Hans Hentzell

Innovation for Growth

2002 was a year of Innovation, Development,
Transfer of results to industrial use,
and a struggle to survive.

During the last three years the direct return on investment for the Swedish government, in industrial turnover based on technology developed by Acreo, was 55 times the money spent.

The conclusion is that it is very benificial for individual companies and for the government to invest in Innovation for Growth with Acreo. Despite this, 2002 was a tough year. Several of our largest industrial partners had to cut down on R&D and we were forced to cut down the number of employees.

Some of the achievements of 2002

- Acreo established in Lund a Socware design center for WLAN design together with Via Technologies of Taiwan.
- Acreo established a testbed for applications and key components for optical broadband communication.
- Ramped up production volumes of the QWIP IR-detector that Acreo and Flir Systems have developed together.
- The spin-off company Silex increased their production volumes in Acreo's Production Incubator for MEMS and Microelectronics production.

For 2003 I hope that a modern innovation system with relevant financing for technical research, and especially for microelectronics and optics, can be established in Sweden, and that we can continue developing our unique expertise together with and to the benefit of our partners.

Despite the bumpy road ahead - this is a challenge we take pride in accepting.

Hans Hentzell
Managing Director

This document describes Acreo's activities and results for the year 2002. Examples of technical activities are presented under the specific sections below together with more information about the different areas. The intention is to present an overview of Acreo's capabilities and achievements.

Acreo's Mission

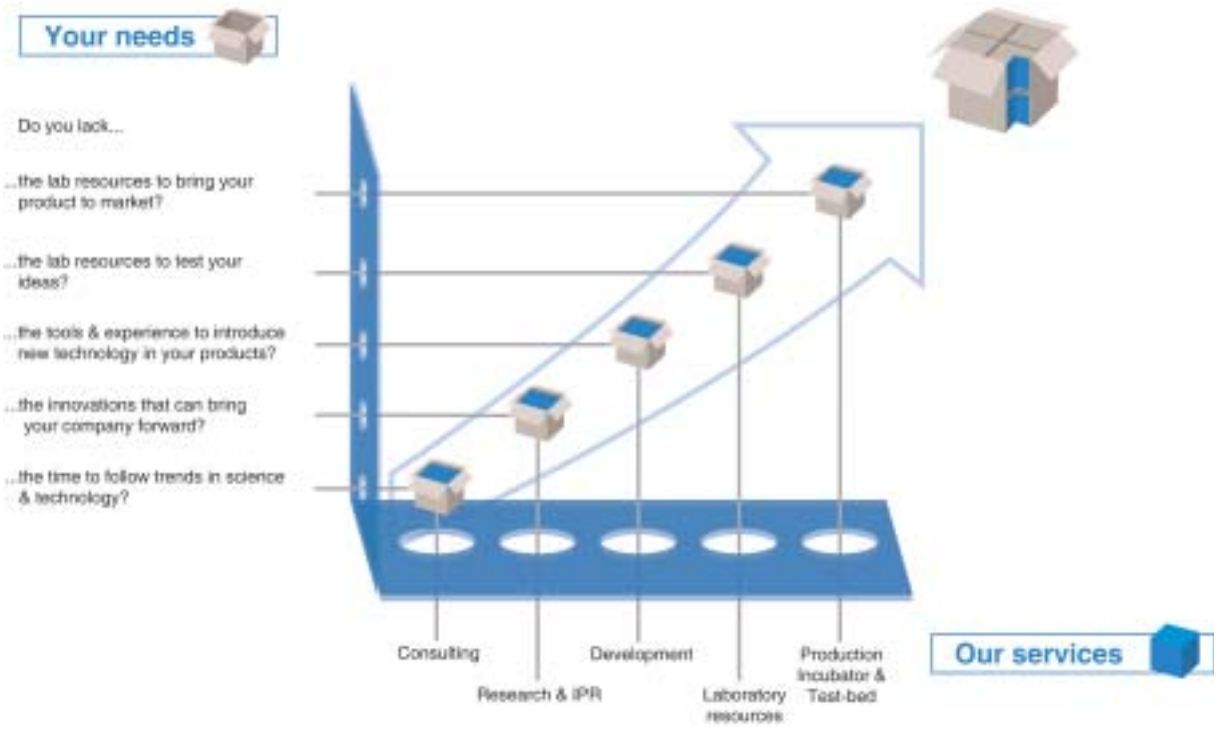
Acreo serves its customers with contract R&D and provides innovative microelectronics and optics solutions for the products of tomorrow. Our spectrum of competence is uniquely broad, and ranges from modelling and design to processing and manufacturing, to the final test and characterisation. The figure illustrates the different services Acreo provides for its customers on the route to growth and profitability.

Acreo's extensive network in the international research community allows us to both generate and have access to new promising research results. This is done in different EU-research projects, and in programs financed by the Swedish government.

In particular, Acreo runs dedicated research programs in:

- Socware/Wireless Communication
- SME-program
- Organic Informatics
- Imaging
- Optical Broadband Technologies
- Test-bed for Broadband Communication

Your route to progress
- with Acreo



With these research programs Acreo builds up new competence that will secure a continued provision of new technology in strategic areas.

In co-operation with partners and customers representing both academia and industry Acreo further refines this research into results that can be commercialised, thus creating growth and profit for our customers. In particular, Acreo helps SMEs to improve their business by transferring new technology for their products and processes.

Results - Innovation for Growth

Besides providing refined research results for our industry customers Acreo influences the growth of the microelectronics and optics sector by supporting entrepeneurship and inward investments.

The bulk of Acreo's services and operations is contract R&D for industry partners. In 2002 Acreo was running approximately 230 projects for external customers. About 75% of the turnover emanates from projects with industrial partners when including some projects partly financed by VINNOVA. Acreo is a partner renowned for its research and competence, and our co-operation in projects financed by the EU commission is important. This type of activities represents around 5% or the turnover.

Projects range from research and development to contract manufacturing in small volumes. This is of great benefit. For example FLIR-Systems in Danderyd has become the world's largest supplier of IR cameras based on QWIP-devices. These are delivered by Acreo.

For start up companies Acreo's production incubator is very important, as it provides means to verify products and processes for customers and investors. Among others Optillion and Silex Microsystems have been helped in this way.

