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Contents

This report comprises Acreo's activities during the period January 2000 to June 2001.

Hans Hentzell
President ACREO

A time of dynamic consolidation

Since the merger between the Institute of Optical Research - IOF - and IMC - Industrial Microelectronics Center - in 1999, Acreo has established itself as a key player in the Swedish innovations system and a competent partner in national and international R&D projects.

The Acreo business idea states that "Acreo refines and transfers research results into industrially viable products and processes in the fields of electronics and optics", thus contributing to increased industrial competitiveness, growth, and entrepreneurship. Our business idea focuses on the market aspect, i.e. what scientific results can be commercialised and the time to bring them from just an idea to a usable technology. This focus has been very successful and Acreo has attracted a lot of new industrial partners.

In the year 2000 Acreo has:

- increased its turnover by 11% to 146 mkr.
- expanded its number of employees by 12% to 142,
- participated in 110 projects with 185 customers (comment: Some projects have several participating customers)
- started its new division for system on a chip design – Socware in Norrköping
- decided to establish a laboratory for development of optical fibre components in Hudiksvall.
- invested 25 mkr. in laboratories and instruments
- become a part owner in 3 new start-up companies.

Given our focus, our main objectives are to:

- be a leading player in R&D in the science and technology of specific areas of electronics, optics and MEMS.
- actively work to develop and transfer results and experiences to existing industry, and
- actively work to commercialise results together with new or existing companies

Our strength is the group of people with the biggest emotional stake in the future – our young and well trained co-workers working together with experienced people – this gives us the driving force and the steering capability. Year 2000 more than 20 employees left Acreo to start working for start-up companies surrounding Acreo.

For the future I foresee an increased demand for the products and services offered by Acreo and a continuing growth at our main locations in Kista and Norrköping, but also at new locations – Hudiksvall, Lund and Jönköping.

After a number of years with steadily decreasing national Swedish support to R&D driven by technology needs I am very optimistic that Acreo can become a valuable partner in developing a new and growing innovation system in Sweden.

This is indeed a time for dynamic consolidation requiring visions for the future and continuous improvements in how to deliver what our owners, partners and customers expect.

Kista and Norrköping

Hans Hentzell
President

Acreo Board of Directors

Teresita Quinteros
Employee Representative

Mietek Bakowski
Employee Representative

Åsa Claesson
Employee Representative

Ulf Gustafsson
Employee Representative

Örjan Pettersson
SCA Graphic Research AB

Claes Nycander
Telia Research AB

Thomas Lewin
Ericsson Microwave Systems AB

Eva Westberg
Ericsson Corporate Technology AB

Peter Holmstedt
KTH Holding AB

Jan-Olof Andersson
Kitron Development AB

Annika Fridmark
Frikab Produktion AB

Karl-Edward Johansson
Linköping University

Pentti Kölhi
Celsius AB

Hans Malmqvist
Consulting H Malmqvist AB

Leif Bergström, Chairman
Cambio Företagskonsult

Magnus Breidne
Vice President ACREO

Research

for our customers' present and future competetiveness

Between curiosity and production plans: The fact that industry today expects and depends on steady progress in technology makes it a very daunting task to try and fulfil the complex and multi-dimensional vision of Acreo – to take curiosity driven research into the realm of industrial commercialisation.

Andrew Odlyzko at Bell Labs said a couple of years ago that "The idea of rapid technological progress is deeply embedded in the minds of managers in high-tech areas". However, the steady progress in science and technology affects more than their expectations This progress means that in order to have an impact on the world of technology the requirements on Acreo's researchers is steadily growing. In a world of rapid change what looks like an important improvement might only be a couple of months along the technology curve. (Take for instance micro-electronics, where microprocessors make 100% improvements every 18 months – an improvement of 25% in just 6 months !).

Hence the research team which has an innovative way to increase capacity, speed or efficiency into a specific product or process has to know how to incorporate this progress into all the other systems without delaying the project more than, say 6 months. The Acreo researchers know that radically new ideas always have to compete against the persistent progress of other technologies.

Another aspect of what has been said above is that when a high-tech manager considers the rare breakthroughs that curiosity-driven research provides, the steady progress of planned research, such as that done at Acreo, looks more appealing.

Acreo's strategic research plan

So, how does Acreo look on future technological trends ? In which areas do we want to be at the leading-edge of technology. What do our different road-maps look like ? Below you will find the list of the research areas to which we give pre-eminence (in order to see our road-maps you have to join the exclusive group of Acreo's Partner companies – FMOF !).

- System-on-a-chip
- Optoelectronic components for the information highway
- Intelligent vehicles
- Micro-electronics and optical devices in biotechnology
- Organic information technology
- Electronic production technology

In these areas Acreo will not only do contract research, but also participate in the broad programs initiated by the Swedish research organisations Strategic Research Foundation and Vinnova, as well as by the European Community.

Owning the future

An important aspect of research is the ownership of the result generated. Acreo has put a lot of effort into securing an efficient patent process – a process that both tries to stimulate the innovativeness of our researchers and to make an in-depth analysis of the chances of commercialisation of the proposed ideas. This process is continuously monitored and will no doubt be further improved to enable our customers to improve their competitiveness.

steps of fabrication of MQW SLM
dulator structure
ated spectrum of a test structure

Industrial infrastructure for the future

During the last few years a great number of new companies have been formed, which focus on fiber optical communication in the Stockholm area, and microelectronic IC and subsystems in Norrköping-Linköping.

Acreo, together with the Royal Institute of Technology (KTH) and Linköping Institute of Technology and existing companies like Ericsson and Telia, are the core base of these new and emerging clusters that are being formed. Based on Acreo's focus and commitment to the future we foresee that these clusters will grow and become stronger. Two emerging clusters are biotechnology and organic informatics.

Companies in the clusters are divided into two groups; direct spin-off companies and new starters that depend on Acreo and our laboratory resources.

