Focus on Polymer Science and Technology

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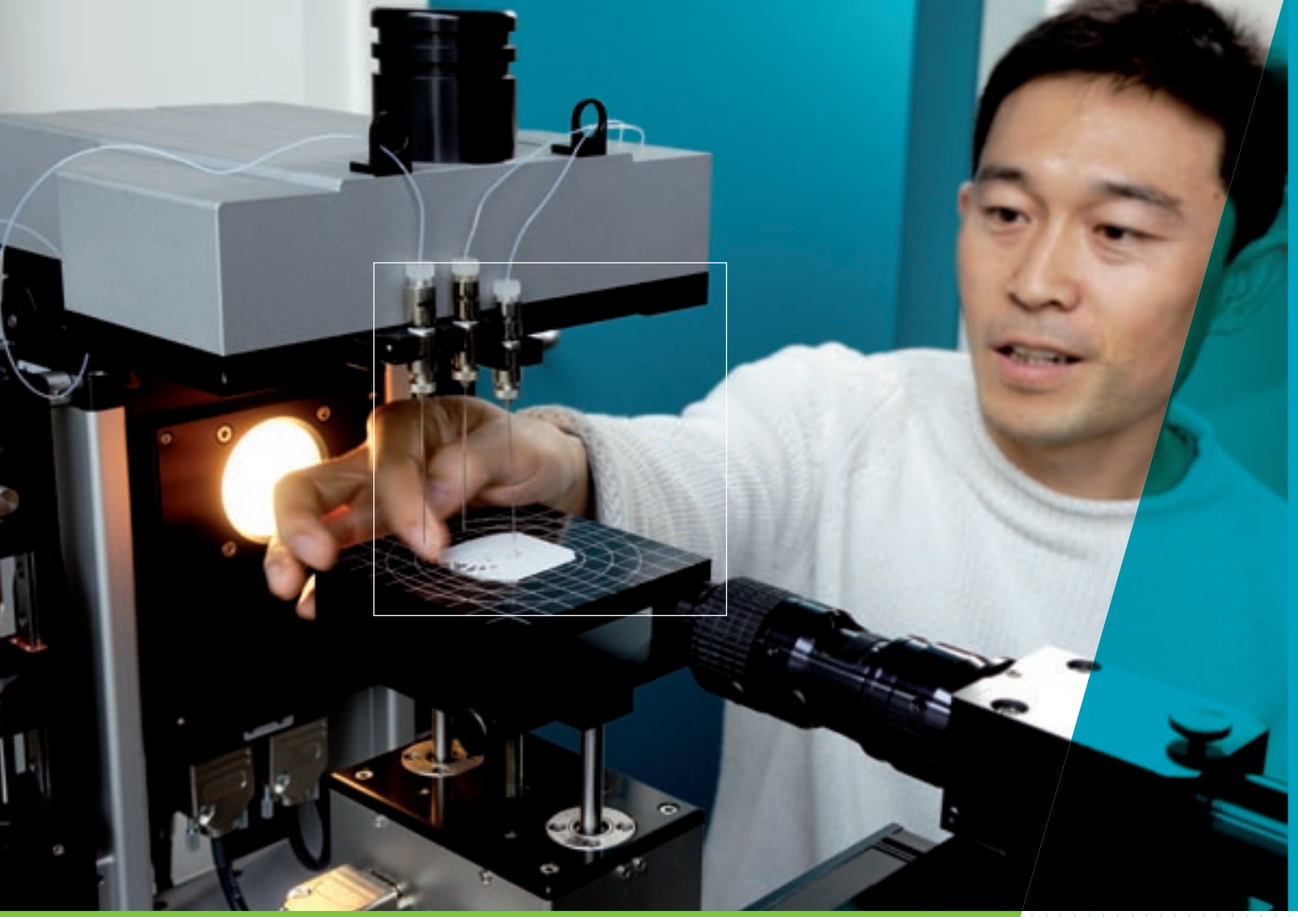
Where innovation starts



Polymer Science and Technology in brief

The polymer research at TU/e is built upon three focus areas:

1. Macromolecular synthesis and design using supramolecular chemistry
2. Design of structures and advanced structure characterization
3. Modeling of structure development and the relation between structure and properties.

TU/e conducts eight research programs within these focus areas. The chain-of-knowledge approach underlines all polymer research activities at TU/e. This approach is built upon the conviction that successful research and innovation in polymer science and technology can only be realized if they focus on the total chain, from monomer synthesis to processing and design.

Coordination and chairs
Coordinator of the research area: Prof.dr.ir. Han Meijer

The following TU/e departments conduct research on Polymer Science and Technology:

Chemical Engineering and Chemistry
- Macro-Organic Chemistry
- Functional Molecules and Molecular Materials
- Supramolecular Polymer Chemistry
- Macromolecular Chemistry and Nanoscience
- Polymer Chemistry
- Polymer Technology Group

Applied Physics
- Theoretical and Polymer Physics

Mechanical Engineering
- Polymer Technology

Biomedical Engineering
- Biomechanics and Tissue Engineering

Participating departments and full chairs

Chemical Engineering and Chemistry
- Prof.dr. Bert Meijer
- Prof.dr.ir. René Janssen
- Prof.dr. Rint Sijbesma
- Prof.dr. Ulrich Schubert
- Prof.dr. Cor Koning
- Prof.dr. Piet Lemstra

Applied Physics
- Prof.dr. Thijs Michels

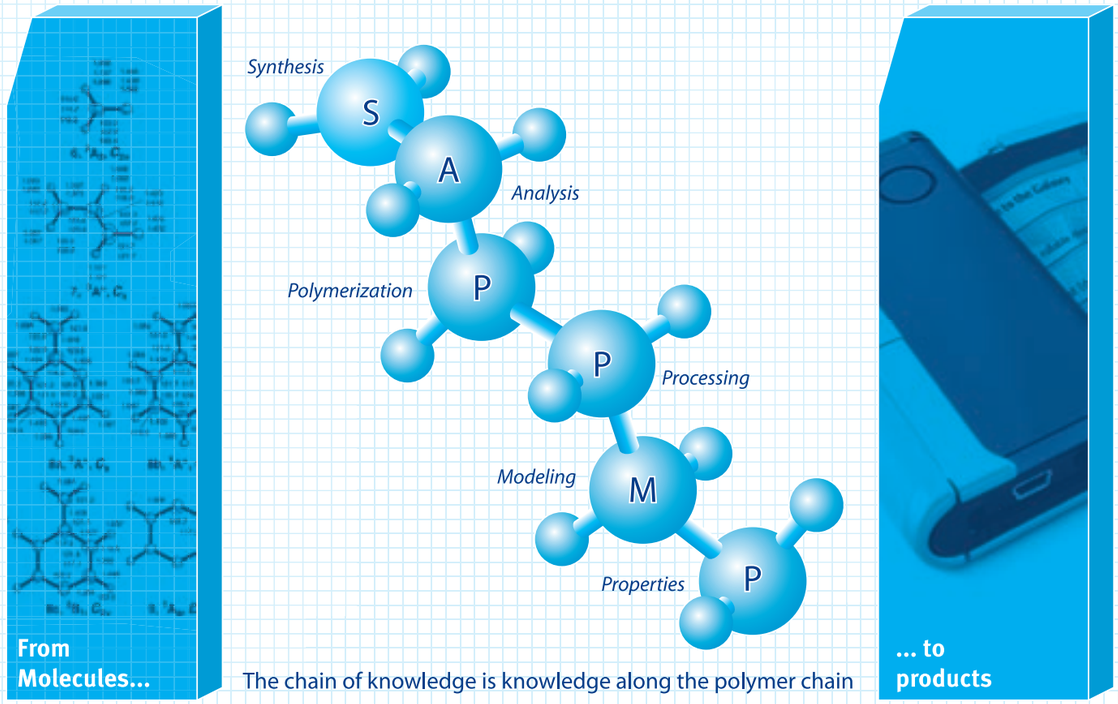
Mechanical Engineering
- Prof.dr.ir. Han Meijer