Acreo runs several governmental research programs funded through VINNOVA, SSF, IRECO and the EU. During 2002, each Euro from the funding agencies generated 5-8 times larger industrial activity based on direct results from the cooperation with Acreo.

Support for entrepeneurship is a very important task for Acreo. The outstanding research in Silicon Carbide technology is now being exploited by the spin-off company AMDS, Advanced Microwave Device Solutions.

In parallel with the technology development programs Acreo supports the development of SMEs. A number of companies have been able to introduce significantly improved products through this program. As a result, the companies' competitiveness is markedly improved.

Within the framework of the governmentally funded program Socware, Acreo also promotes inward investments.

For the benefit of our customers we try to protect our innovations by a strategic IPR policy. Many innovative ideas by our researchers are continuously evaluated, and we annually write more than 20 patent applications. Patents owned by Acreo can either be licensed or sold, depending on the particular interests of customers.

Further examples and more details of the results of Acreo's operations are found below.

Core Competence
System Level Integration and Wireless Communication

This section describes activities in the Research Area **Integrated Circuit and System Design** aiming at Wireless Communication and Automotive applications Two project examples are presented, showing not only interesting technical results but also describing interesting models for Acreo's interaction with customers and research partners in this field.

Integrated Circuit and System Design

System on Chip (SoC) design, where the whole system is built on a chip, is extremely important for the future miniaturising of electronics. Within SoC for wireless applications Acreo has a broad hardware and systems competence, covering an architectural top-level down to the component level. This includes knowledge in IC design ranging from analogue/RF to digital baseband, signal processing algorithms and packaging. The main applications are emerging wireless communication systems.

The Acreo Socware center is the hub of the Swedish Socware design cluster. One important part of the Socware business model is marketing the competence and supporting international companies who wish to establish design centers in Sweden. One excellent example of this unique Socware business model is the co-operation between Acreo and VIA Technologies Inc, a leading innovator and developer of silicon chip technologies and PC platform solutions.

In 2001 Acreo together with VIA established a wireless applications design center (DC) in Lund, dedicated to radio frequency (RF) technology design.

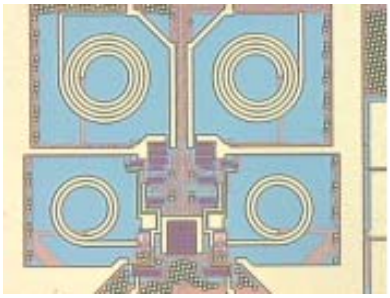
During 2002 the DC was completed and ready with a highly competent team of designers with an impressive past experience working in a competitive development environment. Initial system work, as well as the purchase of necessary design and measurement equipment, was done in parallel to save time and resulted in several 'tape-outs' (design runs) for ICs. The DC grew out of the initial premises and moved into new facilities in IDEON Science Park in 2002.

As the build up of the DC exceeded expectations and original schedules, VIA acquired the main part of the Lund DC early 2003. Wenchi Chen, President and CEO of VIA concludes: "In less than two years, we are reaping the benefits of our partnership with Acreo, enabling VIA to boast wireless system design capabilities as yet another important building block in our overall strategy."

The VIA design center is one very good example of the successful implementation of the Socware cluster, a government supported program started in 2000 under supervision of the Invest in Sweden Agency (ISA). After spinning off the DC to VIA, the center in Lund will continue its work in the Socware demonstrator project SoCTRix together with colleagues in Norrköping and the other project partners.

Socware Demonstrator SoCTRix

Work within the Socware Transceiver demonstrator project, involving a number of industrial partners together with Acreo, reached full speed in 2002 as more partners joined the project.



Chip photo of a Wide Band (2-6 GHz) 0.18 mm RF-CMOS Low Noise Amplifier developed within the SoCTRix project

The project is unique as different partners are offered a broad and open co-operation and research activities are conducted in a way similar to normal product development.

The goal of the project is to develop and design a highly integrated re-configurable radio transceiver ”Software Defined Radio” (SDR) that can handle the plurality of the air interface standards in future wide band communication systems. In this case both WLAN (2.4 GHz and 5GHz), and 3G WCDMA air interfaces will be used, thus addressing the demand for the future wireless broadband access. The research challenges are to find and develop system and circuit solutions allowing the implementation of an SDR terminal, with to some extent an increased performance, at low cost while still retaining a low power consumption.

The project has attracted a lot of interest, and the current contracted partners range from small companies to large international giants: ARC International (UK), VIA Technologies (Taiwan), BitSim AB (Sweden), Chartered Semiconductor (Singapore), Agilent (USA), Samsung Electronics (Korea), Catena (Netherlands), CADENCE (USA), FOI (Sweden) and ITRI (The Taiwanese Research Technology Institute). Discussions with other potential partners are ongoing.

Besides getting access to project results, the partners are contributing to the project with the various resources and comptences they have. The University partners KTH, Linköping University, LTH, Mid-Sweden University, NTNU (Norway) and Chalmers contribute with research students working with research supporting the project.

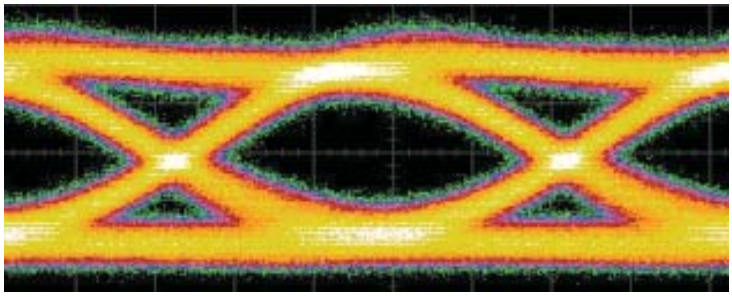
Acreo is responsible for the project management and technical co-ordination of the project, as well as the development of the transceiver hardware and software. Technical activities in the project have resulted in three different ’tape-outs’ (design runs), the last one including three different chip, RF-, mixed signal and digital circuits. Tests of 0.18 µm RF-CMOS chips manufactured by Chartered Semiconductor showed good correspondence between model and actual performance.

In a few years time it will be possible to commersialise the project results in the form of usable design methods and circuit solutions, producing a broad increase of competence and skill in the field.

