, efficient and easy to use. In the future, we may be able to carry out the test ourselves at home. NorChip (represented in the photo by founders Frank Karlsen and Geir Morland) and SINTEF are currently testing the method on a larger scale.

Contact: Henrik Rogne, SINTEF Electronics and Cybernetics

Blood glucose meter under the skin

A tiny little microsystem operated under the skin monitors the body's blood glucose level. Diabetic patients avoid the endless series of injections, while their blood glucose level is kept under control.

The microsystem measures the level of blood glucose in the extracellular fluid, which is found throughout our body. Because the levels of blood glucose in the blood and the extracellular fluid are in equilibrium we do not need to insert the microsystem into a blood vessel. The system consists of a membrane, i.e. a thin film that allows certain molecules in the fluid to pass through it, while others are blocked. Developing this membrane is one of the challenges facing the SINTEF scientists. Past the membrane is a sensor that registers the glucose level, and an electronic part that converts the physical records into electronic signals that are transmitted out of the body by radio. The diabetic patient can read these signals himself on a hand-held terminal or mobile telephone.

The scientists have already tested the ability of the sensor to measure glucose concentrations in water, and the system has met their expectations. The next step will be to make similar measurements in extracellular fluid, and to persuade the body to accept this foreign body. They will also check whether the microsystem affects the body in such a way that the blood glucose level near the system differs from that of the rest of the body.

The system will probably be cylindrical and will be operated under the skin in the abdominal region. The complete microsystem need only be about 5 mm in diameter and 10 - 15 mm long. The project is being performed on behalf of Lifecare AS, and SINTEF is developing the technology. The scientists reckon that the system will be ready for testing on human patients in two years.

Contact: Helge Kristiansen, SINTEF Electronics and Cybernetics

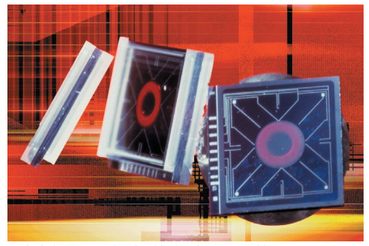

PHOTO: SINTEF ELECTRONICS AND CYBERNETICS

Making sure of fresh air

A company called 54,7 is developing a gas sensor that can be used, among other things, to control ventilation systems in industry and in the home. The sensor measures the amount of carbon dioxide (CO_2) that we breathe into the air. Excessive concentrations of CO_2 give us headaches and make us tired, an experience we have all had in poorly ventilated rooms. If the measurements show that the level of this gas is too high in a room, the ventilation system will be switched on automatically, and fresh air will be brought into the room. This system also saves energy, since most ventilation systems operate continuously, while with the new sensor, the system will only be started when ventilation is needed.

The sensors operate on a photoacoustic principle. Some of the air in the room is drawn into a sealed chamber and infrared light is then pulsed into the chamber. The carbon dioxide absorbs the infrared light, raising its temperature and pressure. If a lot of infrared light is absorbed, this indicates a high level of CO_2, which is shown by the pressure rising sharply. Since the light is passed through the gas in pulses, the increase in pressure also takes the form of a series of pulses.

These pressure rises can be measured as an acoustic signal by means of a microphone, and the acoustic signal lets the ventilation system know if it needs to switch itself on.

The current prototype measures 10 x 5 x 2.5 cm. The sensor is expected to be fully tested and ready for production in about three years. There is a huge market for such gas sensors for industrial and domestic use – probably several million a year. The company believes that in the longer term, the sensor could be used in ventilation systems in vehicles. The same principle can be used to measure other gases than carbon dioxide, for example environmentally harmful emissions of coolant gases from fridges and freezers.

More information is available on the company's web-site: www.fifty-four.no

Contact: Per Øhlckers, former SINTEF research scientist and now managing director of the SINTEF spin-off 54,7.

Pressure sensors in outer space

The space industry is regarded as the one with the most stringent requirements for its components. In sharp competition with other European firms, the Norwegian company Presens has been given the job of qualifying and supplying high-pressure sensors to the European Space Agency, and is currently signing a contract to that effect. The sensors will measure pressure in the fuel tanks of satellites.

The Norwegian sensors were selected because they are small, accurate, and reliable. The little cylinders are about 10 cm long, with a diameter of 15-20 mm, including their signal-processing electronics. Because it costs about USD 2000 to send 100 g into space, weight and size are important factors. The sensors that have been used until now weigh about 250 g, while those from Presens weigh only 50 g. Since many sensors are needed, this involves a worthwhile reduction in cost. The sensors now need to be qualified for use in space, a process that will take almost two years.

The Norwegian Space Centre is providing financial support for the project, while Astrium Space is contributing expertise. Astrium Space supplies pressure sensors to 85% of the European space market, and this company will be the client and strategic partner of Presens. This is a prestigious contract which can open the door to new markets such as civil aviation and military materiel.

Presens is already supplying sensors to the offshore industry. The company's sensors measure pressures up to 2000 times atmospheric pressure. All the major oil companies such as Statoil, Hydro, and BP use these high-pressure sensors. The US company Kavlico is currently developing the sensor for use in the automotive market. Presens and SINTEF receive royalties on sales.

Contact: Frode Meringdal, managing director of SINTEF spin-off Presens AS.

Give it your finger!

You will soon be able to use your finger instead of a password in most situations. In collaboration with SINTEF, the Norwegian company Idex has developed a sensor that scans your fingerprint pattern. The sensor will be capable of replacing PIN codes and passwords in cash machines (ATMs).

The sensor can also be installed on mobile phones (see photo), where it can be used as a fingerprint reader for services that require a password, as well as for screen navigation purposes. When you pass your finger over the sensor, it creates an image of the fingerprint that is recorded as an electrical signal. This in turns allows the distance from the sensor to an extremely large number of points on the skin to be measured, resulting in a three-dimensional image of the fingerprint. This pattern enables the system to identify individual users with a degree of certainty which eliminates any practical possibility of error.

PHOTO BORROWED FROM IDEX

Until now, fingerprint readers have been based on optical reading, which has made them expensive, while they have also taken up a good deal of space. The new sensor is cheap and very small, which gives it many more potential applications. It will probably be used at first as a security device in portable PCs and mobile phones. The sensor is being manufactured and marketed by ST Microelectronics, the biggest producers of semiconductors in Europe.

Contact: Ole Christian Bendixen, SINTEF Electronics and Cybernetics