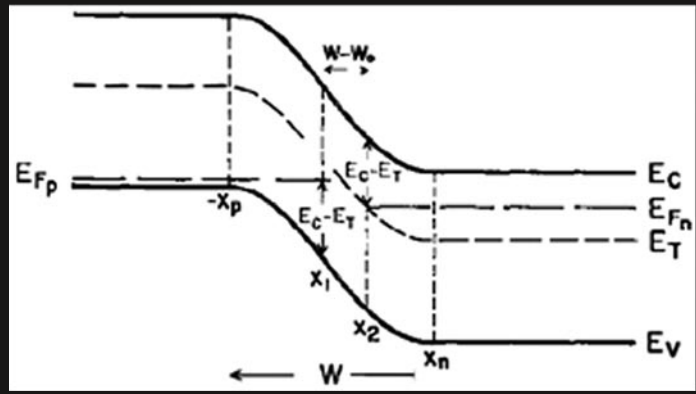


Semiconductor physics

How solid state physics came to Lund.









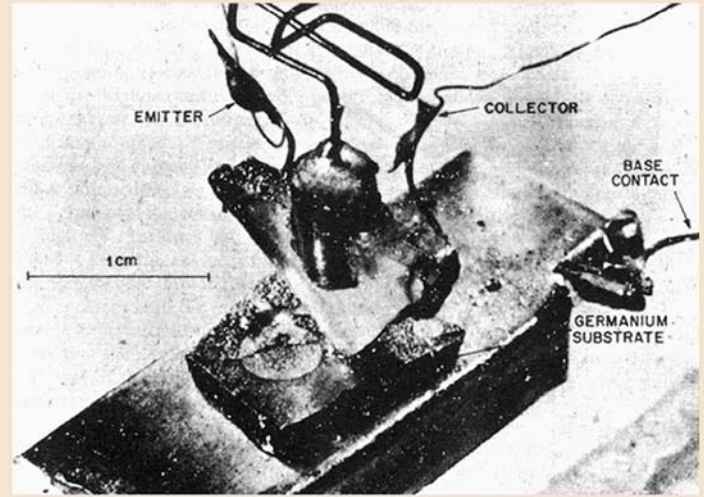



The transistor

Research into metals in the field of solid state physics was already being performed in the 1910s. Janne Rydberg's PhD student, Gudmund Borelius, was a pioneer in the field in Sweden. However, in 1922 he left Lund to take up a Professorship in Physics at the Royal Institute of Technology (KTH) in Stockholm.

What later came to be called *the electronic revolution* started with the realization of the transistor in 1947. A new era in semiconductor physics had arrived.

However, there was still no organised research in semiconductor physics in Sweden at the beginning of the 1960s.

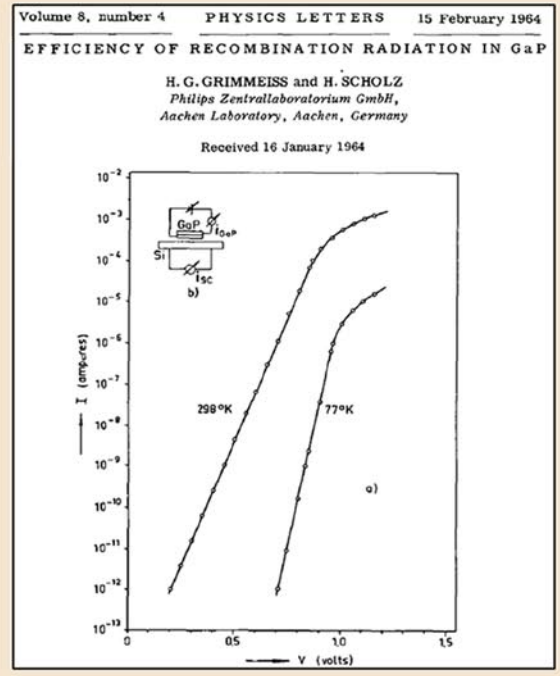


The successor of the electronic valve, the transistor, was first successfully fabricated at Bell Laboratories in 1947 by William Shockley, John Bardeen, and Walter Brattain. Today, transistors are integrated into practically all modern electronics.