Core Competence
Optical Components and Systems

Representing the Research Area **Optical Broadband Technologies** we here choose to present our Optical Systems and Network activities, together with Optical Fibre Components and Speciality Fibres. Spatial Light Modulators are an interesting example of the striking advantages with Optical Information Processing.

Optical Networking – a new Acreo Core competence



"Eye diagram" from high bitrate experiment, representing Optical Networking

With a long established expertise in the field of speciality fibres and fibre-based optical components, Acreo got the unexpected opportunity to add a new core competence, Optical Systems and Networking, to its arsenal. In 2002, Acreo took over a highly competent team of 14 researchers together with a fully equipped systems laboratory. This was made possible when Ericsson decided to divest from their research activities within optical networking in 2002. This activity was transferred to Acreo in August 2002 and the arrangement was made possible by shared funding from VINNOVA and Ericsson.

Acreo is now able to handle all aspects from specialised components to systems development, and the combined expertise promises to bring up new exciting ideas and solutions that will fully exploit the potential of optical transmission. Furthermore, the added competence fits very well with the activities of the Kista Photonic Research Centre, KPRC, which is a joint effort between Acreo and the Royal Institute of Technology, KTH.

The competence portfolio contents include 10-160 Gbit transmission, dynamic dispersion compensation, modulation formats, optical amplifiers, non-linear effects, dispersion management and solitons, long-haul to access network through regional and metro, FTTx and layer1-3 architecture, network management and standardisation.

To fully take advantage of the new possibilities opened up by the combination of optical network and components expertise, together with Acreo's competence in photonic packaging, wireless communication and other aspects of communications technology, Acreo has launched a test-bed project.

The "Test-bed for Broadband Communication" is a national scale project to provide next generation communication services to customers.

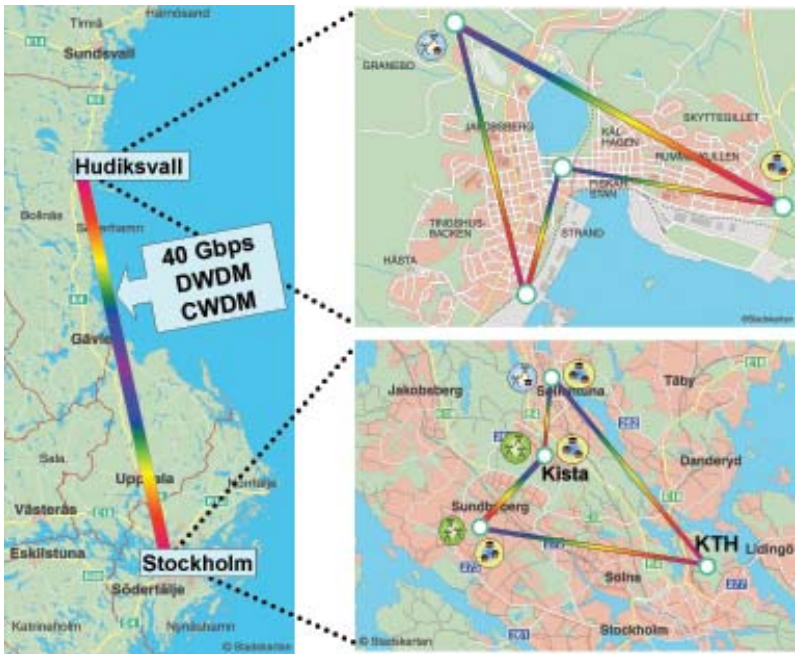
This long-term project, supported by the Swedish government, aims to develop and test the next generation heterogeneous datacom and telecom infrastructure based on frontier optical networking technologies. The initiative is aimed at providing various broadband communication services to customers.

One of the objectives is to demonstrate and realize service/technology transparency and compatibility of a large-scale reconfigurable optical network based on services, equipment and technologies from different manufacturers and service providers. An important expectation of the project is that low cost optical technology applicable for transmission and access networks will be available at a lower price and will move closer to the end-users.

The project goal is to build and demonstrate a multi-vendor, end-to-end, high-speed optical network with novel broadband services offered to end-users. The network architecture will be re-configurable with integrated network management.

As a first step of the realization, the Test-bed will cover a distance of about 400 km, connecting the Stockholm and Hudiksvall metropolitan regions along the coast of the Bothnia gulf. Reaching traffic speeds of up to 40 Gbps, the network will be able to deliver a diversity of services to customers requiring broadband capacity: video-conferencing and video-distribution, IP-TV, IP-telephony, telemedicine applications, distance working and education, storage area networking, video-on-demand etc.

Since most of these services require high-speed access, special efforts will be devoted to solve bottleneck problems for access systems. To break the existing bandwidth limitations in the access networks, a number of advanced approaches will be tested in the system. These include both optical transmission techniques for Fiber-to-the-home (FTTH) and transmission over the classical links (Asymmetric Digital Subscribe Line, ADSL), or transmission over coaxial cables or the air (Wireless Local Area Networks, WLAN, or mobile systems). Of special interest for mobile systems is the configuration with Fiber-to-the-antenna (FTTA) connecting to the base stations.



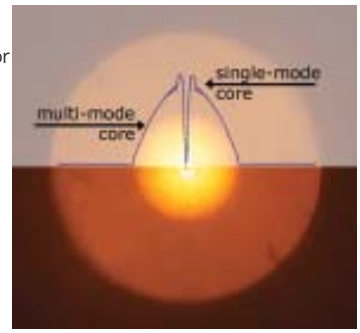
The test-bed uses available high speed infrastructure in Swedish cities

Because of its large scale, the project will depend on the co-operation of participants. In addition to Acreo AB, coordinating the project, it will also include private companies (equipment manufacturers and service providers), universities and local authorities. The project collaborators will contribute to the project with equipment, know-how, manpower, access to network links etc. Pursuing ambitious goals such as providing the end-users with up to 100 Mbps access, the Test-bed project is expected to attract massive investments.

The Test-bed project is an open initiative, which is also available to international participants through the 6th framework EU projects and other means.

The program is planned as a long-term activity on the national scale and is receiving support from the Swedish government through VINNOVA.

Speciality Fibers– Optical Fiber Components



CSM Fiber cross section, developed for Ericsson Network Technologies AB

With the focus on research and development for an increased functionality of fibers and fiber components, Acreo is establishing itself as an important player worldwide in the field of speciality fibers.

