MICRO STRUCTURE BULLETIN

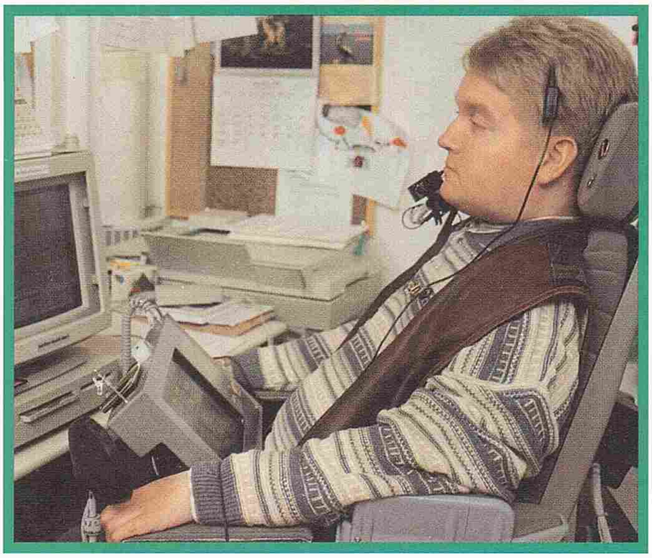
Newsletter for Nordic Micro Structure Technology No.4 Nov 1995

MST Goes Human

Microstructure technology (MST) means more than fancy SEM pictures of ants eating micro-cogwheels (or was it the other way around?). We are now witnessing a new phase in the evolution of this technology, as MST is now being employed in applications of high priority.

This issue of *Micro Structure Bulletin* is dedicated to applications related to health care. In a socio-economic context, this area has an extremely high priority. The changing population pyramid poses enormous problems on health care institutions. An increasing fraction of the population will require health care services including diagnostics, therapy, and follow-up. At the same time, society will hardly accept a further increase in the costs. In Sweden, the health care costs reached 11% of the GNP when it was considered necessary to bend the curve downwards. The specifics may vary from one country to another, but the overall trends are similar. Consequently, the health care sector is facing a gigantic problem of increasing its overall efficiency.

How can MST improve the efficiency of health care? You will not receive a complete answer to this question in this issue of MSB, but you will at least get a glimpse of the opportunities. The picture may look incomplete and fragmented. This is augmented by the fact that we have chosen to concentrate on a few local R&D activities. However, it should be clear that new sensors and microsystems could radically cut the costs for diagnostic investigations, reduce patient risks associated with therapeutic interventions, and improve the quality of life for patients suffering from some chronic diseases.



André Alm: Innovator and test pilot in one person (see the article on MultiPos).

To be successful, we need to adopt a new perspective focused on human needs and benefits, rather than on specific technologies. The message, MST goes human, has a double meaning to professionals involved in MST development or application since all of us are potential customers. The possibility of playing on both sides of the arena adds a new dimension, and new challenges. This is not strange to people living in scarcely populated regions, like the Nordic area. We are historically accustomed to act on our own, and to take responsibility. It means taking risks, and showing "stickability" (word borrowed by a British commentator to describe the success of the Swedish soccer team during the World Championship 1994). We need people like André Alm who turn a severe handicap into an asset, and combine creativity with competence and perseverance. It is also time to go from words to action.

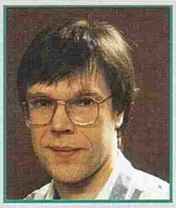
Bertil Hök, Guest Editor

CONTENTS

EDITOR'S NOTE

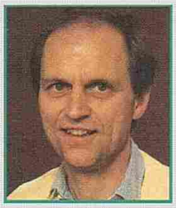
This issue covers the medical field, an arena that show great potential for benefit from MST via new possibilities and more economical solutions. I would like to thank Bertil Hök for his valuable assistance as guest editor in selecting and preparing the material. Suggestions for topics for future dedicated issues are always welcome.

By now, most of you should have received an invitation to *Micro Structure Workshop (MSW)*. The quality of the program depends on you, so make certain to contribute by submitting abstracts.



Jan Söderkvist
Editor-in-Chief

It is my privilege to appear as Guest Editor of this issue of *Micro Structure Bulletin* which is dedicated to MST applications in the health care sector. I decided to pinpoint a few R&D activities in Sweden that could illustrate the MST potential in medicine and health care. I tried to maintain the user's perspective rather than the technological view. The responsibility for the choice of subjects is entirely mine. If you have comments, please call me or Jan as there may be time and space in future *MSB* issues for additions or corrections.