A new professorship

Hellmuth Hertz realised the importance of semiconductors in the field of solid state physics and convinced the powers at LTH that a new professorship was required.

Upon the recommendation of Hertz, a researcher at Philips in Aachen, with considerable experience in semiconductor physics, especially light-emitting diodes, applied for the position. In 1965 Hermann Grimmeiss was appointed Professor in Solid State Physics at LTH.



Volume 8, number 4 PHYSICS LETTERS 15 February 1964

EFFICIENCY OF RECOMBINATION RADIATION IN GaP

H. G. GRIMMEISS and H. SCHOLZ
Philips Zentrallaboratorium GmbH, Aachen Laboratory, Aachen, Germany

Received 16 January 1964

Henry Joseph Round had already created the first light-emitting diode (LED) using silicon carbide in 1907, but it took another 50 years for it to become of any practical use. The first LEDs based on gallium phosphide that found practical applications were reported by Grimmeiss in 1964.

A new division

Members of the Division of Solid State Physics in 1968.

From left to right: Lars Ask, Bo Monemar, Mats-Ola Ottosson, Hermann Grimmeis, Gunnar Björklund, Rune Olsson, Lars-Åke Larsson, Lars Andersson och Erland Ejder.

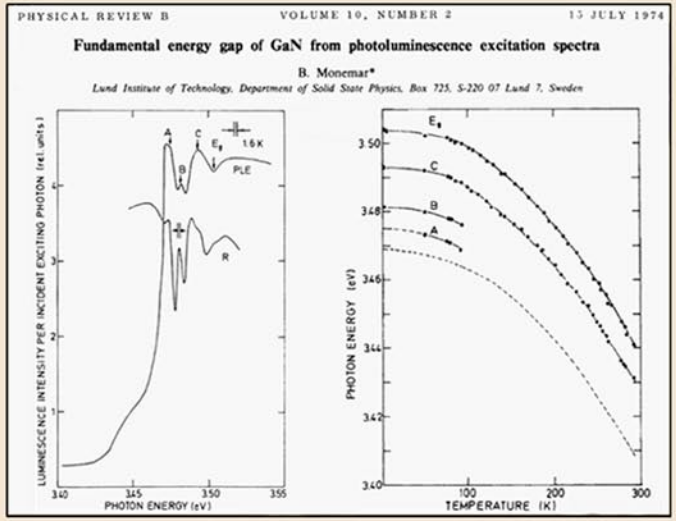
Hermann Grimmeiss arrived in Lund in 1966, and the new Division of Solid State Physics was located in Building A.

Courses in solid state physics were developed, and the nuclear physicist Lars Ask was employed as the lecturer responsible for undergraduate teaching in the subject.

Most of the literature in the subject was only available in German, so Lars set about translating it into Swedish.

An instrument maker was employed and, with a budget of 280,000 SEK, the division's first purchase was a spectrometer.