Biomedical Engineering
- Prof.dr.ir. Frank Baaijens

Participation in (top)institutes and research schools

Eindhoven Polymer Laboratories (EPL), Dutch Polymer Institute (DPI), Polymeer Technologie Nederland (PTN), COBRA, Schuit Katalyse Instituut (SKI), National School of Research in Theoretical Physics and the Center for NanoMaterials (cNM)

Front cover: Polymers are visco-elastic and combine fluid and solid behavior, visualized here after a stirred flow.



The chain of knowledge is knowledge along the polymer chain

A Polymer Powerhouse at TU/e

“We have chosen a multi- and interdisciplinary approach to studying polymers at TU/e. This approach is characterized by sharing expertise, state-of-the-art laboratory facilities and problem-solving capabilities within a critically acclaimed polymer research group. Our group consists of renowned professionals working together to help one another. The close proximity of offices and labs on campus helps stimulate cooperation and personal contacts within the team.”

Although he dislikes the word ‘culture’, professor Han Meijer is convinced that the atmosphere in the Polymer Science and Technology group has been responsible for the fast growth of the research on polymers in past years. Meijer: “Without a doubt, polymer science and technology has increased almost exponentially at the TU/e campus over the last decade. The various polymer groups within the departments of Chemical Engineering and Chemistry, Applied Physics, Mechanical Engineering and recently the Department of Biomedical Engineering, expanded in size due to funding from new and existing funding schemes as well as, notably, the Dutch Polymer Institute. We are proud that polymers have become one of the most profound priority areas of research at TU/e. Our aim is to establish a “Polymer Powerhouse” – a typical phrase of our founding father professor Lemstra – at TU/e that is second-to-none in the academic world.”

‘Our research so far has resulted in molecular design for a multitude of applications’

Mimicking nature

The scientific challenges within Polymer Science and Technology concern the design of new synthesis routes. These routes yield new oligomers or polymers that are aimed to be self-assembly, mimicking the tools of nature. Meijer explains this approach: “Our research so far has resulted in molecular design for a multitude of applications. In close collaboration with industrial partners, we developed methods for drug delivery to gels, new inks and adhesives and the construction of cardiovascular tissues.

Furthermore we focus on how polymer systems can be designed for optimal use in new polymer electronics and light applications. Famous are our hydrogen bonding-based molecular suprastructures that can be (self-) assembled for similar applications.” His colleague, professor Bert Meijer (not related), received the Dutch NWO/ Spinoza Prize in 2001 for his excellent research on supramolecular polymers. Han Meijer continues: “Apart from the design, we are still interested in how even bulk polymers with accurate molecular characteristics can be constructed in a cost-effective and environmentally-friendly way. And of course, advanced characterization techniques are used and developed for all these research areas. Apart from this chemistry-focused research here in Eindhoven, we also have unique expertise in coupling numerical techniques to quantitatively predict the resulting structure property relations of all length scales of polymers. Our infrastructure in terms of scientific equipment and computational tools is almost unparalleled in the academic world.”

Medical Technology

Whereas polymers are usually associated with bulk products and plastics, future developments will be in the area of (bio)medical applications on micro and even nanoscale. Functional polymers, biosensors and micro devices will consist of new polymers which can be manipulated in many different ways. Meijer is enthusiastic about this field of interest: “At the moment the industrial and societal needs are very much focused on medical technology. Our expertise on supramolecular polymers, tissue engineering (concerning artificial heart valves), drug delivery devices and microfluidics will lead us to new scientific and industrial partners and new ways of funding. For polymer sciences, a new era lies ahead of us.”

Résumé Prof.dr.ir. Han Meijer

Han Meijer is full-time professor in Polymer Technology. He received his PhD from the University of Twente in 1980. He joined DSM research, and was active in the area of Basic Research, Polymer Processing Modeling and Explorative Research. In 1985 he became part-time professor at TU/e at the department of Polymer Chemistry and Technology in the area of Applied Rheology. In 1989 he became full professor in Polymer Technology in the group Fundamental Mechanics of the department of Mechanical Engineering. His present interests include structure development during flow and structure-property relations, micro-rheology and microfluidics, micro-macro-mechanics, modeling of polymer processing and design in polymers.

New products with enhanced properties

Polymers are by far the most important materials used in our daily products. Wherever you are, you will be surrounded by or using polymer products. All kind of plastics, fuels, fibers and coatings consist of polymers. For this reason chemists, physicists and mechanical and biomechanical engineers have already been studying polymers for many years. The research into polymers today goes far beyond the products we are so familiar with. It looks at the synthesis of bio-active molecules, functional polymers and composite materials and how they lead the way to a variety of new products with enhanced properties.

The research at Polymer Science and Technology is related to a wide range of applications:

- Organic solar cells, light-emitting diodes and photovoltaic cells
- Fuel cells
- New inks for inkjet printing technologies
- Functional coatings
- Drug release systems
- Engineering of living tissues and artificial implants such as heart valves, small diameter blood vessels, orthopedic implants and extracorporeal systems and devices

‘The research into polymers today goes far beyond the products we are so familiar with.’

- Liquid crystal displays with an extremely wide viewing angle
- Biosensors and micro devices for fluid detection

Polymers are used in all aspects of life: in automotive, displays, coatings, clothing and biomedical applications such as drug delivery systems.

Flexible solar cells

Focus on specific research program

What's new in polymer research?

Professor René Janssen's research is focused on so-called functional polymers. An intriguing definition, because aren't all polymers 'functional'?

Prof. René Janssen explains: "Indeed, from the first plastics made until the latest supramolecular devices, researchers have always tried to make polymers with characteristics that suit their function. We define functional polymers as man-made materials in which we benefit from and use specific properties of the polymers involved. The objective of our research is to investigate and develop functional molecules, macromolecules and nanostructures. We are focused on special electrical or optical properties of those materials that may be of future use in advanced technological applications such as transistors, light-emitting diodes, photovoltaic cells and data storage."

Driven by curiosity

Although the research program is strictly fundamental, the interest of Janssen and his colleagues is very much driven by their curiosity and perseverance in finding new applications of polymers. Janssen: "In the past decades chemists and physicists have revealed all elementary knowledge about polymers. In fact, we know almost everything about the basic elements; how to synthesize them, their behavior and practical use. For a couple of years now, scientists have been exploring new ways in which polymer materials can be used. For instance we all know that plastics are perfectly suited for electric insulation. Other plastics, or better polymers, are equally good for the transport of electricity. Why is that the case, and in what way can we benefit from this? The covalent and non-covalent assemblies of these molecules provide us with intriguing scientific and technological challenges. In exploring new functional systems we use the paradigm of molecule-macromolecule-material-machine to express the notion that ultimately, understanding and control on every length scale and at every interface is required to reach the intrinsic limits of functional polymer materials in devices."