Stockholm and Kista

Spin-off companies
- **ADC-Altitun**: tunable lasers
- **Proximion**: supervision of fiber optical networks
- **Silex**: production of micromechanical systems
- **Gnotis**: development of DNA-analysers
- **Inpact Microsystems**: custom design of system in a package

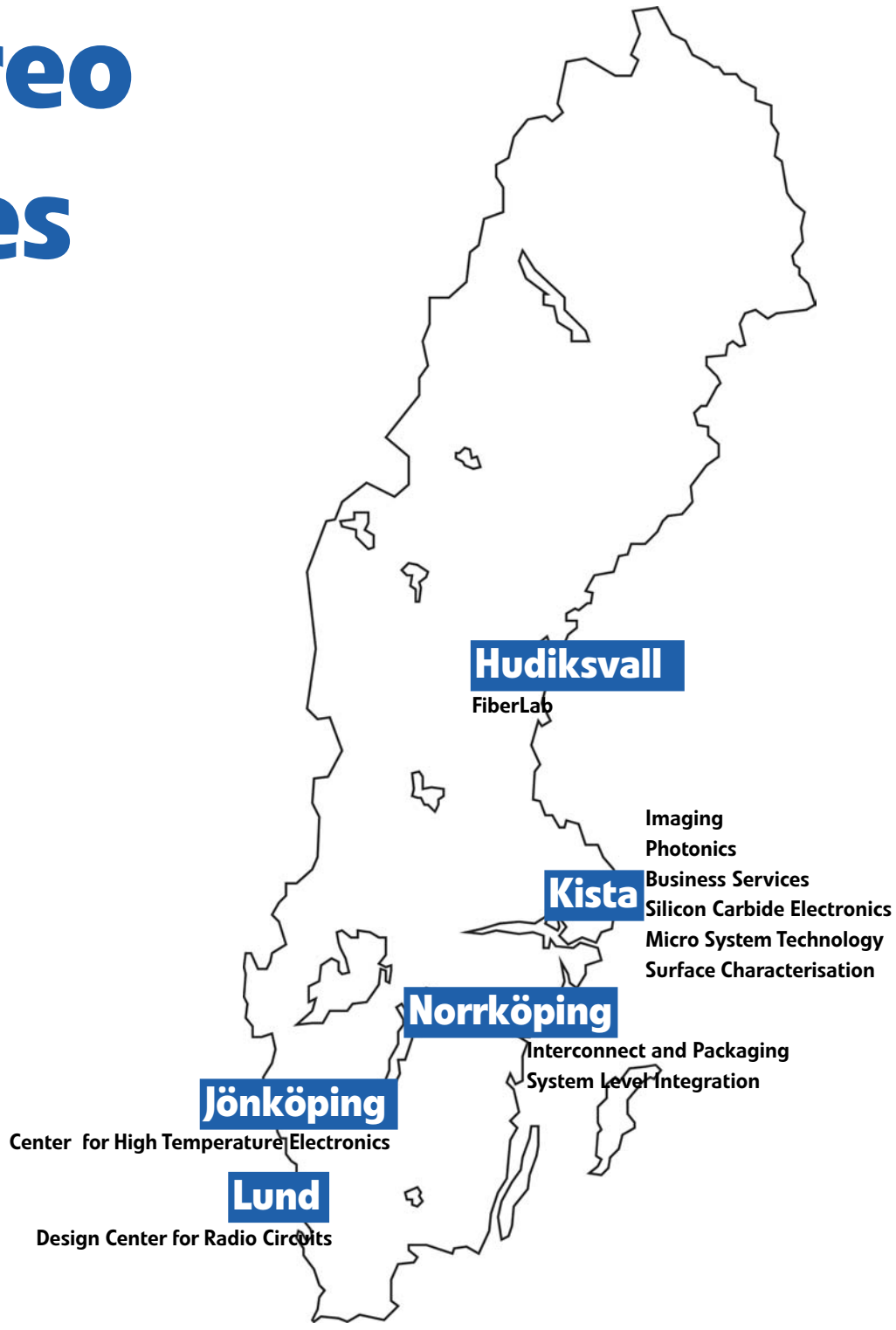
Companies depending on the Acreo/KTH laboratories
- **Optillion**: fiber optic Ethernet tranceivers
- **Comlase**: pumplasers for optical networks
- **Cobolt**: development of crystals for lasers

Norrköping-Linköping

Spin-off companies
- **Swedish Gate Arrays – SGA:** application specific integrated circuits
- **Strand Interconnect:** design of thin film substrates for MCM
- **Bluetronics**: radio modules for wireless electronics

Companies depending on Acreo and Acreo's laboratories
- **Thin Film Electronics:** development of mass memories based on thin film technology

Acreo Sites


Hudiksvall
FiberLab
Kista
Imaging
Photonics
Business Services
Silicon Carbide Electronics
Micro System Technology
Surface Characterisation
Norrköping
Interconnect and Packaging
System Level Integration
Jönköping
Center for High Temperature Electronics
Lund
Design Center for Radio Circuits

"SMEs which are willing to learn and adapt new technology will be the basis for future Swedish industry."

Ove Berkefelt

Acreo´s main objective is to to create growth and increase profitability among especially small and medium-sized companies, SMEs. Acreo´s actions in this respect is to provide new and adequate technology as well as market information.

Technology transfer, training, contact networks and market needs are key factors for Acreo´s support to SMEs. Increased competence, improved products, new partner relations and better market focus are the objectives of Acreo´s contacts with SMEs. Annually Acreo supports some 300 SMEs, all of them benefitting from one or more of the support projects that Acreo operate

TeknIQ

TeknIQ aims at educating SMEs to use embedded systems. Target companies are technology oriented SMEs, but without previous R&D competence in electronics. TeknIQ is managed by Acreo's in cooperation with Mälardalens Högskola. Acreo's specific task in the project is to manage and coordinate SME contacts and projects. For the year 2000, 230 companies have been contacted, of which 75 have participated in comprehensive courses in embedded systems.