New research



PHYSICAL REVIEW B VOLUME 10, NUMBER 2 15 JULY 1974

Fundamental energy gap of GaN from photoluminescence excitation spectra

B. Monemar*

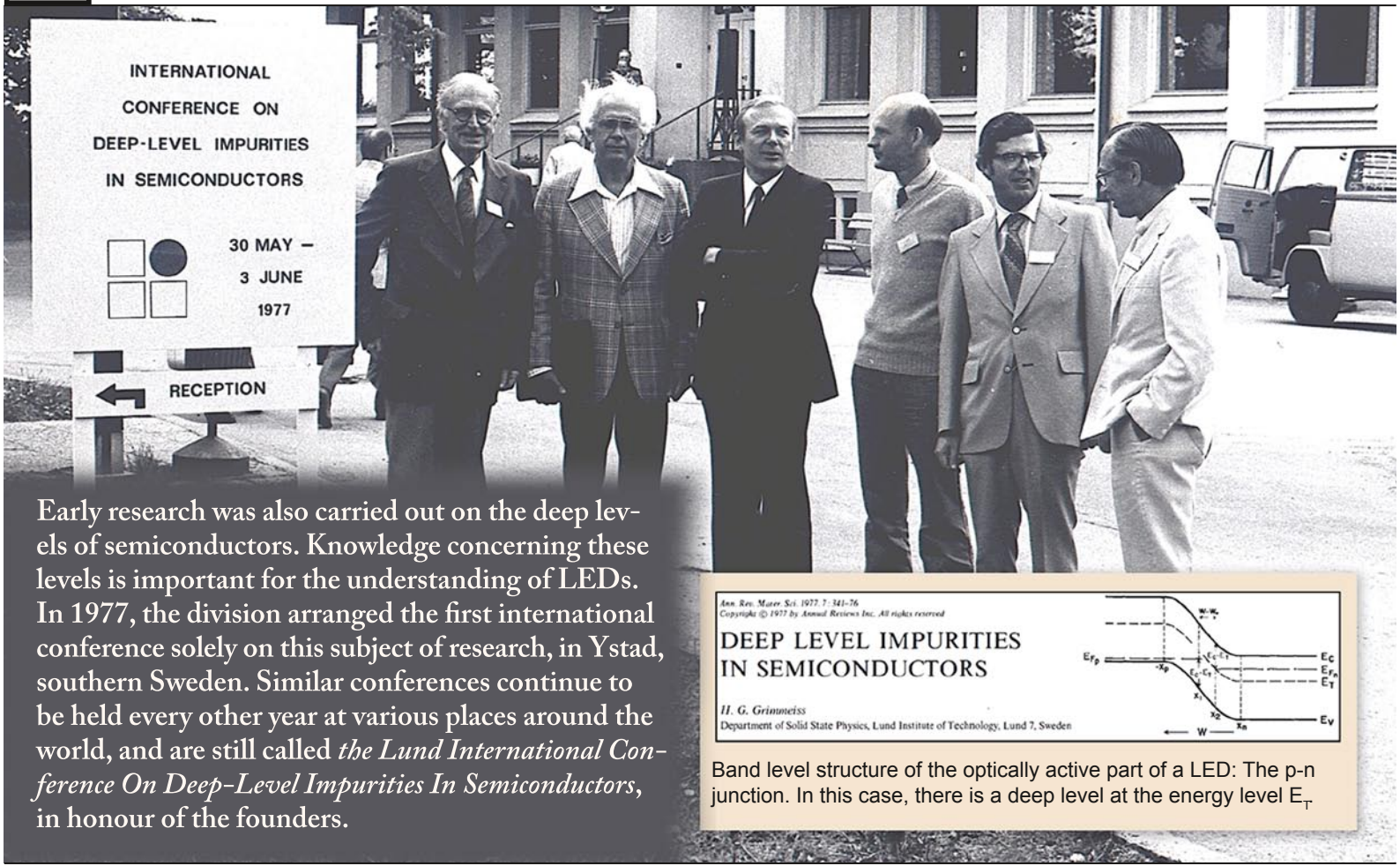
Lund Institute of Technology, Department of Solid State Physics, Box 725, S-220 07 Lund 7, Sweden

In 1974, Bo Monemar published an articel on the band gap in gallium nitride. This is still one of the division's most cited publications.

Research at the new division grew rapidly, and was directed towards two main areas: Electric and photoelectric studies of defects in semiconductors, led by Hermann Grimmeiss and Stellan Braun, and optical properties of semiconductors, led by Hermann's first PhD student, Bo Monemar.

In 1972, Bo recruited his first PhD student, Lars Samuelson, who joined the optics group.

Deep levels



Early research was also carried out on the deep levels of semiconductors. Knowledge concerning these levels is important for the understanding of LEDs. In 1977, the division arranged the first international conference solely on this subject of research, in Ystad, southern Sweden. Similar conferences continue to be held every other year at various places around the world, and are still called *the Lund International Conference On Deep-Level Impurities In Semiconductors*, in honour of the founders.