Polymer-based solar cells

The approach of Janssen's research team has gained a lot interest from the industry. Their exploring research has already led to interesting new products or innovation of existing ones. As an example of this, Janssen worked on polymer-based solar cells for many years. He achieved energy conversion rates of approximately 4-5%. Janssen says about his 'plastic' solar cells: "Our conversion rate is still far from the 15% which is the standard of common silicon solar cells. So that's not breaking news. However, when you take into account that the price of the materials used is only a fraction of the costs of the silicon solar cells, it becomes a very promising line of research. For me this is a perfect example of how scientists can contribute to one of the major problems in today's society: a sustainable and long-lasting energy supply. In my opinion this shows the strength of TU/e: fundamental research driven by innovation to fulfill industrial and societal needs."

'Scientists can contribute to one of the major problems in today's society: a sustainable and long-lasting energy supply.'

Résumé Prof.dr. René Janssen

René Janssen is full professor in physical organic chemistry. He was appointed as a lecturer at TU/e in 1984, as a senior lecturer in 1991, and as full professor in 2000. In 1993 and 1994 he joined the group of Alan J. Heeger at the University of California Santa Barbara as associate researcher. René Janssen has been visiting professor at the University of Angers in France since 2000. His group focuses on research into functional conjugated molecules, macromolecules, nanostructures, and materials that may find application in advanced technological applications. In 1999 René Janssen received the 'Pionier' award from the Chemistry Science Branch of the Netherlands Organisation for Scientific Research (NWO). In 2000 he was co-recipient of the René Descartes Prize from the European Commission for outstanding collaborative research.

Master's student Michiel Baltussen:

'Practical experience keeps my numerical work relevant'

"Polymers represent a relatively new specialization, there are still a lot of questions to be answered and that also means there are a lot of opportunities. I find that a challenge. The Polymer Technology group has a number of international students with different backgrounds and cultures, and they add some new angles to discussions. The group's international network meant that I easily found an internship place in Japan at the University of Tokyo."

"Our group has a broad focus. The aim is to model and understand the behavior of polymers, from raw material through the production process right up to final use. Especially the production stage, injection molding, is complex and dominates the characteristics of the end product. In Japan I carried out practical research into high-speed injection molding using a glass die and a high-speed camera. I looked particularly at the flow effects. This practical experience keeps my work in the Netherlands relevant, as this is mainly numerical. I'm really interested in the flow and material behavior of polymers, and after I graduate I want to do a PhD at TU/e on a subject in this research area. Later I'd like to work in research in industry."

Education profile

Education at TU/e has strong links with research. TU/e offers students an environment in which they are close to the latest technological developments, and have professors who are also involved in research at the university. As well as inspiring lectures, tutorials and supervised self-study, the university also uses design-oriented education as an additional teaching form.

Students work in teams on technological design assignments and can look forward to practical internships and graduation projects in industry or at government bodies. This way, students at TU/e not only benefit from a thorough scientific basic training, they also get the chance to develop their social and communication skills.

Within the research profile Polymer Science and Technology, we distinguish the following study programs:
Master's programs

- MSc Master Track in Polymer Science and Engineering;
- MSc Mechanical Engineering: Master track in Computational and Experimental Mechanics;
- MSc Physics, MSc Chemical Engineering and Chemistry, MSc Biomedical Technology.

Postgraduate courses are successfully organized by the national research school Polymer Technology Netherlands (PTN). Senior scientists from the different research areas participate extensively in this education program that covers a total learning period of two years and consists of courses every Friday. Depending on the interest in a course, 50 to 100 PhD students, postdocs and young scientists from the industry take some or all of the courses in Polymer Chemistry, Polymer Physics, Polymer Properties, Polymer Rheology, Polymer Processing and Polymer Innovations.

All PTN courses are lectured in English by scientists from Dutch universities and from abroad.

Economic impact of Polymer Science and Technology

Operating at the interface of universities and industry

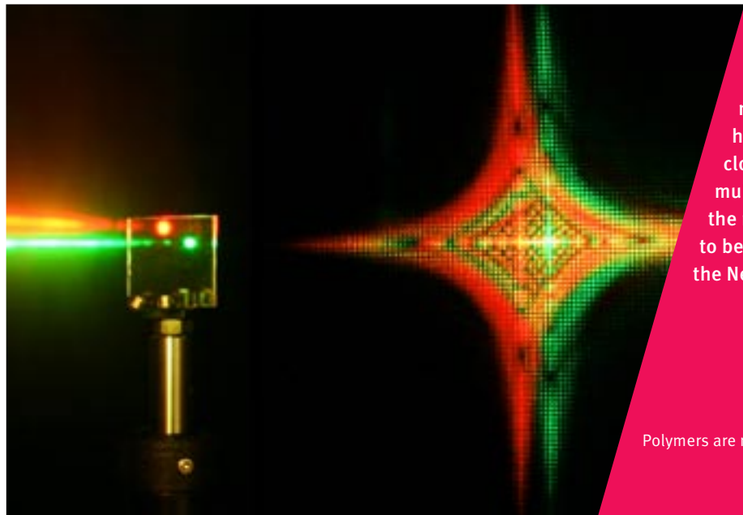
Apart from the fundamental research on polymers, founded by the National Science Foundation NWO, the industry-related research of the Polymer Science and Technology group is conducted throughout the Dutch Polymer Institute (DPI). DPI is a public-private institute funded by the Dutch industry, universities and the government, and was set up to perform exploratory research on polymer materials. DPI is one of the four Leading Technology Institutes in the Netherlands.

The offices and administration of the institute are located at the Kennispoort building on the campus of TU/e and operate at the interface of universities and industry, linking the scientific skills of university research groups to the industrial needs for innovation. In 2005 the DPI had 56 partners of which 60% came from the polymer industry. The choice of programs is determined by those industrial partners on the basis of recommendations by scientists. The DPI programs concern the following areas: Polyolefins, Engineering Plastics, Rubber Technology, Functional Polymer Systems, Coating Technology and High-Throughput Experimentation.

Half of the annual budget of DPI (almost 18 million euro in 2005) was spent on polymer research at TU/e. Through the DPI programs, fruitful working relationships have been established with all major polymer industries in the Netherlands and surrounding countries: DSM, Philips, Shell, Sabic, Dow, Océ, AKZO Nobel, Avery etc.

Such strategic alliances have proven to be very successful. As a result, the numbers of (foreign) PhD students, part-time professors and scientific output (thesis, publications, patents) have increased rapidly. And, more importantly, the industry benefits in a unique way from this pre-competitive research. In its pursuit of a leading European position in the field of polymers, the DPI aims, in collaboration with the TU/e Polymer group, to attract more European funds.

Apart from the collaboration project within the DPI, the polymer research at TU/e has resulted in the setting-up of R&D-oriented companies. Examples of these commercial activities are the founding of the Polymer Technology Group Eindhoven BV and SupraPolix BV.