Innovation Relay Center

Innovation Relay Center, IRC, is a European network for technology exchange. The network comprises 68 centers in EU member states and 15 other non-member states within and surrounding the EU. Sweden houses three IRC- centres. Each centre is a consortium with several partners covering a specific region. Examples of services that the centres offer to SMEs are the import of new European technoloy, the export of new Swedish technology, advice on innovation strategies and exploitation of research results.

Fuse and Swedish Fuse

The European project FUSE (First USEr action) aimed at introducing new electronic technologies to SME's in their existing products. During the course of the program, 19 companies took part in it and developed their products. It was considered so successful that by the end of December 1999 it was followed by a Swedish counterpart, financed by Vinnova/Nutek, in full operation during 2000. One of a total of four projects has been carried out in conjunction with education from TeknIQ.

Pilot

The Pilot program has been in operation since 1995. This program is a door-opener to other programs. It includes pre-studies for companies who want to know if a certain technology is appropriate for their products and organisation. It also includes analyses of the company organisation. Hereby, it is possible to advise a company on its weak points and also how to correct these weaknesses. A good example was to advise a company to sell the contract manufacture and thereby focus in other directions which finally led to a more efficient organisation and increased profit.

During the year 2000, 24 pre-studies and five company analyses have been carried out.

Customers and financing

Imsys AB, Unfors AB, Sordin AB, Assalub AB, Vinnova, EU, The Knowledge Foundation

"Cheap Uncooled Infrared Technology will have great impact on our daily lives in the near future. For example night vision for cars should make driving at night safer and more fun too"

Jan Andersson

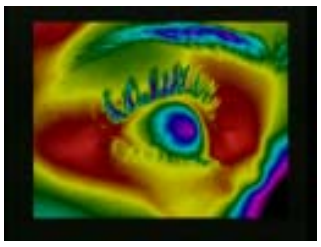
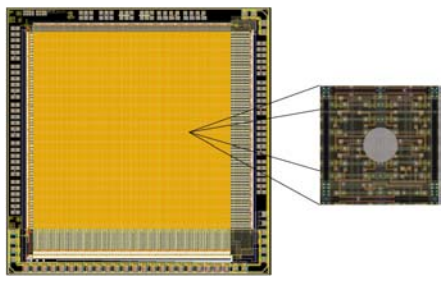


Image of a human eye obtained by a QWIP camera

Imaging

128x128 pixels integrated circuit driver (including zoom on one pixel) intended for Acreo's MQW-SLM



Customers and financing

FLIR Systems, FMV, Saab, Ericsson, Photonyx, Telia Research, Autoliv, SEMKO, TCO

The well-known proverb "An image is worth a thousand words" is something that we take very seriously.

The mission of the Imaging Department is to conduct contract research, development and small scale production within the field of imaging, comprising technology for detection, processing and presentation of image information.

Our business concept is based on worldwide expectations that electronic imaging will become a next major technology to exploit on a worldwide basis, driven by, for example, computer based multimedia and the Internet, the automotive industry, and medicine. US market consultants Frost&Sullivan and Maxtech expect a yearly market growth of up to 40% in the sector for the next five years.

Our core competences include imaging sensor technology, detector physics, CMOS circuit design, optically based information processing, as well as image quality and visual ergonomy of computer displays. Among the numerous applications are night vision for the automotive and defence field, medicine, computer and multimedia technologies. Our business has developed very positively in the course of the year 2000. The department is subdivided into two groups, EIT – Emerging Imaging Technology, and QWIP Technology.

The infrared detector business based on 8-9µm wavelength - Quantum Well Infrared Photodetector (QWIP) has expanded extensively and includes a well functioning detector production. The detector (320x240 and 640x480 pixels) is an example of advanced nanotechnology, and is based on the creation of an artificial small bandgap in aluminum-gallium arsenide/gallium arsenide quantum well structures. New development involves detector arrays for shorter wavelengths (4-5.5 µm). So far high resolution arrays with excellent performance have been demonstrated.

Internationally there is an extensive interest in *uncooled infrared technology*, or more specifically *microbolometer technology*. This has motivated the Swedish Foundation for Strategic Research (SSF) to increase the research activities within the field at Acreo and our partners KTH and FOI in the project. Microbolometers being thermal detectors, have the advantage of not requiring any cooling to liquid nitrogen temperatures, and may operate at room temperature. As a consequence the production cost of a camera system decreases considerably, especially for high volume production.

A new expansive field is that of *SLMs* or *Spatial Light Modulators,* which is another example of advanced nanotechnology. The project is financed by the Knowledge foundation and the industry. SLMs are pixellated devices similarly to detector arrays, with the difference that every single pixel acts as an individually controlled light modulator. In general, SLMs have many fields of application, such as for computer displays (liquid crystal displays is an example), optical information processing, and telecom. Due to our customers' requirements we work with the so-called MQW (multiple quantum well) types of SLMs. Speeds in the GHz range have been demonstrated here. The MQW-SLMs are fabricated in a similar way to the above-mentioned QWIPs. The modulating action results from the fact that the absorption spectrum of the structure depends on the applied electric field. The modulator action has been experimentally demonstrated and CMOS driver circuits have been designed at Acreo, fabricated at an external foundry, and then been characterized by us.

Optical correlator technology for machine vision and more specifically searches for objects and patterns in the environment. We have during 2000 demonstrated excellent performance of our correlator.

Image quality and displays is a new research area. A project with SEMKO and TCO as partners has been started. The object is to develop a new standard for computer displays.

Customers and financing

EU, Opticom, PAELLA, EASIT, FOLC, Flipchip, Strand

"Miniatyrization of electronics is one of the stronges forces for industrial growth"
Per Dannetun

Networks are the key to getting new influences and ideas to change existing ideas and technologies. Our mission is to develop and industrialise new ideas and technologies for interconnect and packaging of electronic systems.