Custom-designed optical fibres

The activities at Acreo's new unique laboratory for development and manufacturing of speciality fibres (inaugurated 2001), were intense in 2002. One of the exciting results achieved is a combined single-mode multi-mode fibre called a CSM fibre.

The advantage of this fibre is that when the need arises to upgrade the transmission system from multimode to single-mode due to increased bandwidth demand, the cost of new cable ducting can be avoided. This work has been done under assignment from Ericsson Network Technologies in Hudiksvall.

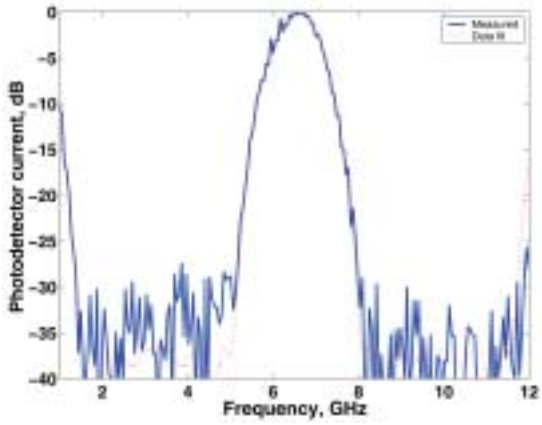
International recognition for activity in the field of Microwave Photonics

The rapid growth of mobile data traffic and telephony is more and more dependent on an efficient interface to fiber optics networks.

Converting signals from radio format to the standard digital format used in fibre transmission requires very costly equipment. One interesting way to circumvent this problem is to transmit the microwave signals directly in the fibres.

Acreo has been working with microwave photonics for several years and this effort has now been internationally recognised as Acreo, starting 2002, is participating in a network of excellence called NEFERTITI. Acreo is also participating in a project called LABELS which is financed by the EU-commission. LABELS deals both with optical filtering of microwave signals and label switching, which is one way to realise optical routing.

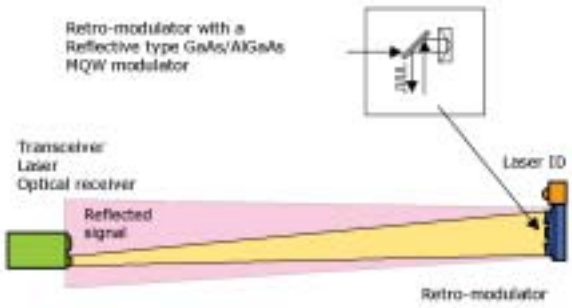
As signal filterering is very important in microwave technology, Acreo's well renowned expertise in fibre Bragg gratings is particularly beneficial.



Microwave filters realised in the optical domain by using spectrum slicing and 8 fibre Bragg gratings with well-adjusted reflectivities. The filter shows an excellent extinction ratio of 30 dB.

Spatial Light Modulators (SLM)

Acreo's work on SLMs resulted in major breakthroughs for applications in retro-communication and high-speed optical signal processing during 2002. Process yields were greatly improved and high-speed modulation was verified.



Principle of retro reflective free space communication

The very high modulation speed of MQW (Multiple Quantum Well) SLMs (several 10's of GHz), low weight and low power consumption, make them ideal for a wide range of applications. In particular, Acreo is working with SLMs for free-space communication and high-speed optical signal processing.

An MQW SLM modulator together with a corner-cube can be used as an optical retro-reflector to constitute an optical link as shown in the figure. Such a system can easily be implemented on, for example, a moving unmanned aerial vehicle (UAV) to build up ground-to-air optical communication links for both civil and military applications. When a light beam is sent from a transceiver mounted on an interrogating ground vehicle to the retro-modulator on the UAV, it is reflected back to the transceiver with modulation bearing the data of interest, like the live video of the scene on the ground for instance.

The large aperture of the modulator makes the field of view wider and the signal tracking process easier during the data transmission. However, modulators with a large aperture suffer from low manufacturing yield as well as limited modulation speed.

To circumvent the problem Acreo has developed large area modulators divided into up to 64 pixels. Singular defective pixels can be removed and hence yield is enhanced significantly. At the same time, small area pixel elements improve the modulation speed.

Devices fabricated in a high yield 4" process exhibit 8 dB contrast ratio at a driving voltage of 8 V and a modulation frequency of more than 10 MHz, which provides low noise and fast data transmission for long distance free-space optical communication.

Acreo's work with process development for SLM arrays has reached the stage of transfer to industry as Acreo during 2002 received a contract from Lenslet Ltd (Israel). Acreo's task is to develop a production process for the SLM arrays, including hybridisation.

By hybrid integration of SLM arrays with a CMOS integrated circuit driver, high speed optical signal information processing is made possible. This is a key element in the world's first commercial reconfigurable Optically based Digital Signal Processing Engine (ODSPE) introduced by Lenslet in 2002.

This unique technology takes electronic digital input, converts it into optical signals (photons), performs the computation at light speed in the programmable optical core, and then converts the optical output back to into digital electronic form. With this innovative product a number of computation-intensive technologies and applications will be enabled.

A 14x14 mm^2 wide aperture modulator divided into 28 rectangular pixels

Representing the Research Area **Organic Electronics** we present work on Polymer Electronics.

Organic Electronics

By adopting printing technology to manufacturing of electronics based on polymers, one can envision a drastic reduction in production cost as well as the enabling of new exciting applications by adding electronic functions to other materials such as paper and plastics.

Demonstrator of a seven segment display printed on paper

The innovative project Paper Electronics for Low cost Applications (PAELLA) was a pre-competitive R&D project focusing on the integration of low cost electronic functions on paper. Acreo developed device technology, building blocks/ systems and manufacturing processes for organic electronics based on for example offset-, flexo-, and screen-printing.

The primary goal is to extend the existing use and function of paper. In the future, however, with improving performance, organic electronics is a candidate for common electronics as well. The possibility of very high speed manufacturing processes that are environmentally friendly will probably revolutionise the electronics industry in the future.

A number of demonstrators, such as displays and ID-functions, were realised based on the polymer technology developed. The striking project results have attracted much attention on the international level and Acreo has established co-operation with a number of international customers.