Bertil Hök
Guest Editor

A Physician's Perspective

I am honored in being asked to discuss how MST applications could impact patient care. Some of the technologies previewed in this issue have the potential to be truly revolutionary. One example is the neuro-electronic interface which may someday be used to allow movement for those paralyzed from nerve injuries or with amputated limbs. With many other innovations, the potential benefit to patients is substantial, but less obvious. Space only permits comments on a few of these projects.

Continuous arterial oxygenation measurement by pulse oximetry is an excellent example of the positive impact that MST can have on patient welfare. Prior to pulse oximeters, arterial oxygenation was determined by a painful and technically difficult needle stick of the radial artery in the wrist. Often, several attempts were necessary, particularly in small children. Today, a nurse simply tapes the light sensor onto the child's finger or toe, avoiding the need for arterial puncture in almost all cases. In addition to being more humane, patient care is enhanced by the ability to make continuous measurements.

Hydrocephalus is a common birth defect, often caused by blockage of cerebrospinal fluid flow. The resulting increased intracranial pressure is surgically treated by the placement of a shunt between one lateral ventricle of the brain and the abdomen or heart. These shunts frequently become blocked at a later date, requiring surgical replacement. The symptoms of a blocked shunt begin with headache and vomiting, and can rapidly proceed to coma and death. Those readers who are parents will note that these early symptoms are very common in children. In practice, expensive and potentially dangerous diagnostic procedures to determine whether the shunt is blocked are frequently performed. On the other hand, in true shunt blockage, a life-threatening condition, diagnosis is often dangerously delayed.

The unplugged pressure sensor has the potential to change this. If the sensor could be placed intracranially at the time of shunt placement, thereafter a simple pressure measurement would immediately determine the status of the shunt. Perhaps a parent could simply turn on a home pressure monitor whenever their child becomes ill, notifying the physician only if the monitor instructed him/her so.

In addition to being a leading cause of death, diabetes is a frequent cause of blindness and loss of limb. Many of you reading this article will someday suffer from it. Current best therapy consists of finger sticks for glucose monitoring and insulin injections prior to each meal. This therapy is very demanding on patients, and only delays the complications. An implantable glucose sensor attached to an insulin reservoir could potentially serve as an artificial pancreas and be a highly effective treatment. A successful device undoubtedly would be cost effective via a reduction in hospitalizations and lost productivity.

I wish to congratulate the efforts completed thus far and to inspire more research and development on MST applications in health care. The potential to improve individual's lives and the market are both great.

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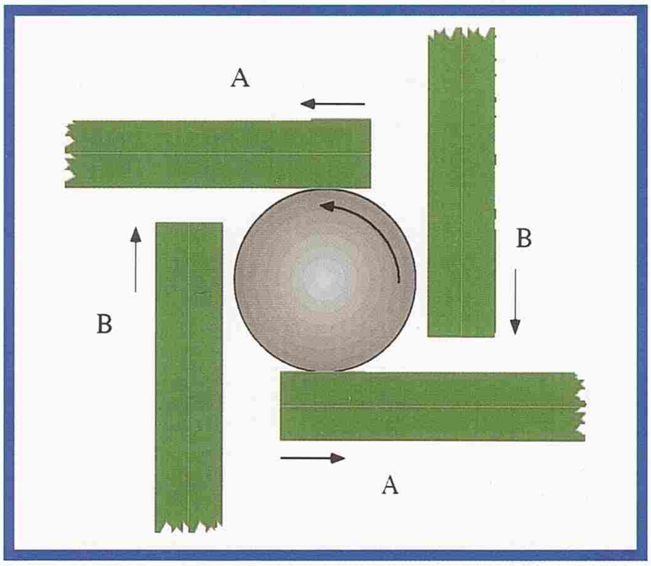
Piezomotor: Small and Strong

Most medical MST devices demonstrated to date are sensors or sensor subsystems used predominantly for patient diagnosis or monitoring. What about therapy? Obviously, there should be a future position for MST devices in areas such as microsurgery, drug delivery, and tissue removal. The microtools needed in these application areas should be capable of cutting, drilling or machining in both soft and hard tissues. Small dimensions are required in order to minimize potential complications.