Thin Film Electronics

One of the largest projects at the department of Interconnect and Packaging during the year 2000 was the polymer memory project together with Thin Film Electronics (TFE), a company owned by norwegian based Opticom ASA and Intel®. The aim of the project is to develop a new type of memory where a polymeric material is used as the active material. The architecture is all solid state with the active polymer in a sandwich structure between crossing electrodes. This gives an extremely dense memory - a storage capacity far beyond what can be acheived by other solid state memory technologies.

LAP

LAP is the acronym for Low cost Large Area Panel processing of MCM-D substrates and packages. LAP was an ESPRIT project which started in January 1998 with a duration of 3 years, thus ending December 2000.

The objective of the LAP project was to develop and demonstrate a low cost manufacturing technology for MCM-D substrates and packages. The cost target will be met by an optimal choice of materials and processes. Partners in the project have been companies and research institutes from many European countries. By the end of 2000 all essential project goals had been met.

PAELLA

The PAELLA project is a marriage between newly developed electronic materials and established techniques used in paper conversion. Using materials such as conducting polymers, inks and pastes and techniques such as inkjet printing, screen printing and lamination, electronics is applied directly onto the surface of paper or paper products.

During the year 2000 three different areas have been adressed, namely paper displays, sensors, and wireless communication.

COIN

A new center dedicated to R&D in organic and polymer electronics has been established in Norrköping, Sweden. Application areas for COIN are the information-processing, -displaying and -storing technologies. Also, the task for the center is to promote spinning out companies from the area in the field of organic and polymer electronics.

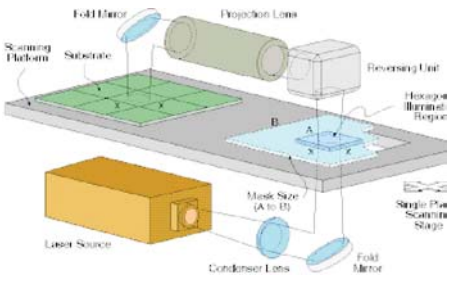
Center for High Temperature Electronics

In order to meet the expanding needs for development of electronics for high temperature applications and other harsh environments like corrosive media and vibration, a Center for High Temperature Electronics was established in Jönköping. The centre is a cooperation between Acreo, the University of Jönköping and relevant industries represented by automotive and aerospace industries.

DONDODEM

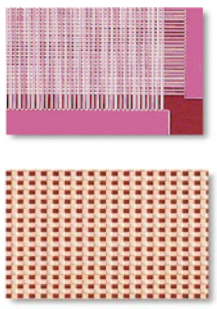
Within the DONDODEM EU-project Acreo has proposed a new concept for low cost & high performance electronics and photonics packaging. Photo patternable ORMOCER™-dielectric and optical materials and the ANVIK large area lithography equipment allows:

1. integrated electrical and optical packaging, even on low cost PCB-substrates,
2. optimized partitioning between base-substrate with standard PCB low density interconnects and added thin films with high density interconnects,
3. to share the processing of several low-volume products on a high-volume platform.



The HexScan™ 2050 SME large-area projection lithography system schematic, showing Anviks seamless scanning technology with variable-area substrate tiling (VAST™).

The images show two different enlargements of a memory matrix where the active polymer is sandwiched between two crossing electrodes



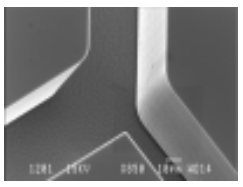
Interconnect and Packaging

"Microsystems open up completely new possibilities in medical and biomedical applications."
Karin Hermansson

Micro System Technology

Micro System Technology (MST) has historically been used mainly for sensor applications such as airbag accelerometers and pressure sensors. Today, MST is used in a variety of applications, telecommunication and biomedical being the fastest growing.

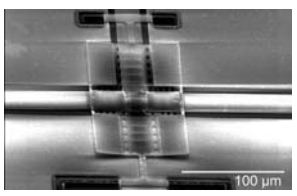
Microstructures for the detection of biomolecules



Close-up of microfluidic channel structure

The KOFUMA project has focused on the development of dedicated microfluidic structures in silicon. The structures have been used for determination of flow behaviour and velocity distribution. The microstructures have been applied to single molecule selection and DNA sequencing. Partners in the project have been medical scientists and industrial companies. Sponsor has been Nutek. The project has resulted in a spin-off company, Gnotis AB.

RF MEMS – Radio Frequency Micro Electro Mechanical Systems



The advantage for using MEMS technology for switches are low loss, high isolation and zero standby power consumption. Acreo has designed and fabricated the first version of RF MEMS switches with promising performance.

Also for other RF devices MEMS is a promising technology due to the possibility to reduce weight, volume, power consumption and cost. Potential application areas are mobile telecommunication, smart vehicles and highways, health care and spacecraft.

VSAMUEL –a versatile system for neural recordings

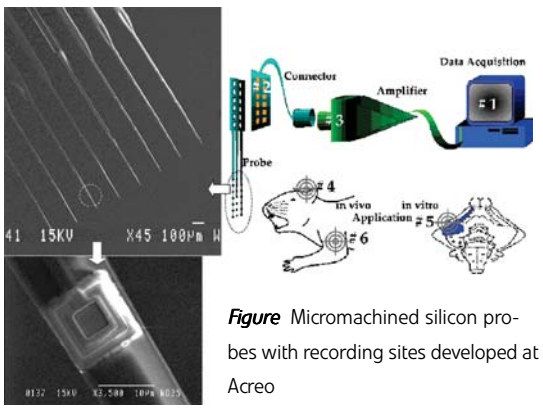


Figure Micromachined silicon probes with recording sites developed at Acreo

The key to understanding the nervous system is to make simultaneous observations of the activity of numerous cells. The objective of the VSAMUEL project is to develop a system for recording of multiple signals from neural tissue and to make it available to the neuroscience community. Acreo has developed micromachined fork-like probes with multiple recording sites (today 32) including a connector solution. VSAMUEL is an EU project with partners from five countries.