Future work in the field includes establishing a ”printing house” for organic electronics. The Swedish Science Council (VR) granted the investment in commercial printing machinery, and by modifications for printing polymers it will be possible to produce electronic paper in a reel-to-reel process. By thus leaving the middle age batch technology, a giant step towards continuous production of electronics is taken with a dramatic impact on manufacturing cost.

Acreo will continue the development of new components and functions for organic materials within the frame of the national Center for Organic Informatics (COIN) operated jointly by Acreo, CTH, KTH, and Linköping University.

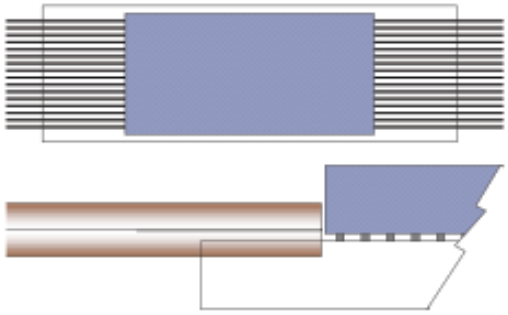
Polymer memories

By combining specially developed polymers and unique system architecture an all-organic memory system can be realised. Stacking thin layers of polymers between two sets of crossed electrodes allows for building up three-dimensional structures having a large area. With this storage technology, memory capacities can be obtained far beyond what can be achieved by other solid state memory technologies. This is combined with a manifold of other advantages: speed, production, energy consumption and cost.

Acreo is involved in this technology through a very large project on polymer memory development together with Thin Film Electronics (TFE). TFE is a research and development company owned by Norwegian based Opticom ASA and Intel®. Acreo’s main focus in the project is the process development of the thin film processes involved.

Photonic Interconnect and Packaging

Along with the growth of the internet traffic the need for low-cost, single-mode based fibre optic solutions increases. To meet this demand, Acreo is developing new packaging and interconnect technologies for photonics.



Schematic picture of the optical waveguide technology platform. Top: Top view of fibre arrays and aligned waveguide chip. Bottom: Cross-section of fibre and flip-chip mounted waveguide chip.

In the world-wide communication network the traffic is still increasing and the access networks will soon become a bottleneck. For the nodes in the fibre optic metro-networks especially, there is a pronounced need for handling large amounts of data traffic in combination with the capability of dynamic re-direction. Here components based on optical waveguides are already in use, but could be employed to a greater extent if a number of assembly and packaging issues were resolved.

For components used in the trunk network, issues such as performance and long term reliability have been of prime interest and there has been no strong driving force to reduce the production cost. For the metro net large volumes are needed and this will require that key optoelectronic components can be produced at substantially lower cost than previously.

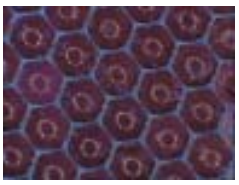
For a number of years Acreo has worked on assembly technology utilising microstructured silicon carriers in combination with electroplated solderbumps. This technique provides for passive alignment of chips by utilising self-aligning flip-chip soldering. Many other assembly methods require that the optoelectronic component is electrically connected and activated. For passive alignment this is not necessary, which greatly simplifies the assembly procedure. Work at Acreo to adopt this technology to large chips carrying multiple optical waveguides has seen a breakthrough during 2002. As no active alignment is required, this technology is inherently compatible with wafer level assembly (WLA). A hazardous risk with WLA, however, is that the final yield can be unacceptably low if no simple means for verifying alignment accuracy are available before fiber attachment.

We have developed a measurement method based on Moiré-effects which requires only an infrared diode laser and a single detector, together with standard electronics. A metallised periodic pattern with a typical feature size of about five micrometres, well within standard processing limits, is formed on the sub-carrier. This together with a similar pattern on the chip to be mounted forms a Moiré-like pattern which can be analysed in real time during solder reflow for single chips, or, more conveniently, in a measurement phase on WLA-scale just after the soldering cycle.

With this measurement method we obtained an accuracy of 0.1 µm or better, which is well in correspondence with the requirements for single mode technology. Currently work is ongoing to implement this method to wafer level assembly, which is a key to the development of an automated assembly chain for optoelectronics.

Core Competence
Imaging and Visual Interfaces

Acreo has expertise and activities in various aspects of imaging - IR detection and imaging are especially extensive and are also covered in other parts of this document. In this section we present work on **Visual Interfaces** where scattering of visible light from surfaces and structures is important. Information extraction, image processing, modelling, and measurements are used to investigate different aspects of these phenomena.



Plastic micro-lens array imaged with the LAMM instrument

"LAMM"

Acreo has studied light scattering properties of rough surfaces and different complex structures for several years and we have developed various computer models to describe and predict various optical properties.

A **Large Area Mapping and Measurement (LAMM)** instrument was developed to allow imaging and measurement of areas from about 1 mm² to about 13 mm × 18 mm. The instrument is based on commercially available microscope equipment. Application-specific software can be developed to help the operator analyse the properties of the samples studied.

For example it is of great advantage to be able to automate the inspection of device processed semi-conductor wafers for accuracy reasons as well as inspection speed and cost. The instrument can scan large areas, which allows for maps of different kinds to be obtained from the image data. Automatic mapping of where defects are, with or without image processing, keeps track of the position and number of features of interest on a sample.

We are currently adopting this very versatile instrument to our own advanced semiconductor device production activities.

Visual interfaces

With the impact of electronics and computers on everyday life the visual quality of displays such as CRTs and LCDs has become increasingly important to the end-user.

Acreo together with SEMKO helped TCO Development establish a new quality standard for CRT and LCD monitors, TCO'03 Displays. This is the forth labelling standard issued by TCO and it includes monitors, computer units, keyboards and portable computers.

Acreo headed the visual ergonomics portion of the standard and was also involved in determining limits for audio noise from the computer unit. This included the development of measurement methods as well as setting recommendations for the specifications. The ergonomic standard pioneered by TCO has evolved to become a de facto standard used world-wide with approx. 50% of all monitors sold bearing the label. Recent polls show that more than 80 % of Swedish customers feel that the TCO certification is important when buying a monitor.

Business Services – SME

Acreo has activities specifically directed towards small and medium size enterprises (SME). These programs include technology transfer to SMEs in the electronics and optics sectors with the purpose of creating growth and helping the SMEs become more competitive.