TU/e is a truly research-oriented university in which the societal and industrial technological needs of the future are reflected. The university has set its strategic research priorities in close alignment with the leading technological multinationals. As a result both the university and the region are flourishing as never before and are proud to be known as an Innovation & Technology Hotspot in the Netherlands.

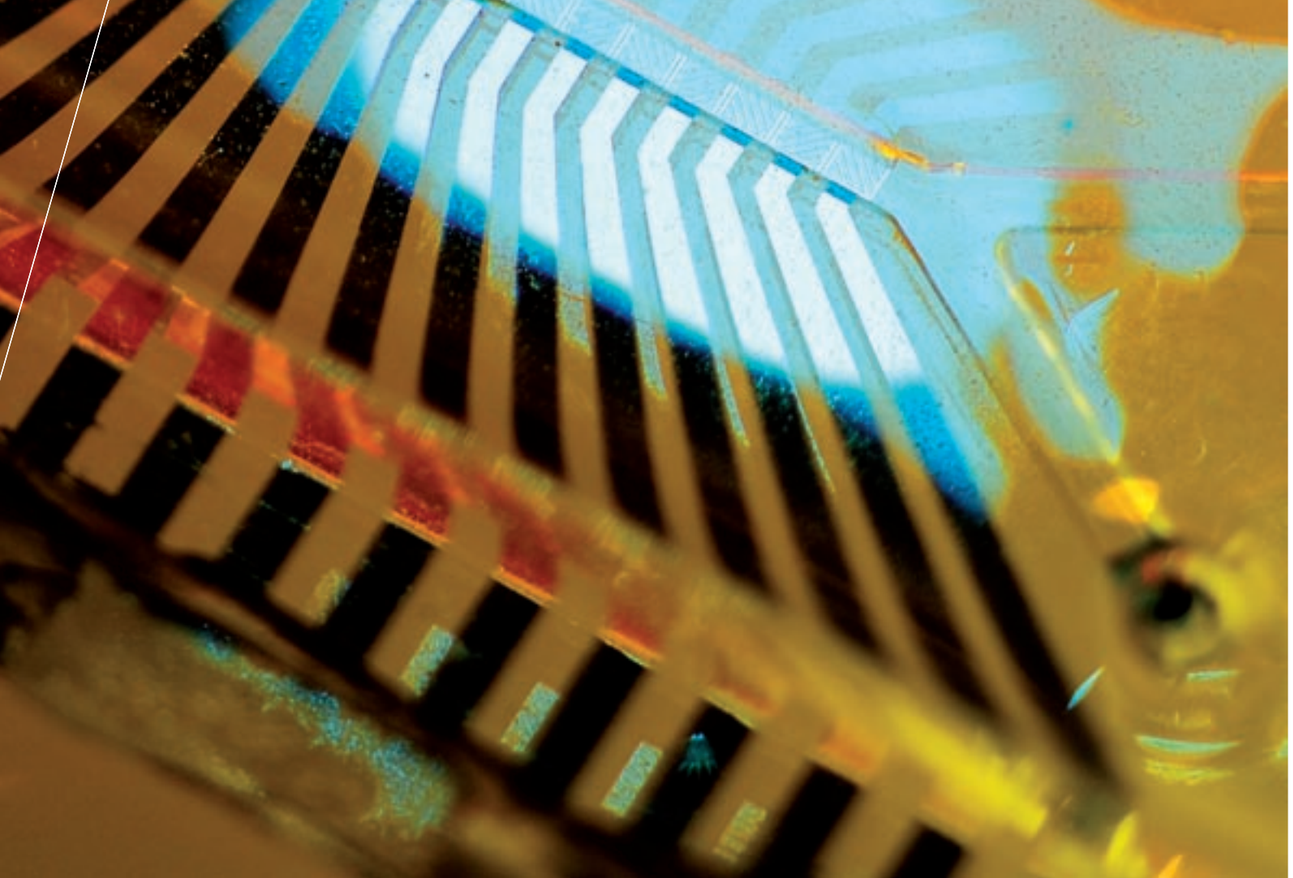
Polymers are manipulated with light

In this device the fluids in micro-scale channels are manipulated

Focus on specific research program

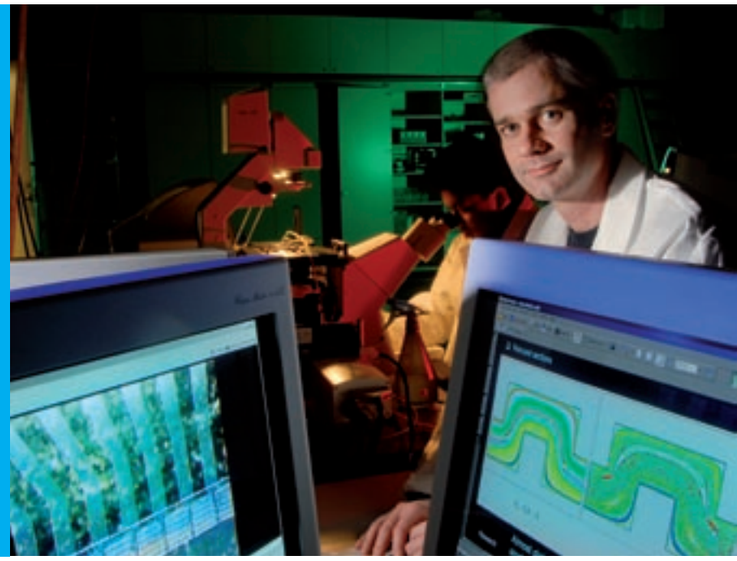
How to mix laminar fluids in micro-channels

Everyone who has had his blood or urine examined knows from experience that such examinations are time-consuming and only carried out in specialized laboratories. An important trend in this field is the transition from centralized lab analysis to cartridge-based near-patient testing using biosensors. An important aspect for a biosensor device is the micro-fluidics modalities that must take care of transportation, mixing and routing of the fluids within a micro-fluidic channel system. Jaap den Toonder, part-time professor at TU/e and senior scientist at Philips Research Laboratory, works on the development of these small devices for the detection of bodily fluids.



Résumé Prof.dr.ir. Jaap den Toonder

Jaap den Toonder studied at the Delft University of Technology and gained his Master's degree in Applied Mathematics in 1991. He received a PhD from the same university in 1996 after a numerical/theoretical and experimental study of drag reduction in turbulent flows by polymer additives. In 1995, he joined the Philips Research Laboratories in Eindhoven, where he started working in the field of the mechanics of solid materials. He is now head of the research cluster "Thin Film Mechanics" at Philips Research, and he co-ordinates the Philips "Microfluidics Working Group". Since 2004, he has combined his work as a scientist at Philips Research with a part-time professorship at the Materials Technology group at TU/e.



Jaap den Toonder's research is on Microfluidics; the manipulation of fluids in micro-scale channels. Den Toonder: "The widths and heights of micro-fluid channels range from several micrometers to several hundreds of micrometers. In those small devices the flow is predominantly laminar and producing turbulence is practically impossible. However, mixing plays a vital role in the speed of the analysis. That's why we want to create artificial methods for turbulence and mixing."