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DEEP LEVEL IMPURITIES
IN SEMICONDUCTORS

H. G. Grimmeiss
Department of Solid State Physics, Lund Institute of Technology, Lund 7, Sweden

Band level structure of the optically active part of a LED: The p-n junction. In this case, there is a deep level at the energy level E_T

Politics and microelectronics

In the 1970s, Hermann realised that more effort should be devoted to microelectronics, as a result of the electronic revolution.

New labs and resources were needed, and at the beginning of the 1980s, the Minister for Industry, Thage G Pettersson, agreed, and grants were awarded for the building of new facilities.

The Swedish Government's decision was probably helped along by the high level of unemployment in the building sector at that time.

Politicians and researchers started to meet more often during the electronic revolution.

In 1980, (from left to right) professors Karl Johan Åström and Hermann Grimmeiss, LTH, Swedish Prime Minister Tage Erlander and his wife, Aina Erlander, Minister for Education Carl Tham and Swedish physicist and professor in material science at Stanford Stig Hagström meet in Bommersvik for discussions.

The division gets a new home

Inaugural speech
to a packed auditorium.

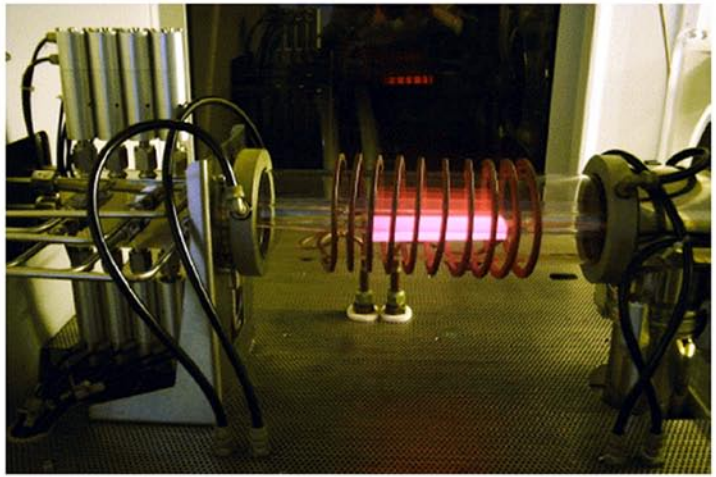
Hermann and Thage.

Hermann Grimmeiss, Bengt Edlén
and Nils Stjernquist at the turf-cutting ceremony.

Work began on the new facility for solid state physics, The Berzelius Lab, named after Jöns Jakob Berzelius, the Swedish chemist who, in 1824, was the first to produce pure silicon. Apart from offices, the new wing of the Department of Physics was to include a modern research laboratory.

The building was inaugurated on 24th May 1984, by the Minister for Industry, Thage G Petterson, with the aid of liquid nitrogen!

A new tool



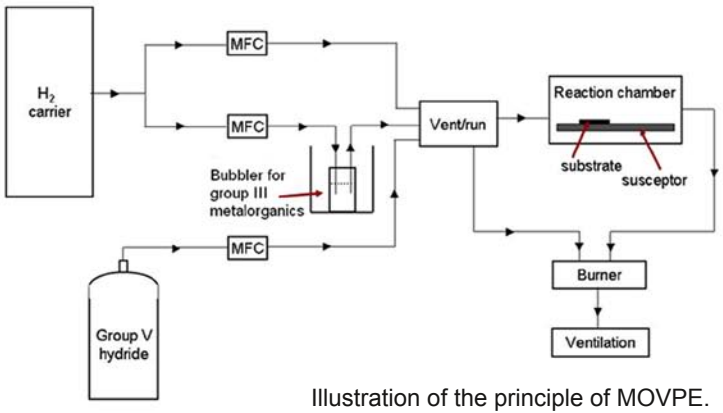
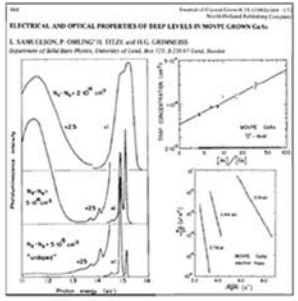


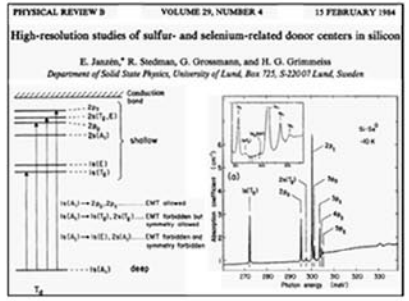
Illustration of the principle of MOVPE.