Customers and financing

Karolinska Institutet, NUTEK, Amersham Pharmacia Biotech, Ericsson Microelectronics, EU, IRECO

"Acreo took an important step forward during 2000 to help making broadband technology viable as we started building our new Fiber Lab"

Anders Josefsson

Customers and financing

Ericsson, ADC-Altitun, NUTEK, Telia, Proximion, Wallenberg Foundation, The Knowledge Foundation

Acreo's department of Photonics, is devoted to the task of research and development for creation and transport of photons in any application where photons provide the best solution to the customer's problem.

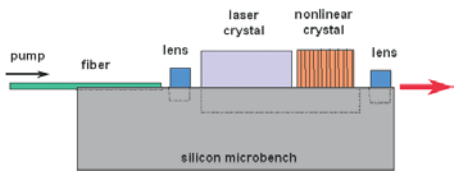
The department is covering Optical fiber technology, Optical building practice and Laser technology for different application areas, although telecom is dominating. With our advanced laboratory resources we are able to work with light in different wavelength regimes depending on the requirements of the customer. Manipulating light in various ways to change its properties and creating new components that can solve different functions in systems based on fibers is an area were we are very active.

The Photonics department is a unique resource for applied research and development in the photonics area as we are able to develop and produce the different components needed for new exciting functions and systems.

Miniature lasers using silicon microbench

Together with researchers from the Royal Institute of Technology Acreo have developed and patented a new versatile design concept for miniature lasers, which is applicable to many kinds of DPSSL (diode pumped solid state laser).

A silicon microbench with wet-etched grooves for the precise passive alignment of all components in a DPSSL is used to obtain efficient heat removal from the laser crystal. A second carrier is placed as a lid to provide robustness and homogenous heat sinking (see figure below).



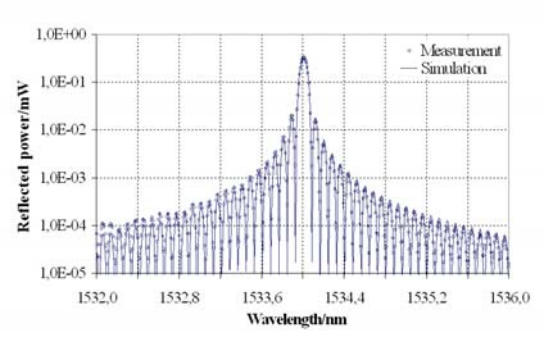
Schematic picture of laser built on silicon microbench. Etched v-grooves provide easy passive alignment of optical elements

In experiments using a 10 W fiber coupled diode as pump source, the miniature laser reached a maximum continuous wave (cw) output power of 3W. The beam profile was very smooth, with a nearly diffraction limited mode

The design has prospects of being very cost-efficient in volume production and is a good example of the achievements possible when combining advanced laser technology with innovative optical building practice.

Fiber Bragg gratings

During 2000 Acreo have invested in a new fiber bragg grating writing equipment. This new design gives us increased possibilities in writing advance fiber bragg gratings and is incorporating a new cw UV lasers source together with elaborate opto mechanics and software for control of the writing conditions.



The figure shows the reflection spectrum of fiber Bragg grating written with the new facility. This homogeneous grating is 10 mm long and has a reflectivity of 20%. The agreement with theory is excellent. This new installation allows for the fabrication of gratings with much better controlled irradiation doses along the fiber, higher writing speeds (up to 10 mm/s) and doubled spatial resolution for the index and phase profiles (100 µm or less).

"The year 2000 has seen the launch of SiC power devices on the market ... a small step for SiC, a great leap forward for semiconductor electronics"
Chris Harris

Customers and financing

Whirlpool, Personal Chemistry, Office of Naval Research, Applied Sensor, EU, VINNOVA

'There are moments in technology when the next 5, 10 or 15 years begin to crystallise; this is one of those times…..'

Glen Zorpette, IEEE Spectrum 1992
(about supercomputers)

The year 2000 marked the fruition of the new developments in SiC that have been on-going since diversification of the department's activities, away from power devices during 1998-1999.

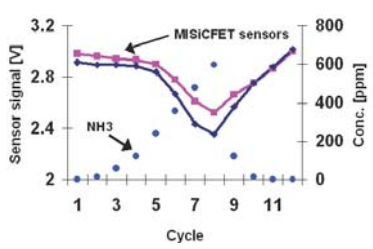
Microwave Transistors and Gas Sensors

In two key areas we have now device results that are close to productification; high power microwave transistors and MOSFET based gas sensors. These results exploit both the electrical and physical advantages of SiC in providing performance in the first case up to 35 GHz and in the second case operation above 700 °C. The development of new products is in line with corresponding developments in the commercial sale of SiC devices that have now been launched by Infineon in Germany.

An example of the developments made at Acreo, in this case as a joint project with the S-SENCE competence center in sensor development at Linköping University.

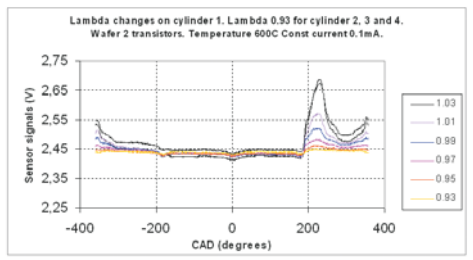
The figure below illustrates the mounting of a gas sensor for measurements of ammonia concentration from a diesel engine.

Mounting of MiSiCFET sensor



Sensitivity of MiSiCFET to changes in ammonia concentration

The dynamic sensitivity to ammonia is shown above, the temperature of the exhaust gas is around 500 °C, however this is cooled somewhat during the feed system. The ability to operate at extreme temperatures places a severe challenge to the mounting and packaging of the sensor device. The SiC element has been shown to be stable even at very high temperatures.