Therefore, there is a need for actuators with maximal performance in terms of delivered mechanical power per unit weight or volume. Stefan Johansson and co-workers at the Department of Materials Science, Uppsala University, identified this need early and set out to investigate possible solutions. Shape memory alloys (SMA) capable of large changes in shape (up to 5% strain due to thermal transformation from one structural phase to another) were considered. But like other phase transforming actuator principles, SMA actuators have relatively slow response due to the thermal effects involved. The main drawback of these actuator principles is slow response due to the involvement of thermal effects. Furthermore, aging effects and overall reliability could be questioned.

Piezoelectric ceramics, such as PZT (lead zirconate titanate), are limited to strain levels of approximately 0.1 %. On the other hand, these materials can operate at MHz bandwidth, as evidenced by their use in ultrasonic transmitters. Using the inch-worm principle of gripping, actuating and releasing in rapid sequence, Japanese researchers have demonstrated linearly operating "ultrasonic motors".

Mats Bexell and Stefan Johansson recently reported (a "Late News" contribution at the *Transducers '95 • Eurosensors IX* conference, abstract No 528) a rotary inch-worm-type motor having a diameter of 4 mm and an operating torque of 175 μNm, which is a factor of 15 higher than any previously reported micromotor. The Uppsala micromotor could offer a new possible building block for microtools in medical applications.



Driving principle for the rotary inch-worm micromotor. The PZT bimorph pairs A anb B alternate in rotating the rotor.

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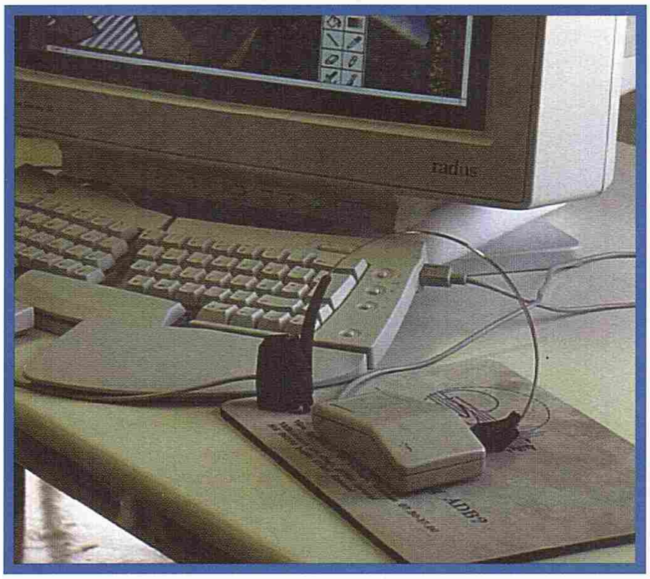
MultiPos – the Touch-Free Mouse


The MultiPos mouse is to be positioned over the ear of the user.

To operate a standard "mouse" you must have one hand with many motor and sensory functions intact. Most of us can live with this restriction. But to some people, like André Alm, it is never the case. Therefore, André and his colleague Erik Carlsson, created *MultiPos*, the touch-free mouse, based on head movements to move the cursor and pulses of air to execute the 'click' function.

MultiPos contains two miniature gyros which measure the angular velocity of the head with respect to two orthogonal axes. The linear movements of a conventional mouse on a planar surface thus correspond to rotational "yes" and "no" movements of the head. The gyros used in the prototype version are hybrid sensors commercially available from Murata Engineering, Japan. Their performances are still not entirely satisfactory. Besides relatively high cost and large volume and weight, a substantial drift must be compensated.

However, the development of integrated gyros is rapid. In the near future, the *MultiPos* may be equipped with gyros that will make its performance comparable with the conventional mice. Micromachined angular rate sensors (gyros) that may be suitable for *MultiPos* will be described in future articles of *MSB*.

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STRATEGIC CENTER

A proposal to the Foundation for Strategic Research was recently filed by Uppsala University. The aim is to become an international leader in the cross-disciplinary fields of MST, thin film processing, and functional surfaces. A graduate school is a key ingredient of The Center.

Participating research groups are Materials Science, Electronics, Inorganic Chemistry, and Solid State Physics. Fully operational, the Strategic Center will engage some 12 senior researchers and 40 graduate students, in addition to guest researchers, industry-funded personnel, etc.

The Center is complemented by the Nutek-financed competence center for Surface and Microstructure Technology (*SUMMIT*) that was described in MSB 94:4.