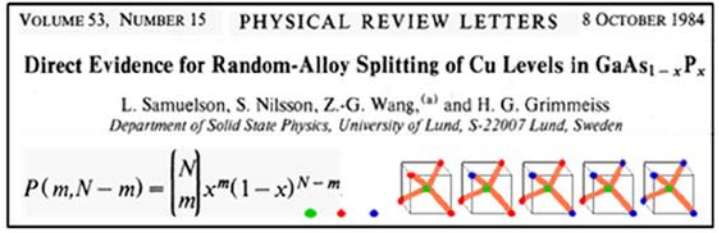
At the beginning of the 1980s, Lars Samuelson started to produce new kinds of materials using an important new method called metal-organic vapour phase epitaxy (MOVPE). With this method, it is possible to tailor semiconductor materials to specific requirements.

The name of the method, epitaxy, is derived from the Greek, *epi* meaning above, and *taxis* meaning in an ordered manner, and makes use of chemical reactions between gas phases.

MOVPE gives results





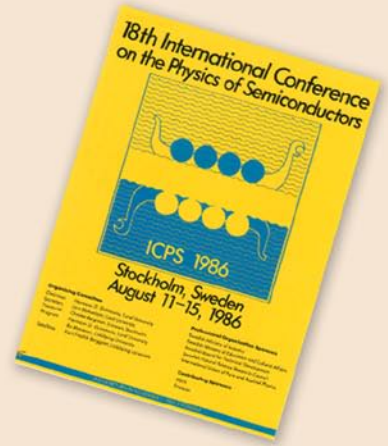


New fields of research were developed, including Fourier-transform infrared spectroscopy and molecular spectroscopy in semiconductors.

Researchers at the Division of Solid State Physics in Lund were the first in the world to carry out experiments on deep levels with a resolution below 1 meV, and to demonstrate and identify molecular defect configurations in semiconductors.

International recognition

Prins Bertil, Hermann Grimmeiss and Lars Samuelson.



In 1986, Hermann Grimmeiss and his researchers arranged the renowned international semiconductor conference, ICPS, in Stockholm.