Inspired by nature

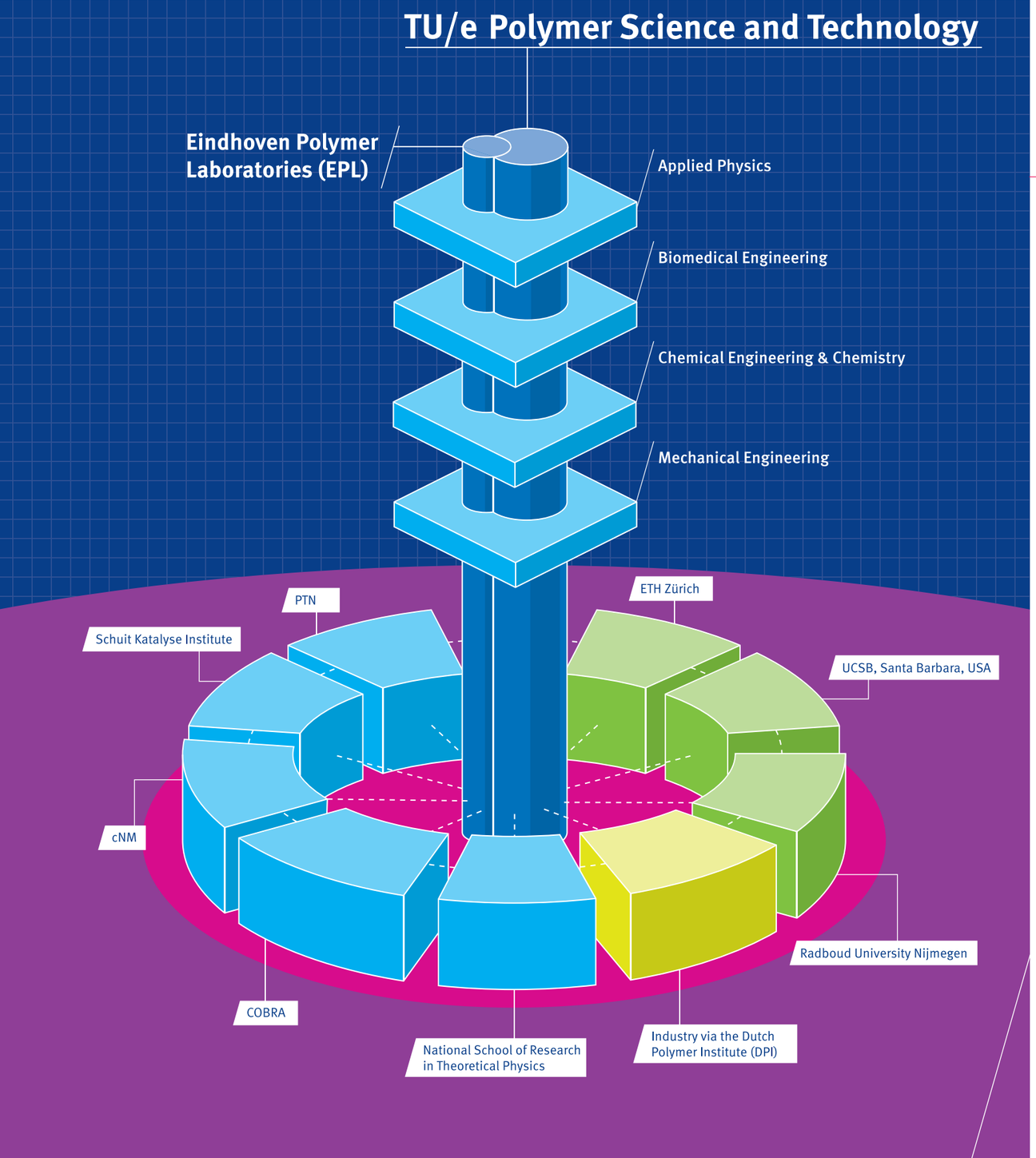
Den Toonder and his research team at Polymer Science and Technology are designing methods for mixing laminar fluids. New methods involve adding small magnetic particles (1-10 micrometers) to the fluid and the designing and manufacturing of micro-actuator materials that evoke chaotic mixing flows in the channels. Den Toonder has promising news on the construction of those micro-actuators: "These tiny structures are made of specific polymers that are very flexible, easy to construct and, most of all, easy to manipulate by external influences such as light, temperature or magnetic fields. Our latest method of active micro-fluidic manipulation is inspired by nature. For instance, one particular micro-fluidics manipulation mechanism 'designed' by nature is due to a covering of beating cilia over the external surface of micro-organisms. Such cilia can be viewed as small hairs or flexible rods which are attached to the surface. The movement of individual cilia is asymmetric in nature and allows effective transport of the organism. We have developed polymer-based micro-actuators that can be set in motion electrostatically. When integrated in a micro-fluidic channel, the effect of the moving actuators resembles that of the cilia of the micro-organism. We have shown experimentally that, indeed, our artificial cilia can induce significant flow velocities of at least 75 µm/s in a fluid with a viscosity of 10 mPas."

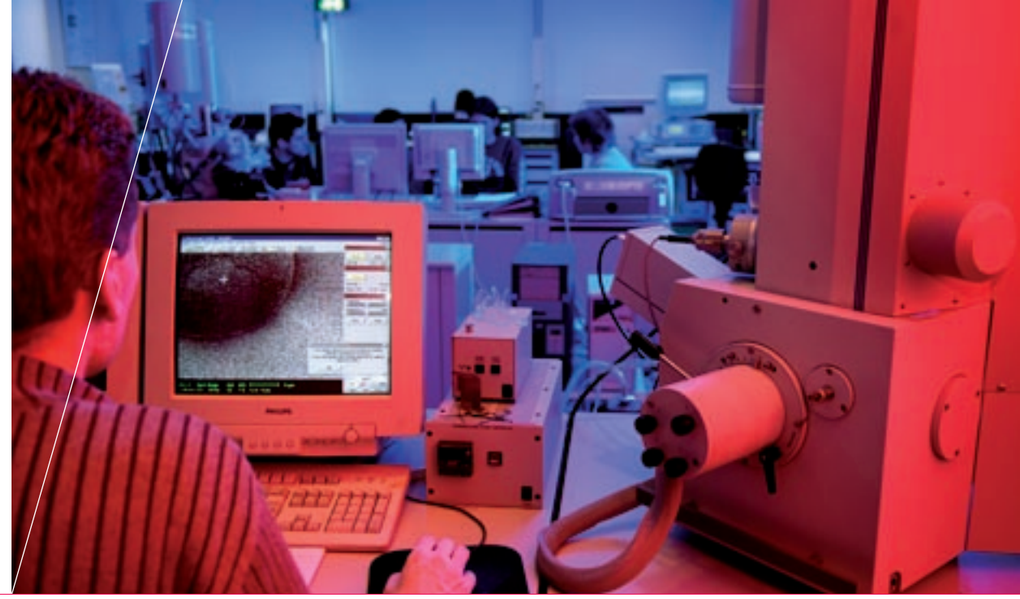
Industrial needs and consumer demands

Although the scientific impact of his research is great, Den Toonder is realistic about the practical application in biosensors. Den Toonder: "It's obvious that our research at TU/e is purely fundamental and serves long-term objectives. However, I'm truly surprised by the attitude of the scientists here at the university. They are very much aware of the industrial needs on R&D and consumer demands. This makes my work at Philips and TU/e so synergetic. In addition, I find it really exciting to participate in the education of young scientists and to work with excellent students from all over the world. The same goes for my colleagues from other disciplines like Theoretical Physics, Computer Science and Chemistry. As a mathematician, I experience the added value of interdisciplinary research every day."