MME '95

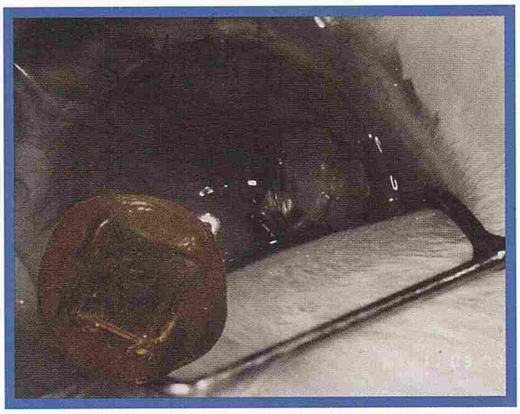
The 6th MicroMechanics Europe was a success with almost 100 participants. Eight invited and 52 poster presentations covered areas such as materials and processing technologies, system considerations, modeling and characterization, and industrial concerns. The informal atmosphere in Copenhagen was further enhanced by a workshop dinner at Tivoli Gardens.

Two posters were awarded for best scientific content and presentation, both from Sweden: "Terracing of (100)-Si ..." (UU) and "A valve-less planar pump ..." (KTH).

The chairmanship of *MME* was handed over after three successful years from Prof. B. Puers, Belgium, to Prof. Per Øhlckers, Norway.

MST Chips May Be Unplugged ...

Medical technology is expanding from the operating theaters and intensive care units, to conventional hosptial beds, and home care. There is a great potential for new sensors in the diagnostics and monitoring of patients, but the requirements are difficult. The sensors should be small, non-invasive, non-contacting, biocompatible, rugged, user-friendly, and fail-proof. They must also be inexpensive as the days of an ever-expanding health care sector are over.



The unplugged sensor chip implanted in a rabbit eye during an in vivo *experiment. The insert shows the prototype sensor with the pressure sensitive capacitor in the center, and the microcoil wound around the plastic fixture.*

Principle

The unplugged sensor chip could be one solution to this problem. Using light, ultrasound, or radio waves for wireless communication and power supply, the sensor could be taped to the patient's skin or implanted under it, allowing him/her to move freely between measurements. Sounds like science fiction? Unplugged electronic chips are already in industrial and military use for identification and counting. The new Uppsala company Pricer is actually based on the concept of the unplugged chip for price marking in department stores.

Lars Rosengren and Pelle Rangsten, Electronics Department, Uppsala University, are developing an unplugged pressure sensor chip for measuring intraocular and intracranial pressures. The silicon sensor chip consists of a capacitive microsensor, with a thin diaphragm deflecting over a vacuum cavity sealed by Si-Si direct bonding. The capacitive element together with a microcoil forms a passive LC resonator, with a resonance frequency depending on the ambient pressure. The resonance can be detected by another coil, which is located nearby.

Applications

The unplugged pressure sensor is believed to be a viable concept for the monitoring of patients suffering from glaucoma. This disease is one of the most common causes of acquired blindness and is caused by improper drainage of fluid within the eye. It can be treated either by surgery or drug treatment, but the present methods for diagnostics and follow-up are either imprecise or invasive for the patient.

In a similar fashion, a pressure sensor implanted in the skull could monitor intracranial pressure. Applications include the monitoring of children with non-communicating hydrocephalus, caused by an analogous blockage of intracranial fluid drainage, or victims of head trauma with swelling of the brain.

This research project was initiated by Dr. Björn Svedbergh, Department of Ophthalmology, Uppsala University Hospital, and is now entering an industrial development phase.

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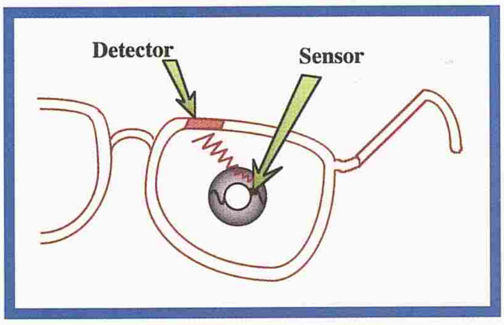

A schematic picture of the intraocular pressure mesuring system. The sensor is implanted in the eye, fixed to an intraocular lens. The resonance frequency, and hence the pressure, is detected by an outside coil, located in a spectacle frame.

... or Plugged Into the Neural World

Implanted microdevices can also interact in a more complex fashion with the living organism. One example is the artificial cochlea which mimics the auditory sensor of the ear. Acoustic signals are transformed into coded nerve impulses for interpretation by the auditory center of the brain. Another example is the control of artificial limbs and other prostheses. In this case, both sensory and motor nerves should be interconnected in a complex network.

