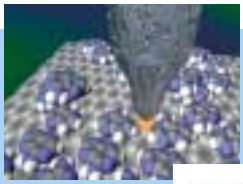
Nanotechnology – Exciting Insights and Novel Products

It all began on 29 December, 1959 when the American Physicist and later on Nobel Prize Winner, Richard P. Feynman, spoke at the American Physical Society. In his presentation 'There is plenty of room at the bottom', he described a vision, the production of the tiniest systems ever, using techniques in the nano cosmos, on a scale within millionth's of a millimetre.
Today's advances in research and development indicate that nanotechnology will form the future of technological quantum leaps – from material sciences to electronics, from analytics to biosciences. The future potential of nanotechnology is addressed in reports from the scientific technical advisory board of the Bavarian State Government to the Economist, a truly international business journal.



Fascinating insights: Nanomanipulation of molecules with a scanning tunnelling tip (GeoBio-Center, University of Munich)

Novel piezo electric motor for nanopositioning (attocube systems AG, Munich)

There are 2 principal approaches within nanotechnology – 'top down' in physics and 'bottom up' in both physics and chemistry.
The top down approach focuses on the miniaturisation of structures and microtechnological processes. Examples here include semiconductor electronics. According to Professor Ebeling, Corporate Research, Infineon and Ulm University, 90 % of these elements contain nanostructures.
A model example for the bottom up approach is the use of molecular modelling to design and produce liquid crystals. Using these methods, liquid crystals in nano dimensions with unique optical characteristics can be realised. Their application for a new generation of television screens and monitors won Merck KGaA the German Future Award 2003.
The discovery of the scanning tunnelling microscope by Gerd Binnig and Heinrich Rohrer formed the basis for the rapid development of nano tools such as the nanomicroscope designed by Professor Heckl from the University of Munich. These tools allow the observation and manipulation of complex atomic and molecular structures.
'Of course nano defined isn't just small, its also different' to quote Professor Kotthaus, Speaker of the Center for NanoScience at the University of Munich. Nanoparticles demonstrate distinctive characteristics such as an increased mechanical stability, modified electrical properties and chemical selectivity within the surface structure.
The unique properties of carbon nanotubes are an excellent example. The latest applications of nanotechnology include the improvement of windscreen thermal insulation by silver coating, varnishes containing nanoparticles to protect damageable surfaces, lab on a chip technology for high throughput analysis in the pharma industry, bio-nanomineralisation for the hardening of tooth enamel or nano-engineered systems.

A teaming up of disciplines, from left: Dr. Henco, Evotec OAI (Drug Discovery), Prof. Domdey, Bio^{M} (Biotech), Prof. Nassauer, Bayern Innovativ (Technology Transfer), Prof. Heckl (Nanobiotech) and Prof. Kotthaus (Nanoelectronics), both CeNS, University of Munich

As State Minister Dr. Otto Wiesheu expounded upon in a press statement from 26 October 2003, Bayern Innovativ will extend its support of nanotechnology in 2004, both as a science as well as its economic implementation.

Trends in Nanotechnology

LifeScience

BAIKEM

New Materials

Nanobiotech – Discoveries and Applications

Nanotechnology is enabling new and exciting ways to directly observe biological molecules, their surface properties and their interactions. Professor Gaub, University of Munich, has designed a process to measure the interactions between biological molecules such as DNA or receptors and active substances. The resulting information could provide important clues for the development of new drugs.

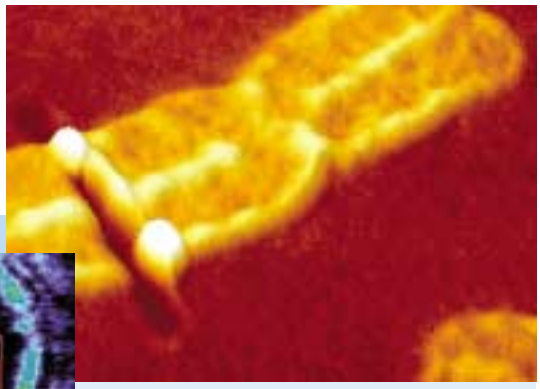
Interactions between biomolecules also form the basis of bottom up, self-assembly processes such as in biological membranes. Professor Sleytr from Vienna, utilises reproduced bacterial membranes to develop extremely sensitive biochips with, for example, incorporated ion channels. These are important for ion exchange within biological systems.