'Our latest method of active micro-fluidic manipulation is inspired by nature. '

Network of contacts in academic world and industry





The Netherlands' three leading technology universities aim to enlarge their impact on the country's knowledge-based economy through more intensive cooperation. To that end, Delft University of Technology, University of Twente and Eindhoven University of Technology started a federation in 2007.

3TU.Federation: innovation with impact through university cooperation

In 2006 the Dutch government supported the initiative with an investment of 50 million euro to found five interuniversity Centers of Excellence. These funds will help the three universities appoint thirty new senior professors over the next five years. These professors will reinforce research expertise in the five main fields of academic collaboration. Seventy-five currently active professors will join these Centers of Excellence immediately.

The five new Centers of Excellence focus on the following research areas:

- 3TU.Centre for Intelligent Mechatronic Systems
  Microsystems – robotics precision technology – embedded systems
- 3TU.Centre for Sustainable Energy Technologies
  Solar energy – hydrogen production – fuel cells – bio refinery – storage
- 3TU.Centre for Dependable ICT Systems
  Dependable computer networks – communication, information and security systems – ambient intelligence
- 3TU.Centre for Multiscale Phenomena
  Turbulence dynamics – multiphase flows – transport – integrated numerical-experimental approaches
- 3TU.Centre for Bio-Nano Applications
  Single molecule and single cell studies – nano-sensing and bio-sensing

Apart from these five centres, the three universities have started a sixth center:

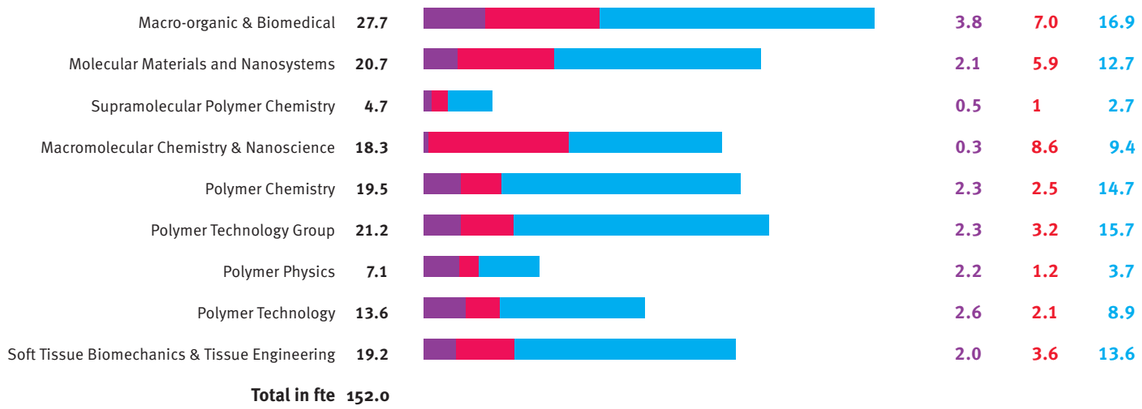
- 3TU.Centre for Ethics and Technology.

The research on Polymer Science and Technology is partly integrated within the Centers of Excellence for Sustainable Energy Technologies and Bio-Nano Applications.

Figures Polymer Science and Technology

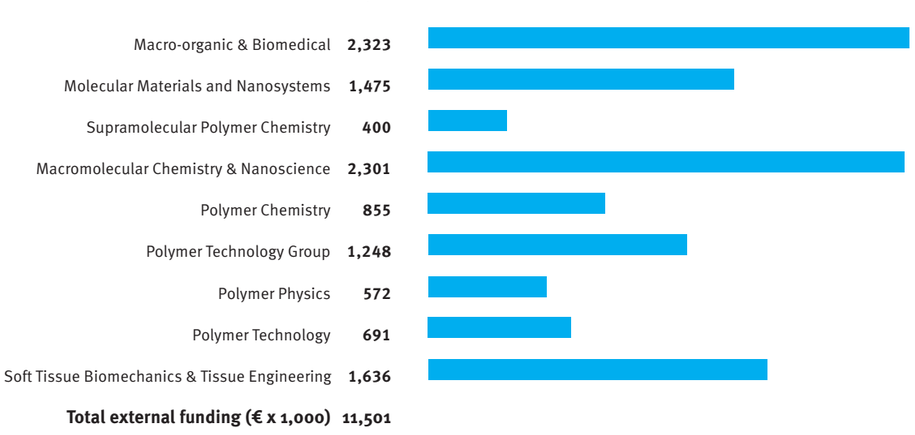
Research Staff

In fte 2006



Total external funding

In thousands of euro 2006



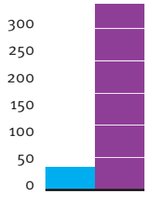
Sources of external funding

2006

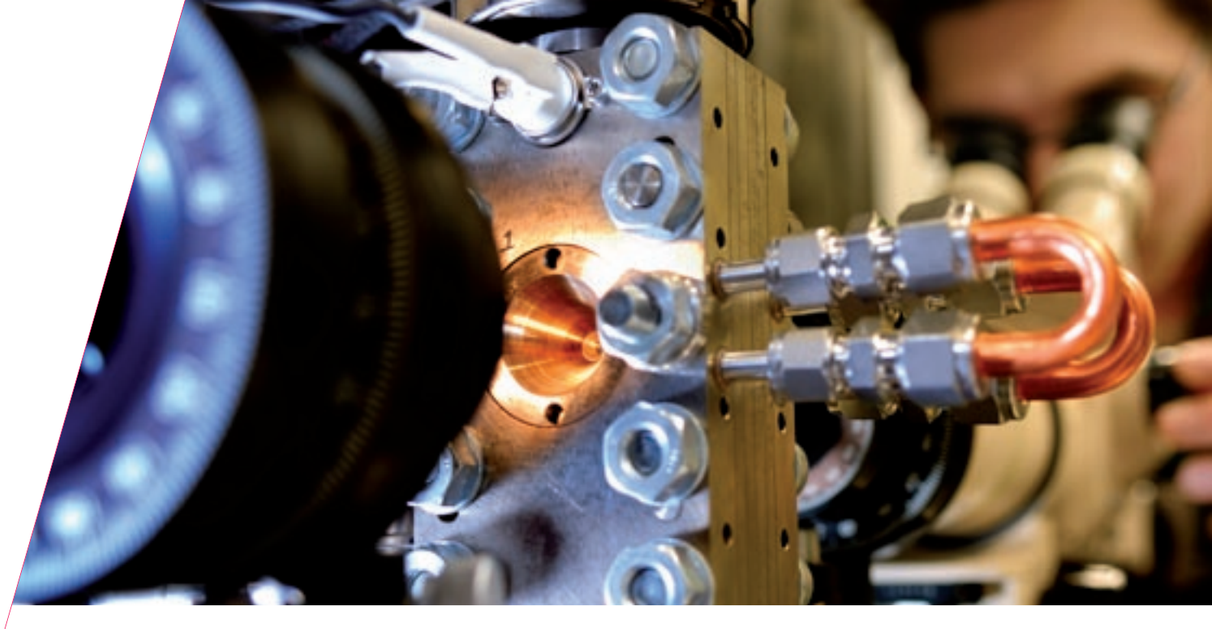
30% Ministry of Economic Affairs
30% NWO (Netherlands Organization for Scientific Research)
15% Industry
10% European Commission
15% University (matching budget)

Scientific output

2006



39 Dissertations (total)
317 Publications (total)



Available facilities Polymer Science and Technology

The research groups within Polymer Science and Technology have access to a number of joint laboratories which are used in various research programs.