Researchers at the Department of Electrical Measurements and Solid-State Physics, Lund University, Sweden, in cooperation with neurologists at Malmö University Hospital, have designed a silicon chip with the capability of functioning as an interface with nerve cells. The chip has the shape of a sieve which can be placed between the cut endings of a nerve bundle. As the nerve bundle heals, the individual neurons grow and reconnect through the holes of the sieve. The electric potential of each nerve fiber is capacitively coupled to doped regions on the chip. Interconnections between these regions provide access to individual holes, or groups of holes. The holes are defined by anisotropic etching, and can have a size of between 10 to 100 µm in all three dimensions.

The sieve-shaped silicon chip thus forms a simple electronic "plug," or interface, to the neural network, allowing signals to pass in either direction. Experiments carried out so far indicate that the sciatic nerve of the rat can revover up to 50% of its original capacity after sectioning and chip implantation. The initial results concerning biocompatibility are also promising.

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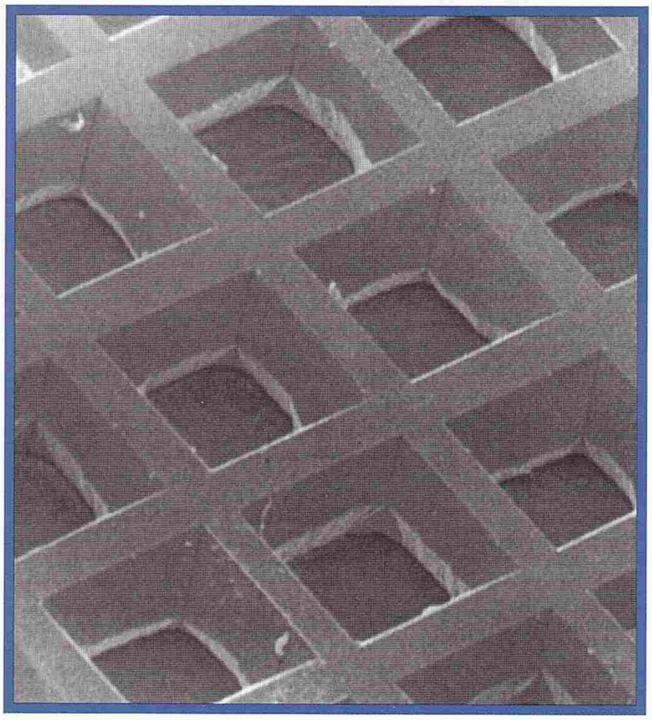

Microelectronic plug to neural networks: A sieve-shaped silicon chip forms the electronic interface to a cut section of a nerve, where the neurons reconnect through the holes of the sieve.

Sweet, Sweet Sensors

Diabetes is one of the most common chronic diseases, striking a large portion of the population. Many diabetics must monitor their blood sugar, or glucose, level on a continuous basis in order to accurately adjust the dose of insulin given. Despite a tremendous R&D effort, this sensor problem is still not solved in an entirely satisfactory way.

Thomas Laurell, Department of Electrical Measurements, Lund University, Sweden, presented an interesting approach to this problem in his Ph.D. thesis which was defended in May of this year. Laurell's sensor consists of a thin microdialysis fiber which is inserted under the skin. The interior of the microdialysis fiber is connected to a micropump and a glucose sensor. Small molecules, like glucose, diffuse across the fiber walls, and if the pump rate is slower than the diffusion rate, the glucose concentration inside the sensor will be approximately equal with that of the blood.

The actual glucose sensor is based on an immobilized enzyme, glucose oxidase, which is a highly selective catalyst for the oxidation of glucose. The consumption of oxygen by the enzyme is the primary variable being measured using a classical Clark electrode. The enzyme reaction chamber is micromachined in silicon technology. One solution uses vertical walls created by anisotropic etching to increase the active surface area, and another solution is based on porous silicon.