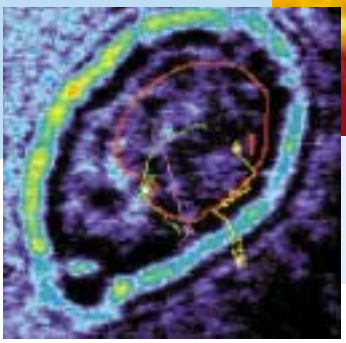
Nanion Technologies GmbH, a spin off from the Center for NanoScience, University of Munich is transferring patch clamp technique into a high throughput system, to examine the influence of new drug candidates on ion channels. This is a further way of assessing drug effectivity.

Modern drug development involves the screening of a multitude of potential lead candidates.

Nanofluidics coupled with miniaturisation and parallelisation enables the conducting of more than 200,000 experiments a day.

Advances in nanofluidics allow the development of lab on a chip systems that can tackle the transport and mixing of nanolitre sample volumes.





top: Nanodissection of human DNA (GeoBio-Center, University of Munich)

bottom: Using nanotechnology to image viruses infecting a cell in real time (Virus Tracing Group, Munich)

Advalytix AG in Munich/Brunnthal have developed nanopumps. These pumps can precisely move nanolitre droplets on biochips thus controlling mixing and subsequent chemical reactions. The movement is generated by 'nanoquakes' on the chips surface, using surface acoustic waves.

Continuing in this theme, Evotec OAI in Hamburg has developed a commercial system, based on the findings of Professor Fuhr, Fraunhofer Institute for Biomedical Engineering (IBMT), St. Ingbert that allows the touch free manipulation of individual cells. This system means that only nanolitre quantities of reagent and sample amounts are required – a valuable trait for instance when dealing with clinical diagnosis and the taking of biopsy material.

P.A.L.M. Mikrolaser Technologies AG in Bernried, have developed through advanced laser technology, a method that can beam and aim living cells onto a chip as well as into a sample plate – without touching the cells.

Nanotechnology has also successfully been used to elucidate systemic associations in biological processes. Professor Bräuchle, University Munich, applied single molecule spectroscopy and succeeded in visualising the infection pathway taken by individual viruses on their invasion of a living cell. This information could further the development of novel antiviral drugs.

The broad range of insights achieved through nanotechnology and its application in biotech was the focus of the 'Biotech meets Nanotech' cooperation forum in October 2002 in Munich.

This successful platform will be followed by a further forum in the near future.

'Nanotech meets Biotech' October 2002, Munich

top: Dr. Schütze, P.A.L.M. Mikrolaser Technologies, presented applications of lasertechnologies for single cell handling

bottom: Dr. Gauer demonstrated the lab on a chip system equipped with nanopumps from Advalytix

Nanoelectronics – New Dimensions for the Semiconductor Industries

The International Technology Roadmap for Semiconductors (ITRS) is an assessment of semiconductor technology requirements and developments. Objectives include ongoing increases in computing power and storage density as well as lower energy consumption.

Visiting the chip production facilities of Infineon Technologies AG, Regensburg during the Forum 'Mobile Communication Technology', February 2003

These developments will form the basis of new generations of computers and mobile devices.

Today's elements, e.g transistors, are composed largely of silicone and contain layer structures on the atomic scale. Current processes achieve lateral structures of 130 nm. Taking structures below 100 nm will mean entering the true nano cosmos. Nanotechnological effects will have a stronger influence on the properties of semiconductor devices. The production of this new generation of components will require novel processes. These include the improvement of lithography processes by means of light sources with shorter wave lengths (such as extreme ultra-violet) or ion beams.

The Fraunhofer IISB Institute in Erlangen is developing simulation tools for these novel processes. The results obtained form the basis of technical realisation making the implementation of new production processes more efficient and consequently improving market entry opportunities.

Quality control at each individual process step is essential for the production of semiconductors.

Nanotools GmbH in Munich is a start up company that provides leading technology in this sector. The unique 1 µm long needle, with a diameter of just 90 nm, used in atomic force microscopes, will enable new standards of quality control.

Nanotips for diagnostics of surface structures (nanotools GmbH, Munich)

US-Delegation of the Nano Business Alliance visiting a laboratory at the University of Munich

Delegation members from the Nano Business Alliance, New York were extremely impressed by the developments they saw during a visit to Nanotools as part of a tour organised by Bayern Innovativ in September 2003.