- The Laboratory of Macromolecular and Organic Chemistry. This laboratory possesses research equipment for both organic/polymer synthetic and analytical use. Much of this equipment is dedicated to determining the molecular structure of (macro-)organics.
- Laboratory of Macromolecular Materials and Nanosystems. In this laboratory, all equipment is found for synthesis of functional polymers and for devices made from those polymers like sensors, memories, LEDs and photovolltaic (solar) cells.
- Laboratory of High Throughput Experimenting. This facility comprises a number of different techniques, necessary for high throughput experimenting, including inkjet printing techniques, sequential automated analyses, AFM analyses etc.
- Laboratory of Polymer Chemistry. This laboratory is fully equipped for all diferent polymer syntheses of nylons, polyesters and block-copolymers, including high throughput parallel synthesis of poly-olefines.
- Laboratory of Polymer Technology and Optics. This laboratory is equipped for optical investigation involving manipulating polymer characterization and analytical equipment, including thermal, structural and in-situ characterization.
- Multi-scale Laboratory. This facility is equipped for microscopic and mesoscopic analysis of materials and devices. It allows for quantitative in-situ microscopic measurements during deformation.
- Mechanical Testing Laboratory. This laboratory is equipped for testing of polymers and metals, evaluation of solid-state forming processes in instrumented set-ups and evaluation of the structural integrity of objects.
- Laboratory of Biomechanics. In this laboratory studies for cardiovascular physiology are conducted.
- Polymer Processing Laboratory. In this facility fundamental aspects are analyzed of polymer processing such as PVT behaviour under non-equilibrium conditions, structure development in blends and semi-crystalline polymers and the relation between properties and flow conditions in real and model processing flows.
- Rheology Laboratory. The rheology laboratory is equipped to measure rheological properties over the full range of viscosities, both in shear and elongation, including rheo-optical measurements.
- Laser and Laser- Scattering Laboratory. This facility houses equipment for point- and field-wise velocity measurements, structure development during (mixing) flow and 3D flow visualization.
- Laboratory for Cell Mechanics and Tissue engineering. This laboratory consists of a cell and tissue culture facility, a preparation room and a large optical microscopy room.
- Computer Laboratory. This virtual laboratory comprises all computational facilities.

TU/e ranked as best Dutch university in QS World University Ranking

In October 2006 the Times Higher Education Supplement published its QS World University Rankings. TU/e, listed in 67th position, was ranked as best Dutch university. The rankings were based on a survey of 3,703 academics worldwide, who were asked to identify up to 30 universities best for research within their own field of expertise. This ensures that the rankings are topical and liable to change from year to year if institutions do not maintain the highest research standards. The table also includes data from 736 graduate employers from around the world, as well as the ratio of faculty to student numbers and a university's success in attracting foreign students and internationally renowned academics.

Eindhoven University of Technology

Eindhoven University of Technology (TU/e) is one of Europe's leading universities specialized in engineering science and technology. Through our top quality education and research programs, we strive to bring about advancement in engineering science and technological innovation that will lead to economic and social prosperity within and beyond the greater Eindhoven area.

TU/e has clustered research activities within the following eight Strategic Research Areas:

- Biomedical Engineering Sciences
- Broadband Telecommunications Technologies
- Catalysis and Process Engineering
- Logistics, Operations and their Information Systems
- Mechanics and Control
- Nano-engineering of Functional Materials and Devices
- Polymer Science and Technology
- Science and Engineering of Embedded Systems.

Two additional research fields are likely to be added in the near future: Ambient Intelligence and Comfort Technology and Design.

TU/e aims to meet or outperform international standards in the quality of its educational programs and research. To that end, we provide our students and staff with a truly international and intellectually stimulating environment that will inspire them to broad social and cultural engagement, personal development and an entrepreneurial mindset. We provide our students with a sound scientific foundation and depth of knowledge as well as the necessary competences that will enable them to develop successful careers in a wide range of fields and functions within the community. The Bachelor's degree programs (BSc) are designed to serve as a basis for further education at the Master's level (MSc). TU/e also trains teachers at the Master of Science level, designers at the Professional Doctorate in Engineering level and researchers at Doctor of Philosophy level. In addition, the university provides post-academic programs and courses.

Scientific contribution

TU/e is a young and modern university that continuously strives to strengthen its position in the field of engineering science and technology. Therefore our research concentrates specifically on those areas in which it can make a significant contribution to the scientific world. Additionally, the university conducts research in areas relevant and useful to knowledge-intensive industries and other sectors of the community with high or rapidly developing technology intensity.

Our network of international contacts in both the academic world and industry is expanding rapidly and proving to be of mutual benefit to all participants. Our scientists have leading positions in international committees and are well recognized experts in their fields of research. Based on its citation impact score, TU/e is third in the ranking of universities in the EU, behind Oxford and Cambridge.

Climate for innovation

At TU/e, we want to ensure that our research results are translated into successful innovations and serve as a basis for the creation of new enterprises. As a university we cultivate a climate that stimulates innovation. Our mission to foster innovation expresses itself in our programs, our staff, our students and our slogan: TU/e Where innovation starts.

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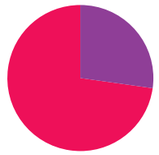
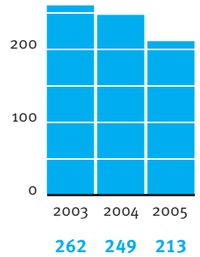
TU/e in numbers

Students

BSc/MSc students and Engineering program

2003	2004	2005
		
4515 Engineering program[1]	**2776** Engineering program[1]	**1962** Engineering program[1]
2517 BSc/MSc students	**4430** BSc/MSc students	**5525** BSc/MSc students
7032 Total students	**7206 Total students**	**7217 Total students**

PD Engineering students



262 **249** **213**

1/ 5 years program

Personnel

Scientific personnel and supporting staff

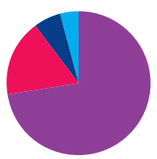
2003	2004	2005
		
1765 Scientific personnel	**1750** Scientific personnel	**1729** Scientific personnel
1473 Supporting staff	**1246** Supporting staff	**1136** Supporting staff
3238 Total personnel	**2990 Total personnel**	**2865 Total personnel**

Professors and PhD students

	2003	2004	2005
Part-time professors	51	51	46
Full-time professors	117	111	107
PhD students	574	594	622