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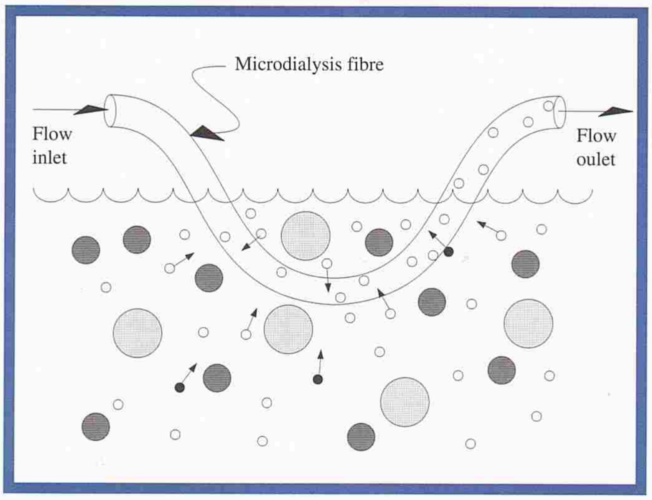


Principle of the glucose sensor based on a microdialysis fiber.

Fibers to Fingers

In 1974, T. Aoyagi, an employee of the Japanese company Nihon Kohden, patented the basic principle of pulse oximetry. Commercialized in the early 80's by the U.S. company Nellcor, Inc., Aoyagi's invention is now a cornerstone of patient monitoring. Pulse oximeters measure the oxygenation of arterial blood, a variable of vital importance. The technique is noninvasive and does not require any calibration.

A pulse oximetry sensor consists of a clamp for illuminating a finger at two wavelength bands, centered at 660 nm (red) and 940 nm (near IR), respectively. A silicon photodiode is used for detecting the transmitted light through the finger. The ratio between the signal due to the volume pulsations of the finger and the DC signal is computed at both wavelength bands, and the ratio between these values is a monotonous function of the oxygen saturation. This function is based on the difference in the absorption characteristics of hemoglobin in the oxygenated and deoxygenated states. Extensive clinical experience has verified the reliability of this relationship despite interfering factors, such as skin pigmentation.

Since pulse oximetry is based on an optical principle, it would seem ideal in hazardous and noisy environments, such as during magnetic resonance imaging (MRI). The fiberoptic sensor, *SafeSAT*, uses bundles of fibers having a diameter of 40 µm for signal transmission. The fiber diameter gives increased bending flexibility, which is important both for the mechanical and optical functions of the sensor. *SafeSAT* is the result of cooperation between two Nordic companies, Datex, Finland, one of the larger worldwide suppliers of patient monitoring equipment, and Hök Instrument, Västerås, Sweden.

Bertil Hök

It bites but it doesn't hurt: Ordinary pulse oximetry sensors with electrical leads have caused burn injuries in the MRI environment due to induced currents. The fiberoptic sensor, SafeSAT, eliminates these problems.

Smaller Than Smallest

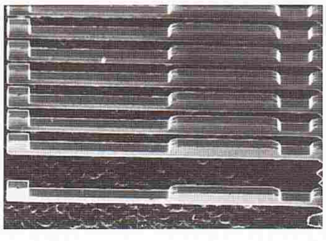
Introduced on the market four years ago by Radi Medical Systems AB, Uppsala, *Pressure Guide .018"* has been the smallest commercially available pressure sensor. The sensor has a micromachined silicon sensor element mounted at the end of a guidewire, and uses fiberoptic signal transmission (see MSB 93:1).

The guidewire is inserted into a catheter and the tip is brought to the point of interest, e.g. the coronary arteries of the heart, using X-ray guidance combined with "plumber's skill."

By measuring the pressure upstream and downstream of an obstructed region of an artery, it is possible to assess the significance of the obstruction. In fact, by using *Pressure Guide*, clinical researchers have been able to verify the superiority of using a single variable in evaluating atherosclerotic diseases: the fractional flow reserve, which is approximately equal to the ratio between these two pressures.

This autumn, Radi is launching *Pressure Guide .014"*, a still smaller sensor, having an outer diameter of only 0.36 mm. The silicon elements used for the *Pressure Guide* sensors are manufactured in the semiconductor laboratory of Uppsala University on a contract basis for Radi. The new structure is the result of cooperation between Carola Strandman, Uppsala University, and Lars Tenerz and Leif Smith at Radi.

The *Pressure Guide* sensor consists of a number of microparts, assembled in a high-precision semiautomatic production line. Each assembly step needs to be carefully monitored to ensure the highest possible quality. The personnel responsible for this production need to be highly qualified and motivated. Development and maintenance of a production line of microstructures is perhaps the most challenging task in the future evolution of MST.



The sensor elements of Pressure Guide form a comb structure from which they are dismounted and assembled to the individual sensors.