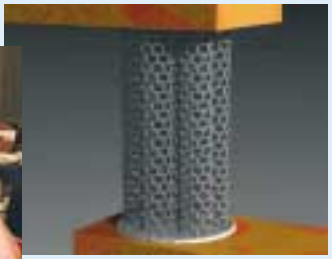
The self-assembly of nanostructures as a bottom up approach is also important for future semiconductor technology. At the Forum 'Innovations from Eastern Europe – Nanoanalytics Nanoelectronics', May 2003, Dr Hönlein, Infineon Technologies AG, Munich reported on carbon nanotubes grown on wafers at predefined points. Infineon says the first possible application of the technology is in vias – the junction between two metal layers in integrated circuits. Advantages over conventional metal junctions include reduced heating combined with improved mechanical stability.

Professor Abstreiter, Walter-Schottky-Institute at the Technical University Munich, investigates the properties of quantum dots. These are obtained by self-assembling processes and are comprised of just a few atoms. Just by changing the number of atoms involved, the physical characteristics can be defined and altered. Professor Abstreiter reports that the wavelength of future lasers could be defined by the number of atoms per quantum dot. This process could be carried out in reverse, with optical excitation of the quantum dots resulting in a unique photodiode effect (Nature 418, 2002).

Much further on in the future of nanoelectronics, it is hoped that a replacement for silicone through organic materials could be found. These materials could be used for example as single molecule transistors, uniting nanobiology and nanoelectronics. So called molecular electronics is considered by many experts as a major change in technology and is to be compared to the replacing of tubes by transistors.

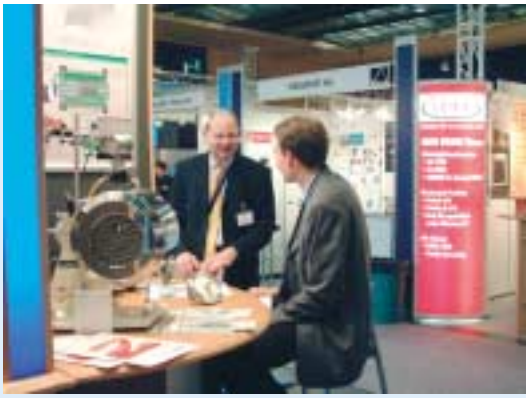
Nanoanalytics – Nanoelectronics, Munich, May 2003

Dr. Hönlein, Infineon presented the use of carbon nano tubes as vias in semiconductor devices (Infineon Technologies AG, Munich)



left: Members of the Russian delegation in the audience

Nanomaterials – Perspectives for Products and Markets



Dr. Schütz, Future Carbon and Dr. Jung, Netzsch exhibitors at the Bayern Innovativ stand at the Nanofair 2003, St. Gallen

Nanomaterials with particles or layers less than 100 nm are an important application of nanotechnology. The unique properties of these materials are based on their high surface to volume ratio. Nanomaterials are used for example as additives or as ultra thin coatings to achieve new functional properties. At the Nanofair 2003 in St. Gallen, innovative companies had the opportunity to present their market ready developments on the Bayern Innovativ joint stand.

The company NETZSCH Feinmahltechnik GmbH, Selb introduced their proprietary ball mill that can grind powder to nanoscale. This top down process can be used to produce nanoparticles for example as additives for long life tyres, scratch proof lacquers or improved fuels. Nanoparticles can also be obtained bottom-up, by deposition out of gases or liquids. The nanoparticles selfassemble due to interactions between the atoms or molecules.

This technology is used by Future Carbon GmbH in Bayreuth, who also exhibited at the Nanofair. They produce carbon nanotubes and special graphite structures. These are used for fuel cells and batteries, as a component of polymers to enhance conductivity and as a storage material for hydrogen.

Strategies for Future Cooperations and Network Activities

Interdisciplinary collaboration in nanotechnology will lead to new insights in science, to the development of novel technologies as well as to innovative products and processes.

This will be supported by Bayern Innovativ with the following strategies:

- In house team of physicists, material scientists, biochemists and pharmacologists
- Focusing of activities according to: Nanomaterials, Nanoelectronics, Nanobiotech
- Close cooperation with industry and science e.g. the Universities of Munich, Concern Nanoindustry, Moscow and Center of Excellence in New Materials, Bayreuth
- Conception of tailor made cooperation platforms for industry and science
  - Dissemination of the latest research results
  - Technology transfer for the development of innovative products
  - Presentation of marketable products and processes at international trade shows

Coming Next

The congress 'Material Innovativ' on the 10 March 2004 in Würzburg:

Opening speech by Dr. Otto Wiesheu, the Bavarian State Minister for Economic Affairs, Infrastructure, Transport and Technology.

Nanomaterials and their applications in the automobile and aircraft industry as well as in mechanical engineering will be a major part of the congress.

Platforms Nanoelectronics and Nanobiotech will follow later in 2004.

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