Assalub's CVLS lubrication gun developed in the IST project

Introducing electronics and embedded systems to SMEs outside the electronics sector makes it possible to create new intelligent products with enhanced features.

To help SMEs build up the competence needed to introduce and exploit electronics and embedded systems in their products, Acreo together with local universities inaugurated four competence centres for embedded systems during 2002 in Västerås, Norrköping, Jönköping and Halmstad. With support from the Knowledge Foundation (KKS) these so called "teknIQ" centres can provide education adopted to the specific needs of a particular SME.

The first step in a Competence project with an SME is a company audit where ideas for enhanced products and specific training needs are identified. Writing an action plan and the specifications for new products follows this step which initially is supported by the KKS.

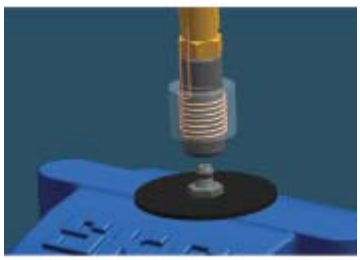
One very successful project involved Assalub in Åtvidaberg. The company had been marketing equipment for lubrication for several years. In a teknIQ audit in 2000 the idea of a Computerised Verifying Lubrication System (CVLS) was identified and followed by a competence project in 2001. Furthermore an IST project with financing from the EU and coordination by Acreo resulted in the presentation of a prototype of the new product in 2002.

A conventional lubrication gun was equipped with a sensor and electronics that can accurately measure and control the amount of grease delivered to a specific lubrication point.

Furthermore, every lubrication nipple is identified by RF-ID technology. Data is logged in the lubrication gun and can later be transferred to a PC. This makes it possible to keep track of the exact amount of lubrication delivered to each nipple and when this was done.

The software promises to be a very powerful tool in preventive maintenance and can thus create great savings - not only on lubrication usage through precise control of the amount delivered, but in for example a paper mill having several thousands of nipples, delivering the right amount of lubrication in the right time can prevent costly breakdowns.

Assalub will start marketing the unique CVLS product in 2003 and has greatly improved its competitivenses through the support of the teknIQ project. The support given has also considerably shortened the time-to-market compared to Assalub implementing this development alone.



Identification of each individual lubrication nipple with RFID (radio-frequency identification)

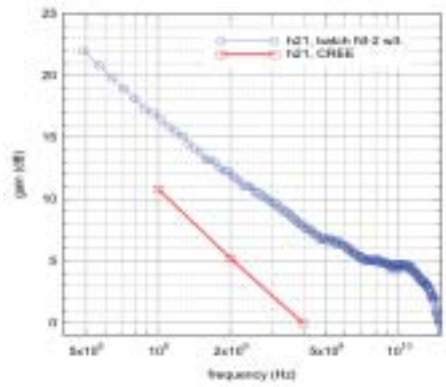
Core Competence
Semiconductor Device Processing

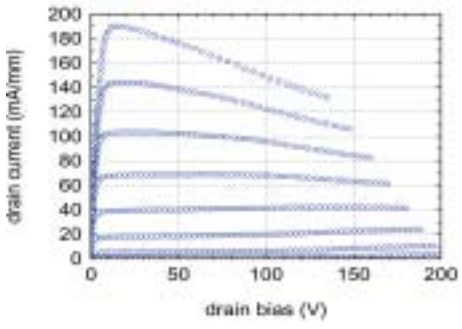
With advanced lab resources and a long history of R&D in semiconductor device process technologies in different material systems ranging from Silicon, Silicon Carbide to III/V Compounds, Acreo works with many different applications. Here we present some interesting results from our Silicon Carbide activities.

RF Power Devices

During 2002, Acreo and the spin-off company AMDS developed and produced SiC RF transistors which demonstrate a unique performance. These transistors combine a high breakdown voltage and high power output with a high frequency response.

High frequency characterisation showing cut off frequency f_T ~ 16 GHz





Measurement showing high voltage performance (Vbd>220V limit of meas.)

Silicon carbide is an ideal semiconducting material for the production of high power, high frequency, and high temperature electronic devices. Acreo has accumulated 10 years experience in design and processing of devices on this material. At the end of 2001 the spin-off company AMDS, Advanced Microwave Device Solutions, was launched to exploit the development carried out during the last 5 years of a high power, high frequency device which can enhance performance in telecom, microwave heating and lighting applications.

To achieve high power at high frequencies has been a desire of the microwave engineer for many years. The unique electrical properties of the semiconductor Silicon Carbide (SiC) open the possibility for a new era in solid state microwave power generation, allowing very high power levels at frequencies up to 10 GHz. SiC based devices have the prospect of making a major impact on what has been a difficult launch of 3rd generation mobile telecommunications. In addition, they open new possibilities for the multiband ideas of the 4th generation technology now being discussed. In parallel to the development for telecommunication applications, the prospect of replacing the magnetron that has been the cornerstone of microwave generation, in for example ovens, with a realistic and convenient semiconductor solution opens a diverse range of application areas and an enormous market potential.

During 2002 Acreo and AMDS worked together with the proprietary technology to bring the device nearer to commercialisation and this work has resulted in unique results. A number of batches with various improvements in design and process were realised.

A summary of on-wafer measurements from one batch is presented in the figure. The measurements illustrate state of the art performance for a high-voltage SiC RF transistor. This unique result is the combination of a high breakdown voltage while at the same time maintaining a high frequency response. The results shown are from a small transistor capable of approximately 5-8 W in output power. The larger transistors are still under evaluation, but are expected to reach the target for high power of around 50 W.

Custom SiC epitaxy services

Acreo's work with advanced SiC epitaxy technology reached internationally acknowledged results during 2002 and was successfully marketed as a custom design epitaxy service.