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@-LIST

Want to reach those in Scandinavia interested in or working with MST? An E-mail list with 'aliases' for each country (DK, FIN, N, S) will be created at Uppsala University if the interest is large enough.

The creation of the list depends on your participation. So, please mail me an alias containing the MST-interested people at your location. As an example, the alias for the micromechanics people at Uppsala University is mikromek@teknikum.uu.se. The alternative that you mail me your local addresses has limitations from the updating point of view.

Jan Söderkvist
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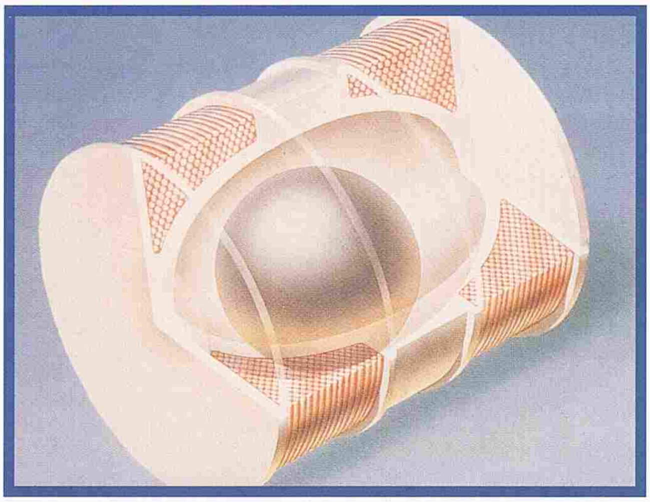
Pacesetting Sensor

The pacemaker, invented by Dr. Rune Elmqvist and introduced by the company Elema-Schönander, Solna, Sweden, in the 50's, is one of few microelectronic therapeutic products. The original pacemakers had a constant pulse frequency, with no response to patient's level of activity.

Modern pacemakers are equipped with activity sensors which are mostly based on inertia by responding to body movements. Pacesetter AB, Solna, successor of Elema-Schönander, has recently introduced an innovative design using a small magnetic ball having a diameter of 1.5 mm. The ball consists of two counteracting dipole permanent magnets, thereby generating an approximate quadrupole field. It is moveable within an ellipsoidal enclosure, and the magnetic field variations due to the movements generate a small current in an enclosing pickup coil.



Activity sensor used for modulating the pulse rate of pacemakers. The sensor coil picks up a current induced by movements of a small permanent magnet generating a quadrupole field.

Using an electromagnetic principle means that the sensor itself has no power consumption, an evident advantage in an implantable device. The quadrupole configuration means minimal sensitivity to external magnetic fields.

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PUBLICATIONS

Some MST-related results published during the last months:

- Micromachined Medical and Chemical Sensor Structures; J. Drott (LTH); Licentiate thesis, ISRN LUTEDX/ TEEM — 1058—SE.
- One Approach Towards the Fabrication of a Microrobot System; S. Johansson (UU); *Materials Science & Engineering* C2 (1995) 141–149.
- Phenomenology of Silicon Wafer Bonding; K. Ljungberg (UU); Doctoral thesis, Acta Univ. Ups. 166, ISBN 91-554-3633-1.
- Surface Induced Effects in Long Narrow Channels; P. Norberg (LiU); Licentiate thesis, Linköping Studies in Sci. and Tech. #505, ISBN 91-7871-588-1.

Dissertations

MSB wishes to congratulate the following three individuals on successfully having reached the point in research when the time has come to summarize and present their work.

Karin Ljungberg, UU

On November 24, K. Ljungberg will present her Doctoral Thesis: Phenomenology of Silicon Wafer Bonding.

Wafer bonding is a versatile technique both for microelectronic and micromechanical applications, to form joints between materials and for Silicon-On-Insulator (SOI) materials.

The present thesis concerns fundamental phenomenological aspects of direct bonding of Si surfaces, particularly the influence of surface chemical and morphological properties. The main focus is on the bonding of bare, hydrophobic Si surfaces, which is interesting as an alternative to epitaxial layers, as well as for the formation of very abrupt junctions.

Based on experimental results, a model for the hydrophobic bonding mechanism is proposed. It is argued that the initial room temperature bonding of bare Si surfaces is caused by van der Waals forces between the H-terminated surfaces.

Buried conductive layers of $CoSi_2$ were formed in silicon, by bonding of silicon wafers with a Co intermediate layer. Buried conductors are of interest in, for instance, certain electronic devices and electrical interconnections.