Sensitivity of MiSiCFET sensor to cylinder specific changes in air/fuel ratio.

SiC in automotive applications

The figure above illustrates a further use of the sensor in this case for the cylinder specific measurement of hydrocarbon emission from a petrol engine. The gas environment of the sensor can reach as high as 700 °C. The figure demonstrates the sensitivity to intentional changes in the air to fuel ratio for a specific cylinder of the engine. It shows the sensor response when three cylinders are run at a constant lambda value, and the lambda value is varied on cylinder 1. (The lambda value is the air/fuel ratio; <1 is a rich mixture; =1 is a stoichiometric mixture; >1 is a lean mixture.) In this picture, cylinders 2, 3 and 4 are run slightly rich, and the mixture made more and more lean in cylinder 1.

"As boundaries between products are more and more blurred – is a book with an electronic keypad a book or a musical instrument? – recognising where existing knowledge applies to new fields becomes a strength to build on"
Marie-Claude Béland

Optical development tools for the paper industry, advanced measurement technology for infrared optics, and simulating light scattering from different materials are our key areas for research and development. .

Light Scattering in Paper

Improving existing paper products and developing new ones requires a better understanding of the optical properties of paper and its components. We assessed the reliability of our light scattering simulation program, Grace, by obtaining the optical properties of new paper structures and comparing the simulation results to the actual measurements. We also developed a new tool for generating virtual paper structures from information about the physical properties of the fibers and the production process. The virtual paper can be used as input for light scattering simulations.

IR

In order to meet increasingly broad measurement needs, we are extending the measurement capabilities of our scatterometer. We currently have the capability of measuring angle-resolved scattering at two different wavelengths, namely 633 nm and 10.6 µm. When the reconstruction is completed, it will also be possible to make measurements at 3.39µm.

Customers and financing

MoDo Paper, Stora Enso, SCA, Assi Domän, CelsiusTech Electronics, FMV, FOA, Flir

Guest Researcher From China Lake

The Surface Characterisation Department was privileged to have as a guest researcher Dr. Jean Bennett from the Naval Air Warfare Center, China Lake, CA. She supported a number of Acreo researchers in the field of surface roughness measurement and also collaborated with KTH, preparing material for a course on appearance.

Landmine detection

We proved the applicability of the Discrete-Dipole method, initially developed to study light scattering from small particles in coating layers, to the problem of radar waves in soil components and landmines. The problems are similar if scaled with the wavelength of the incident waves. During 2000, we also showed the possibility of including the antenna (receiver-emitter) in the calculations without the need of a costly reprogramming of our software.

Multi-disciplinary Approach

The combination of light scattering and topography allowed us to evaluate the performance and appearance of different materials by measuring, modelling and optimising their light scattering properties. We also identified new areas, such as biotechnology and tissue optics for example, where Acreo's multidisciplinary approach can bring forth exciting challenges. We look forward to the possibilities!

The angle-resolved scatterometer is used to measure the light scattering distributions from different samples. Measurements can be made in either reflection or transmission both in-plane and out-of-plane. Wavelengths in the visible and the infrared regions can be used.

Maria Kindlundh (Micro Systems Technology) and Erik Petrini (Surface Characterisation) measure a silicon-based optical component on the AFM. Here, the AFM is operating in the tapping mode and the image displayed is the surface topography

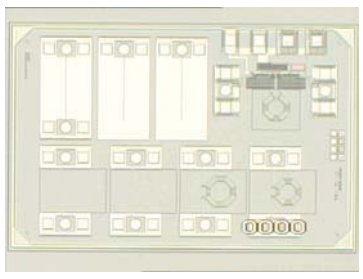
"Acreo's Socware Center is now running at full speed, ready to implement your radio system on chip solutions."
Magnus Danestig

The department of System Level Integration is active in the field of integrated circuit design for emerging wireless communication systems. The department also forms the Socware Center, the important hub of the Socware cluster.

System Level Integration

The Socware cluster is the Swedish open initiative for System on Chip (SoC) design, a government supported program, started in the year 2000 under the supervision of the Invest in Sweden Agency (ISA). Additional Socware partners are Linköping University, Lund University, the Royal Institute of Technology and several national and international companies within the areas of electronic design, semiconductor components and system design. The Socware program is divided into four subprograms; Research and Education, Business Development, Intellectual Property Rights and finally the Acreo Socware Center. An important role of the Socware Center is to stimulate and support new companies to establish themselves in the cluster.

The department of System Level Integration was formed in November 2000. It is now (March 2001) composed of 14 engineers and scientists and has an ambition of doubling in size before the year's end. The activities within the department are based on core competence in design and evaluation of integrated circuits and advanced electronics packaging. New design solutions and design methodologies are developed for prototypes from system to component level design. The main competence areas are today radio frequency (RF) and analog-mixed signal design and radio transceiver architectures, but will develop also towards complex digital ASIC design.



Photograph of a SiGe chip including a VCO with on-chip inductor, seen in the top-right corner, and some test structures.