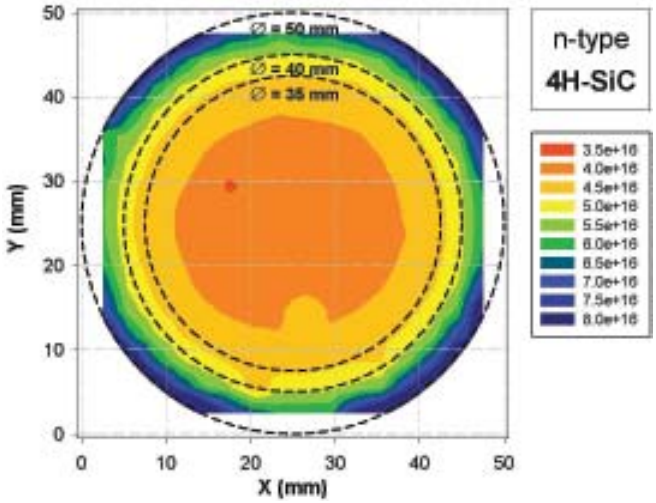
Working with SiC device technology aiming at FET RF, bipolar and power applications, Acreo is engaged in the development of the highly successful hot-wall silicon carbide reactor, which is commercialised by the equipment vendor Epigress AB in Lund, Sweden.

One of the advanced features of the epi system is an additional hot-wall reactor with substrate rotation, which improves thickness and doping uniformity of the grown layers.

Precision doping is up to date a challenge for the SiC technology, and Acreo can offer epitaxial layers with a wide range of controllable doping. Anything from low-doped n-type layers with high carrier lifetime for bipolar applications, to high-resistivity buffers can be supplied. Ohmic contacts can easily be realised with high doping levels sufficient for ohmic-as-deposited contacts using specific metallization. The excellent control of doping and thickness results in very good device performance, for example threshold voltages of FETs are typically kept within 10-20% of the target value.

Growth can be performed on various types of substrates including substrates with already processed device structures for advanced 3-dimensional device design and ion-implanted substrates. After epi-services Acreo can also provide support in prototyping, processing, and characterisation of devices and materials.

The custom epi facility at Acreo attracted international attention during 2002. We typically provide very cost effective solutions under strict confidentiality.



Graph showing typical doping uniformity for low concentration n-type doping in the CVD-reactor cell with mechanical rotation

Small Scale Manufacturing – Production Incubator

Many successful R&D projects are consecutively taken into production. Acreo can take on the responsibility of small volume production for the developed components and products. Start-up companies rely on Acreo's Production Incubator as a resource of great value.

When volumes become high Acreo will help its customers find a solution for mass production. As one of Acreo's core competences is Packaging Technology, we are frequently attacking cost and productivity problems.

Start-up companies in the phase of establishing their business idea rarely have their own labs. Acreo's advanced lab resources support innovative growth by offering start-up companies lab access for process development and personnel training.

In 2002, QWIP manufacturing ramped up and our production incubator was very important for the spin-off company Silex Microsystems.

QWIP

Acreo has been involved in QWIP research and development since 1986. Since 1992 FLIR Systems, FMV (Swedish Defence Material Administration) and VINNOVA (Swedish Business development Agency) sponsored an R&D project aiming to develop QWIP detectors and start up production.

In 2002 production of 320x240 pixel QWIP detectors for FLIR Systems was established and volumes ramped up. This detector type is now used in several IR-camera models by FLIR System: ThermaCAMTM SC3000, Therma Vision 2000, new triple-QWIP system, BIRC system and other FLIR Systems products.

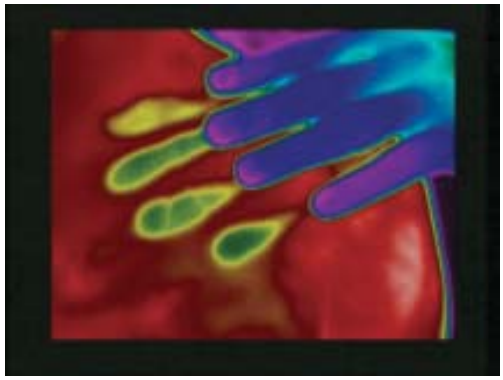
These cameras solve problems in many different applications, such as surveillance, process control, medical, research and development. FLIR Systems gained unique market position based on its advanced IR-camera systems and Acreo has become the number one supplier of detectors based on QWIP technology.

In order to meet the increased demand triggered by the high performance of the detectors produced by Acreo, further development and production projects are ongoing. During 2002 an important step was taken as the high resolution 640x480 pixel QWIP was brought into production.

Silex Microsystems

Silex is an Acreo spin-off company developing and producing MEMS-based components for applications in telecom, biotechnology and biomedicine.

Acreo's production incubator enabled Silex to introduce its products quickly to the market at the same time as new products were being developed and verified. Silex has doubled its turnover every year since its conception and is a good example of what we mean by innovation for growth.



Infrared image of the shoulder and hand of a human

Acreo Lab resources

Acreo's well-equipped lab and fab resources are important tools in our R&D activities.

Picture from transmission lab experiment

Acreo is certified according to the quality system ISO 9001:2000, which means that our lab activities comply to the highest standards and yield consistent results.

OSNL

During 2002 further improvements and substantial investments were made to our laboratories. The single most important event was the establishment of the Optical Systems and Networks Lab (OSNL). This includes; simulation tools for modelling of WDM systems, a complete transmission lab for 40 Gb/s WDM systems experiment and characterisation of EDFAs, SOAs, and Raman Amplifiers.

Semiconductor lab

Together wih KTH Acreo runs a semiconductor lab with a clean room area of more than 1000 m^2. Acreo's lab activities focused on component development and fabrication. During 2002 our commitment to fabrication was further strengthened as another 15% of the lab was dedicated for production.

Our unique position is related to wide processing capabilities, including several different component processes that run continuously in the laboratory. We offer process lines to fabricate devices in several material systems. The lab does not only provide pure front-end process facilities we also have back-end processes and access to various analytical instruments.

Interconnect and Packaging Lab – Polymer electronics

This lab comprises a clean room facility of 600m^2 and equipment for thin film and laminate substrate technologies with a focus on MCM solutions and polymer electronics.

A special feature is the capability to process very large substrates up to 600 mm x 600 mm and 150 mm wafers. Deposition of extremely thin metal layers on large areas is a vital capability in this context.

The position in Polymer Electronics will be even more advanced as the Swedish Research Council recently granted funds for investing in a printing machine to be adopted to polymers.

FiberLab

Our unique resource for the development and production of specialty optical fibers was inaugurated in 2001 and the increased pace of the research and development work during 2002 gave many pioneering results.