The thesis comprises an introductory chapter on silicon surface properties and an overview of the wafer bonding technique.

Petronella Norberg, LiU

On September 19, P. Norberg presented her Licentiate Thesis: Surface Induced Effects in Long Narrow Channels.

Gas flow in long (5 cm) narrow (100 nm) silicon-quartz channels was investigated with a mass spectrometric system. Due to the extreme length to depth ratio, which promotes gas molecule-surface interaction, the observed flow differed from what would be expected for a purely molecular flow. The thesis presents these findings as well as a model for some of the findings. A preliminary study of catalytic reactions in a channel, whose walls were covered with a 10 Å Pt-layer, is also discussed.

Johan Drott, LTH

On November 17, J. Drott will present his Licentiate Thesis: *Micromachined Medical and Chemical Sensor Structures.*

This thesis reports on two methods to microstructure silicon in order to achieve a surface enlarging structure for enzyme coupling. The activity of enzyme reactors comprising deep vertical trenches etched in (110) silicon is scrutinized. The surface enlarging structure of porous silicon for enzyme coupling is also investigated.

Furthermore, the thesis reports on peripheral neural fibers reconnecting through via-holes in a silicon membrane. The effect of different hole geometry is studied.

POSTTIDNING B

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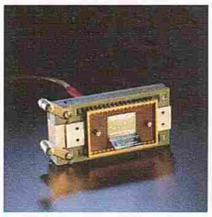
MICRO STRUCTURE BULLETIN NO.4 NOV 1995

NEXT ISSUE

Some topics covered will be:

- MST at Industrial Microelectronics Center (IMC)
- Excitation methods
- Photo-acoustic gas sensor



MSW '96
Call for Contributions

The second Scandinavian Micro Structure Workshop will be held in Uppsala on March 26–27, 1996. The purpose of *MSW* is to stimulate the use of Micro Structure Technology and to bring together informally those interested in MST. In order to create an information exchange, your contributions are requested.

A short abstract describing your contribution should be sent to Jan Söderkvist before December 31. The official languages are "Scandinavian" and English.

Invited speakers are: Matthias Müllenborn (MIC, Denmark) and Martin Nese (SINTEF, Norway), in addition to a European keynote speaker.

For more information, please contact Jan Söderkvist (Fax and address listed in the editorial column). The complete program will be sent out in mid-January.

MSB subscription (✉ or ✂)?

Micro Structure Bulletin is distributed free of charge within Scandinavia and to a limited number of international experts. Please contact the Editor-in-Chief if you wish to receive a personal copy of *MSB* on a regular basis, or if your address label is incorrect. In response, a ✉-sign will be included on your address label.

A ✂-sign on your address label means that there is a 20% risk for each issue of you being removed from the mailing list.

The editors also encourage you to put *MSB* on circulation.

FUTURE EVENTS

Materials for Microstructures (course), Uppsala, Sweden, Dec. 5–6, 1995. For information contact: FSRM, Fax: +41-38 200 990, or Jan Söderkvist, Fax: +46-(0)8-510 116 15.

Mikromekanik och Mikrosystem (course for teachers, in Swedish), Uppsala, Sweden, Feb. 2–3, 1996, For information contact: Kurssekretariatet, Uppsala University, Fax: +46-(0)18-55 84 05.

MEMS '96 (Micro Electro Mechanical Systems), San Diego, U.S.A., Feb. 11–15, 1996. For information contact: Preferred Meeting Management Inc., Fax: +1-(619) 298 3459.

MSW '96 (Micro Structure Workshop), Uppsala, Sweden, March 26–27, 1996. See separate note.

Actuator 96, Bremen, Germany, June 19–21, 1996. For information contact: Dr. H. Borgmann, Fax: +49-421-17 16 86.

Eurosensors X, Leuven, Belgium, September 8–11, 1996. *Abstract deadline: March 15, 1996.* For information contact: Timshel Conference Consultancy & Management, Fax: +32-16-29 05 10.

MME '96 (MicroMechanics Europe), Barcelona, Spain, October 21–22, 1996 (preliminary). For information contact: Dr. J.R. Morante, Fax: +34-3-402 11 48.

THE AIM OF the *Micro Structure Bulletin* is to promote micromechanics and micro structure technology. It constitutes one part of Uppsala University's effort to share scientific and technological information.

MSB is published quarterly and is distributed free of charge. Deadline for contributions to the next issue is January 1, 1996.

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