Customers and financing

Ministry of Industry, Employment and Communcation, TBS, Atmel, VIA Technologies, The Knowledge Foundation, SGA, FOI, EU

The following application areas have been identified for focused activities together with leading companies and the universities:

- Integrated transceivers for emerging wideband wireless communication systems and networks.
- Applications with high demands on performance, physical size and reliability.
- Integrated antenna systems

Within these application areas the research and development activities aim at the following themes:

- Design methodologies for "Wireless SoC" design
- Complex circuits with respect to functionality and flexibility as well as the mixing of RF, analog and digital signals and embedded software.
- Area and cost-efficient receiver and transmitter topologies including optimum choice of placement of analog /digital and best trade-offs between on- and off-chip implementations of critical components and sub-blocks.
- New solutions for critical building blocks for integrated wireless systems such as filters and analogue-to-digital converters.
- Integrated passives and antennas for microwave and millimeter wave applications
- Signal processing for wireless communications

The results of the starting year include recruitment of experienced engineers, set up of a state of the art CAD and measurement laboratory for GHz frequencies and initiation of several projects. The designers use software tools from Agilent (microwave/RF, radio system), Cadence (RF/mixed signal, digital) and Mentor (digital). The measurement lab includes network analyzer for on-wafer measurements up to 50 GHz, spectrum analyzers, an anechoic chamber for antenna measurements, and other equipment. The start of the first international Design Center was prepared for the US company Atmel. In December 2000 the first design tape-outs were sent, including RF circuits in a SiGe BiCMOS technology. A photo of one of the dies is shown in the figure.

"Development in electronics and optics is so fast that it is essential to have access to the latest information for being competitive".

Pentti Kölhi

FMOF

Acreo Industrial Group

Facts about FMOF
FMOF (Acreo Industrial Group), previously Swedish Association for Optical Research, is a non-profit association of companies with the objective of promoting technical and scientific research and knowledge development in microelectronics and optics. The objective is fulfilled by a majority ownership in Acreo AB and by encouraging the members to use knowledge and participate in activities of Acreo.

Members of the board of FMOF are
Pentti Köhli, Saab AB chairman,
Jan-Olof Andersson, Kitron Development AB
Hans Malmkvist, Consulting H. Malmkvist AB
Claes Nycander, Telia Research AB
Örjan Pettersson SCA
Eva Westberg , Ericsson Generic Technologies
Ove Berkefelt, adjunct member, Acreo

FMOF members
At the transformation of the Swedish Association for Optical Research to FMOF, at the beginning of the year 2000, the number of members were 22. During 2000 and 2001 the number of members have reached 39. Spin off companies from Acreo have chosen to keep close ties with their mothercompany by joining FMOF. Other important groups of new members are companies belonging to collective research projects like the Paella project.

A continous dialogue
Pentti Kölhi, the chairman of FMOF, clearly points out that the association takes a great responsibility in promoting the development of Acreo. FMOF aims to identify strategic questions that are relevant to Acreo. For FMOF it is essential that the industrial perspective is in focus for Acreo and consistent with FMOF´s opinion. Hence a continuous dialogue is going on between FMOF and Acreo on issues of importance for both parties.

Membership benefits
FMOF has a broad industrial experience with representatives with background in marketing, manufacturing, and technology, and with a different frame of reference than Acreo. The major argument for membership of FMOF is the opportunity to benefit from the combination of this industrial experience and Acreo´s deep technological competence.

Membership of FMOF entitles the members to partnership in collective research projects at a reduced Acreo manhour rate. For most companies this amounts to the yearly membership fee. In addition, access to Acreo´s annual presentation of roadmaps in electronics and optics is highly valued for development decisions in many companies. (For detailed information on FMOF membership benefits and other conditions, please visit Acreo´s website www.acreo.se)

Acreo Laboratory Resources

Acreo's research and development laboratories are located in Stockholm, Norrköping and Hudviksvall. The profile for each of the facilities is slightly different: from mainly component development and small-scale fabrication in Stockholm, through MCM substrate and organic electronics development and production at Norrköping, to fiber development and fabrication in Hudviksvall.