Income 2005

In millions of euro



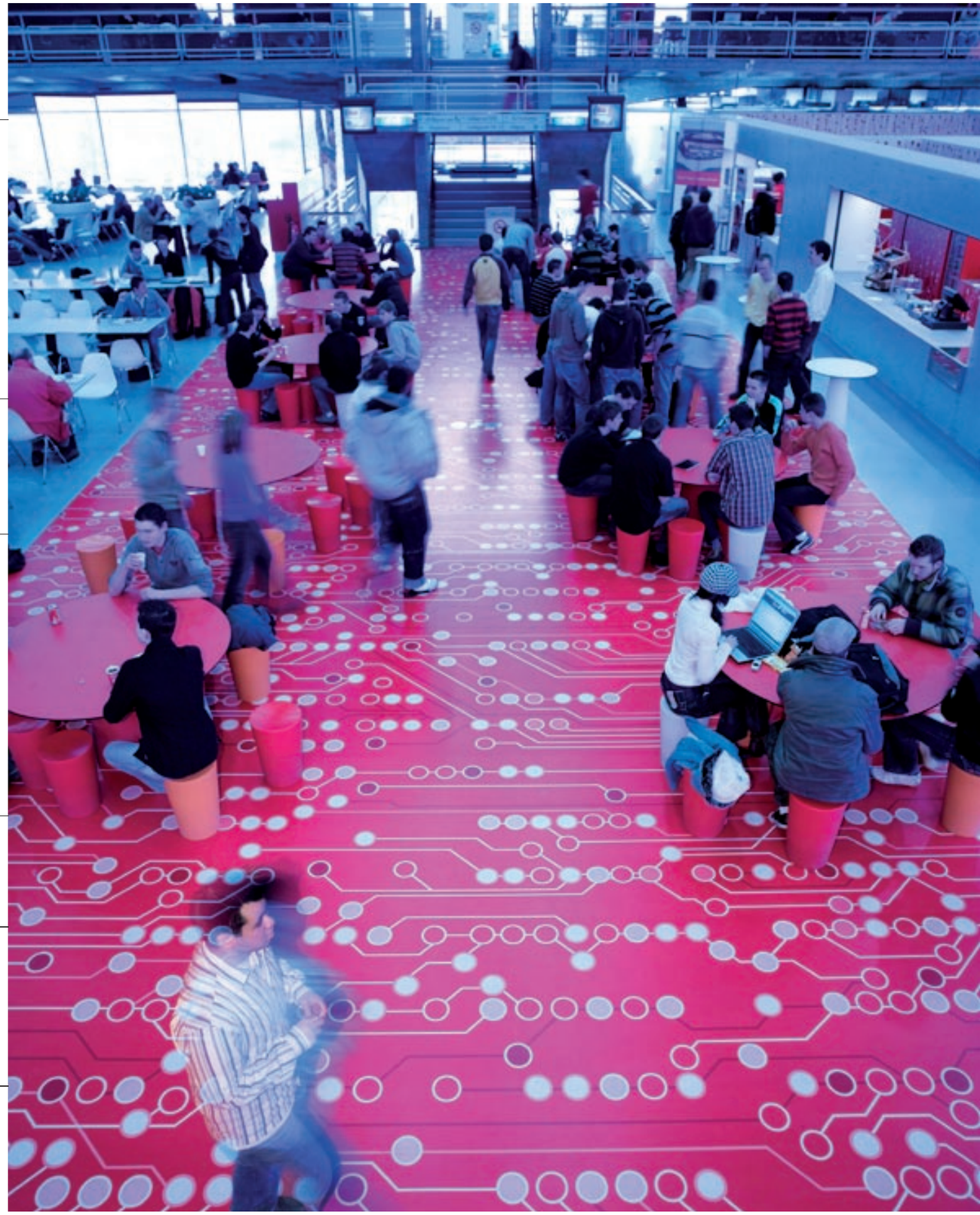
182,3 Government subsidy[1]
43,6 Contract research
14,8 Research subsidy
10,3 Other income
251 Total income

1/ including tuition and examination fees

Costs 2005

In millions of euro

154,3 Personnel costs
92,1 Other costs
246,4 Total costs



Eindhoven University of Technology aims to achieve optimal knowledge and technology transfer to industry and technology-driven organizations. TU/e has a long history as a leader in developing public-private research institutes such as the Dutch Polymer Institute, the Embedded Systems Institute and recently the Centre for Molecular Medicine. On its own premises, TU/e operates the TU/e Innovation Lab which is responsible for the process of generating and maintaining information and provides industry, small businesses and academic entrepreneurs with a wide range of services.

Knowledge and technology transfer

Eindhoven: Innovation and Technology Hotspot

Researchers from high-tech enterprises are provided with easy access to TU/e research staff through seminars, expert meetings and personal contact. In turn, the Innovation Lab assists TU/e researchers in realizing their business plans for the commercial exploitation of scientific research and applications. To provide these services, TU/e participates in Incubator3+, an organization that was set up by governmental and commercial partners in the Eindhoven area to support new entrepreneurs from the high-tech academic world.

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TU/e's Innovation Lab provides the following support to industry and small businesses:

- Contract research and contract education
- Joint research and development projects within TU/e research fields
- Research and development studies in the form of research or graduate traineeships
- Design assignments such as a twelve-month practical assignment in the postgraduate design program.

Science and technology without borders

Outside Europe, TU/e continues rapidly to expand its international partnerships. For example, TU/e and the National University of Singapore have strengthened their cooperation over the past few years on joint promotions. More recently TU/e has offered assistance to the Northeastern University in Shenyang, China, in helping them create Bachelor's and Master's degree programs in biomedical technology and computer science. TU/e has also joined forces with universities in China and India in the fields of polymers, electro- and information technology and ICT systems and with universities in Australia and the USA in the field of industrial design.

Greater Eindhoven: one of Europe's most innovative regions

Noteworthy facts:

- The industrial and technological mainstay of the Netherlands. 50% of the Dutch research and development expenditure takes place in this region, and 30% of the regional employment is linked to the industrial sector. The Dutch government has accordingly named the Eindhoven region as The Netherlands' Innovation and Technology Hotspot.
- 700,000 population and 32,000 enterprises (with many start-up companies in the technology sector). The Eindhoven region is home to many high-tech enterprises such as the multinational Royal Philips Electronics.
- Eindhoven is home to the High Tech Campus Eindhoven, where Philips Research and a growing number of research groups, institutes and companies work together in an open innovation environment. The most recent institutes to join the region are the Holst Centre for intelligent wireless microsystems and systems-on-foil, an initiative of IMEC Leuven (Belgium), TNO and Philips, and the Center for Translational Molecular Medicine in which a cluster of institutes from Aachen (Germany) participate.
- The Eindhoven area has a high concentration of educational institutes including TU/e, Fontys University of Applied Sciences, ROC Eindhoven (vocational education) and the Design Academy Eindhoven. Together with TNO, these institutes participate in United Brains, a partnership devoted to fulfilling the educational needs of small and medium enterprises.
- Eindhoven provides direct connections to the European road system and the European railway network as well as direct flights to European destinations from Eindhoven Airport.
- The greater Eindhoven region is home to such respected cultural facilities as the Van Abbe Museum for Modern Art, the Frits Philips Music Center and the Park Theater.

Overview of High Tech Campus Eindhoven

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