The FiberLab also has resoures for studies of basic material properties, such as photosensitivity and process techniques for fiber development and manufacturing. Besides fiber-making resources Acreo has a laboratory for post processing of fibers such as the fabrication of special fiber Bragg gratings. Our grating writing facility allows for the fabrication of long and complex-structured fiber gratings. It is possible to realize almost any phase and index profile.

Characterisation Labs

Supporting device development there are extensive resources for characterisation of different parameters to verify performance and design.

Our equipment for the characterisation of light scattering properties of different materials is a unique resource.

Innovation for Growth
– Industrial infrastructure for the future

During the last few years a great number of new companies were formed.
Due to the present market situation some of these are struggling to survive.
But there are a number of start-ups already showing a positive cash flow.

As pointed out in a report from VINNOVA* (Swedish Agency for Innovation Systems) these start-ups are the result of research activities founded several years ago. In particular, the support for applied research by the Swedish government in the period 1975 to 2000 is estimated to have had direct economical effects for the society in the order of 30 times the invested amount, considering optoelectronics only. In the period 2000-2002 the return on investment for government funding was 8 times in industrial turnover, excluding sales of spin-off companies. The process continues as recent investments and efforts in some companies will yield further growth in the future.

Acreo, together with the Royal Institute of Technology (KTH), Linköping Institute of Technology, and Ericsson and Telia, are the core base of these new and emerging clusters that are being formed.

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

*"Impact of problem-initiated R&D support from VINNOVA's predecessors" VINNOVA 2002.

Stockholm and Kista

Spin-off companies

- **ADC-Altitun:** tunable lasers[3)]
- **Proximion**: supervision of fiber optical networks[3)]
- **Silex**: production of micromechanical systems
- **Gnothis**: development of DNA-analysers
- **Inpact Microsystems:** custom design of system in a package[2)]
- **AMDS**, Advanced Microwave Device Solutions: RF-amplifier components.

Companies depending on the Acreo/KTH laboratories for their start up phase

- **Optillion**: fiber optic Ethernet transceivers
- **Comlase**: pumplasers for optical networks[3)]
- **Cobolt**: miniature solid-state 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[1)]
- **Addmarkable**: e-paper

Companies depending on Acreo and Acreo's laboratories

- **Thin Film Electronics**: development of mass memories based on polymer thin film technology

Lund

- **VIA-Technologies Design Center in Lund**, development of IC for wireless applications

closed in
[1)] 2001, [2)]2002, [3)]2003

Facts and Financing

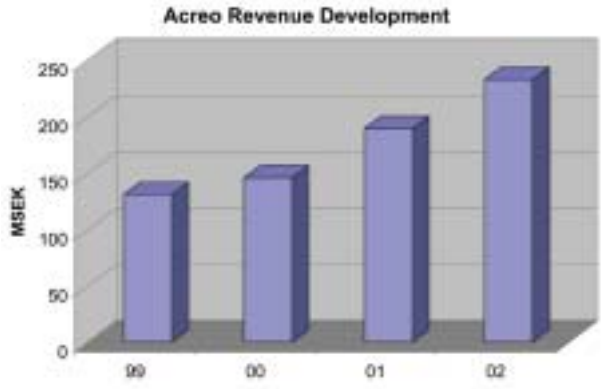
Acreo is a research and development company working in microelectronics and optics. The company is owned jointly by an industrial group, FMOF (60%), and the Swedish state-owned company IRECO (40%). Acreo has its head-office in Kista and branch offices in Norrköping, Hudiksvall, Jönköping and Lund.

Human resources

In 2002 Acreo had a staff of about 200 highly qualified scientists, engineers and support personnel, with a high proportion of graduate engineers and scientists, PhD candidates and PhDs. 28% of our employees are women, and 25% of non-Swedish origin.

Quality Certification

Acreo Kista and Norrköping are certified according to ISO 9001:2000.



Financial information

In 2002 Acreo´s revenues continued to increase rapidly with 23% to 232,8 MSEK and profit after financial items amounted to 0,1 MSEK. Industrial financing accounted for approximately 50 %.

Key figures (MSEK)	2002	2001	2000	1999*
Revenue	232,8	189,4	145,8	131,0
Profit/loss after financial items	0,1	1,2	3,8	-5,8
Share capital	15,5	15,5	15,5	15,5
Equity	24,5	24,4	24,0	19,1
Total assets	134,1	144,5	125,5	102,5
Total investment	15,0	49,5	26,4	38,8
Cash and bank balances	39,6	49,0	34,4	34,7
Equity/assets ratio	19%	18%	20 %	19%
Employees (year end)	202	179	142	127

* 1999 Revenue and profit after financial items for 1999 refers to IMC AB + AB IOF merged to form Acreo AB.

Acreo Organisation

Management Committee

Hans Hentzell, Managing Director
Magnus Breidne, Deputy Managing Director
Anders Josefsson, Marketing Manager
Mårten Armgarth, Sales Manager
Monica Lundquist, Financial Director

Patent Liaison

Anders Josefsson

Acreo e-mail addresses: first name.surname@acreo.se
(no å ä ö)

Departments

Business Services
Stellan Granström

Interconnect and Packaging
Per Dannetun

MicroTechnology
Christian Vieider

Optical Engineering
Jan Andersson

Photonics
Magnus Breidne

Semiconductor Lab
Wlodek Kaplan

QWIP Technology
Bernhard Hirschauer

System Level Integration
Magnus Danestig

Administration
Monica Lundquist

Marketing
Anders Josefsson

Board of Directors

Jan-Olof Andersson, Kitron Development AB*
Mietek Bakowski, Employee Representative*
Leif Bergström, Cambio Företagskonsult
Åsa Claesson, Employee Representative
Peter Holmstedt, Stiftelsen Electrum
Pentti Kölhi, Saab AB
Thomas Lewin, Ericsson Microwave Systems AB*
Hans Malmqvist, Consulting H Malmqvist AB
Mille Millnert, Linköpings Tekniska Högskola*
Claes Nycander, Telia Research AB*
Örjan Pettersson, SCA Graphic Research AB
Teresita Quinteros, Employee Representative
Daniel Selberg, Employee Representative*
Jane Walerud Boreta, Panoptic (from May, 2002)
Eva Westberg, Ericsson AB

*not available for the picture