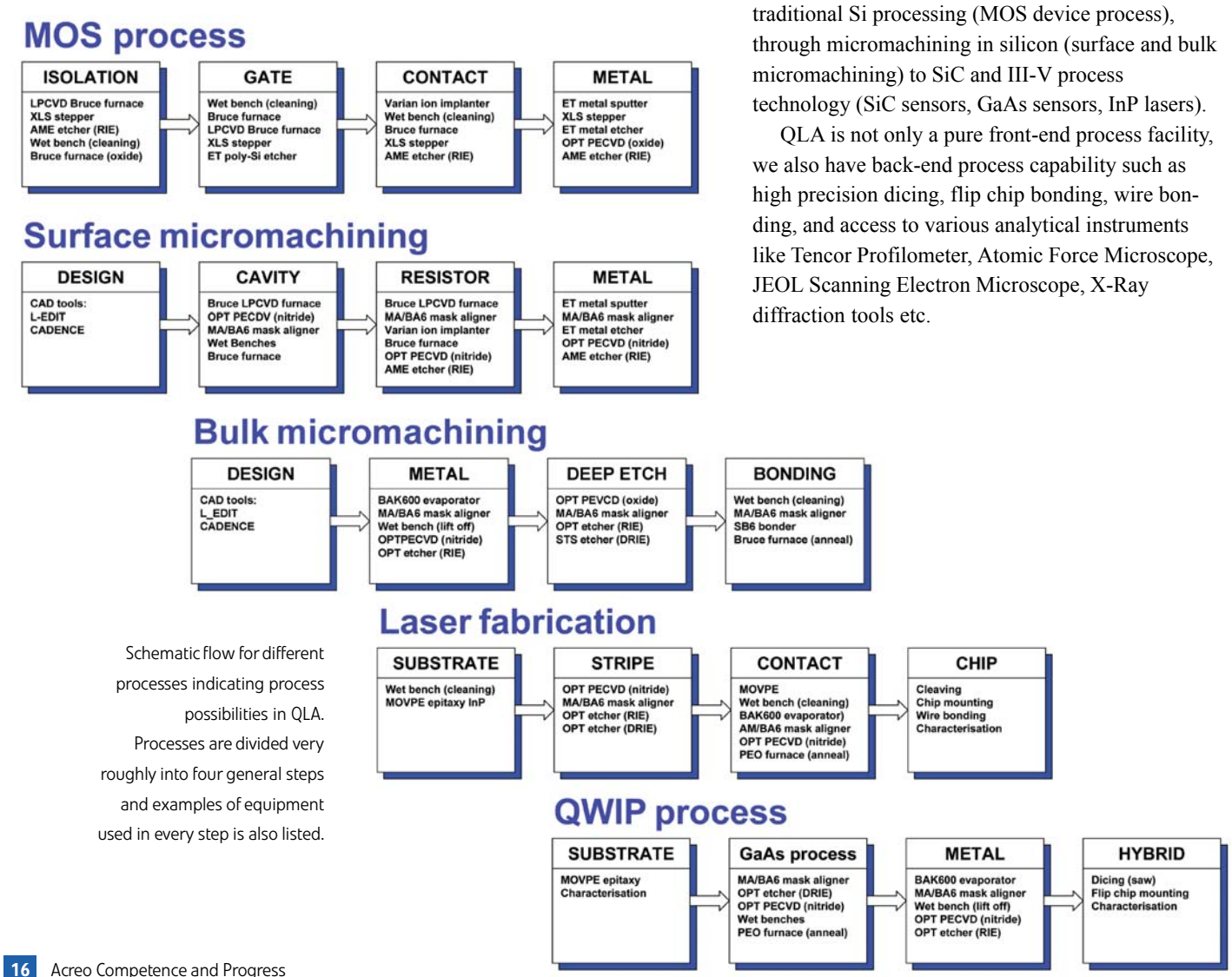
Wlodek Kaplan
Stockholm

The Stockholm facility - QLA

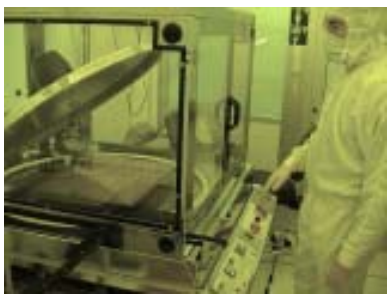
The semiconductor laboratory is located in Kista. The clean room facilities, covering a total area of more than 1000 $m^{2,}$ is a common resource for research and education in semi-conductor technology and devices, owned by KTH, but used and run by Acreo and KTH in cooperation.

Quality Laboratory Acreo (QLA) is a first rate laboratory to serve a multi-user environment with focus on component development and fabrication. It covers academic as well as industrial oriented R&D. QLA is one of Europe's most advanced laboratories for component development. Our unique position is related to a wide process capability, including several different component processes which are being used continuously in the laboratory. We offer process lines to fabricate devices: beginning with traditional Si processing (MOS device process), through micromachining in silicon (surface and bulk micromachining) to SiC and III-V process technology (SiC sensors, GaAs sensors, InP lasers).

QLA is not only a pure front-end process facility, we also have back-end process capability such as high precision dicing, flip chip bonding, wire bonding, and access to various analytical instruments like Tencor Profilometer, Atomic Force Microscope, JEOL Scanning Electron Microscope, X-Ray diffraction tools etc.



Schematic flow for different processes indicating process possibilities in QLA. Processes are divided very roughly into four general steps and examples of equipment used in every step is also listed.



Magnus Svensson
Norrköping

The Norrköping facility

Our newly-built laboratory in Norrköping has a focus on MCM solutions. Thin film and laminate substrate technologies are combined and they are already a reality of considerable benefit to our clients.

In our cleanroom we have complete process lines for substrate up to 600 mm × 600 mm and for 150 mm wafers. The deposition of extremely thin metal layers is a vital capability in this context. Our modern high vacuum sputter deposition system, capable of handling large substrates, can deposit up to four different metals in any sequences without breaking the vacuum. The translation of electronic design into patterned surfaces starts with a laser writer designed for photomask manufacturing and direct patterning on planar substrates. The laser interferometer controlled stage can handle substrates of up to 625mm in size, with a write area of 400 mm x 400 mm and a resolution of 125 nm. In order to expose photo resist and other photo sensitive materials on large area panels we have an excimer patterning system, Anvik HEXSCANTM 2050 SME.

The Norrköping facility also impresses with its activity within the field of polymer electronics. The polymers offer new interesting properties, e g soluble, flexible, environmental friendly, printable etc, i e they open a new field of electronics. Our competence within classical interconnect and packaging together with our laboratory resources and knowledge in polymer electronics put the Norrköping facility on the map.

In our plating laboratory we have made considerable effort in flip-chip bumping and we are currently developing safe and cost-effective process technology in this area.

Ingmar Höglund
Hudiksvall

Acreo "Fiber Lab Nouveau"

October 13th, 2000 was the date for the first shovel starting the construction work of the new laboratory for the fabrication of specialty fibers in Hudiksvall to be operational in September 2001.

The effort with the investment in the new lab will create a resource for advanced R&D in the optical fiber technology that will be unique in many aspects and able to serve various demands from customers in the fiber optics industry.

Installation of preform analyzer, May 15th, 2001

Control equipment of drawing tower middle of May

FiberLab beginning of May

Monica Lundquist

Acreo is owned jointly by an industrial group, FMOF (60%), and the Swedish state-owned company IRECO (40%). Acreo was, in the year 2000, located in Kista and Norrköping, and is, during 2001, establishing offices in Hudiksvall, Jönköping and Lund.

Personnel

During the year 2000, Acreo had a staff of about 140 highly-qualified scientists, engineers and support personnel, with a high proportion of graduate engineers (70%) and scientists, Ph.D. doctors (23%) and Ph.D. students.

Financial information

Key figures (MSEK)	2000	1999
Revenue	145,8	131,0
Profit after financial items	3,8	-5,8
Share capital	15,5	15,5
Equity	24,0	19,1
Total assets	125,5	102,5
Total investment	26,4	38,8
Cash and bank balances	34,4	34,7
Equity/assets ratio	20 %	19%
Employees (year end)	142	127

In year 2000 Acreo´s revenues totalled 145,8 MSEK and profit after financial items amounted to 3,8 MSEK.

Facts and Financing