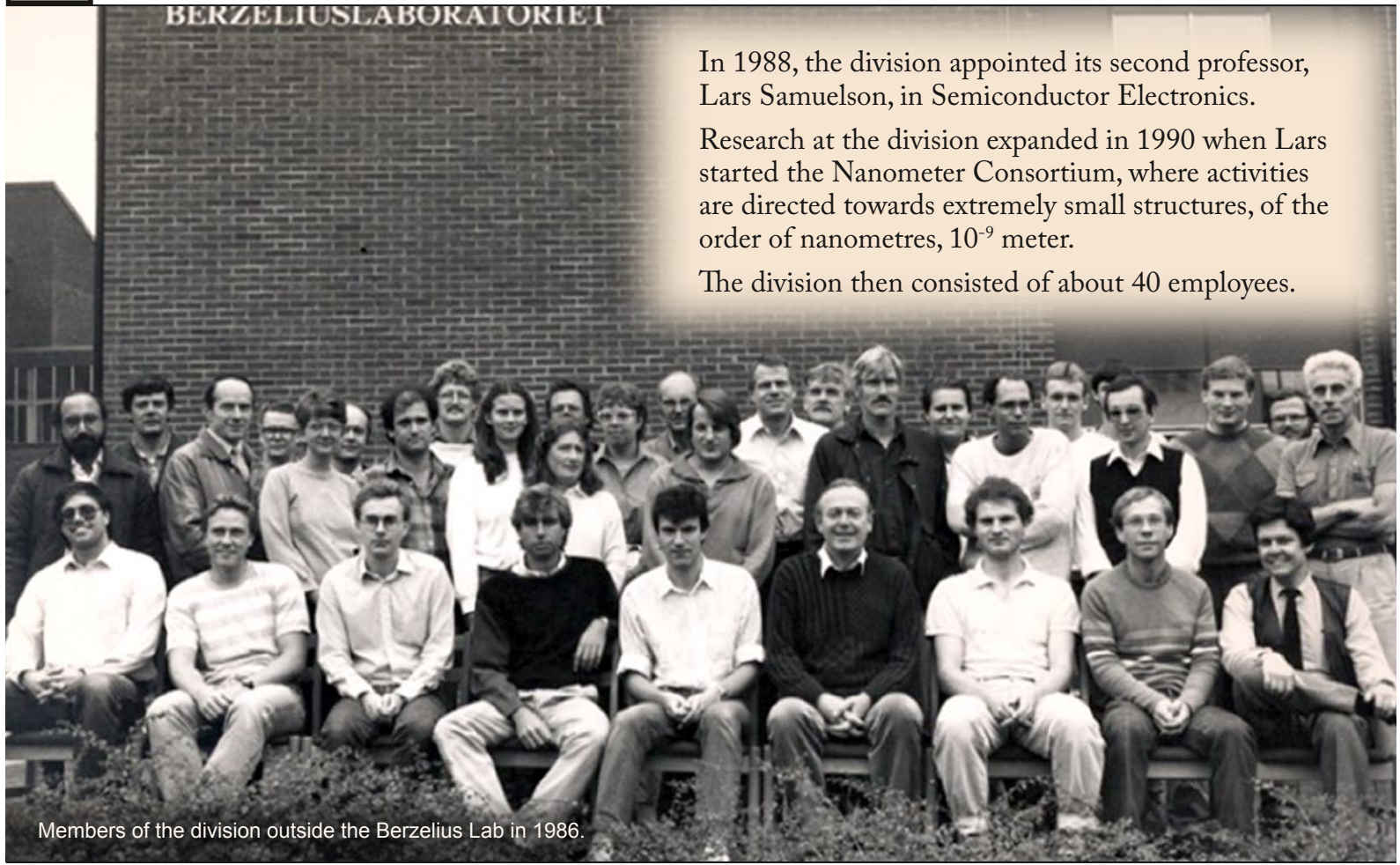
Among the 1 100 participants were guests of honour such as Prince Bertil of Sweden and the Nobel Prize winners Kai Siegbahn and Klaus von Klitzing.

Solid State Physics expands

In 1988, the division appointed its second professor, Lars Samuelson, in Semiconductor Electronics.

Research at the division expanded in 1990 when Lars started the Nanometer Consortium, where activities are directed towards extremely small structures, of the order of nanometres, 10^{-9} meter.

The division then consisted of about 40 employees.



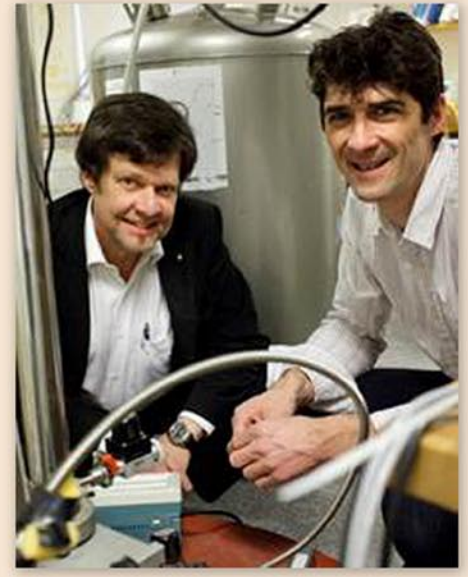
Members of the division outside the Berzelius Lab in 1986.

A change in leadership

After 30 years at the helm, Hermann Grimmeiss retired in 1996, and Pär Omling was appointed Professor in Solid State Physics, and Head of Division.

Five years later saw another change in leadership as Pär was appointed Director General of the Swedish Research Council, and Lars Samuelson took over.

In 2010, Heiner Linke became Head of Division, and three years later he handed over responsibility for the division to Dan Hessman, and took over as coordinator of the Nanometer Consortium after Lars.



Lars Samuelson and Heiner Linke.