Center of Competence: Applications of NanoTechnology

Center of Excellence: Bio-NanoApplications

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2 Participating chairs

The embedding Center of Competence consists of all research groups participating in:
a) the **Kavli** Institute of NanoScience, with selected groups from Imaging Science and NanoChemistry (TUD),
b) the **MESA+** Institute for Nanotechnology and **BMTI** (UT)
c) the **cNM** / Research Priority Nano-Engineering of Functional Materials and Devices (TU/e).

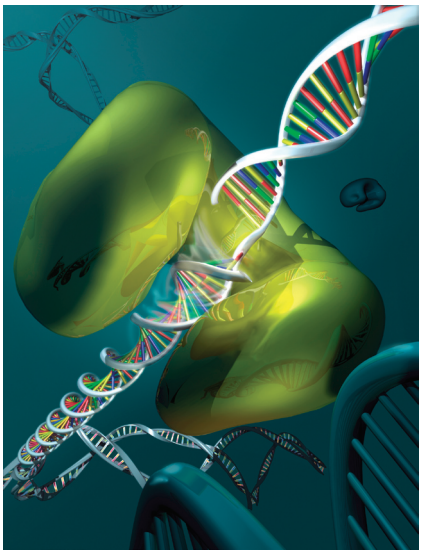
All these research groups participate in the Dutch BSIK Nanotechnology Initiative NanoNed. This Center of Competence encompasses an outstanding research environment across broad and relevant fields. Ultimately, this allows founding a few Centers of Excellence, each with defined focus-area, adequate critical mass and survival chance in the international competition. Participating chairs per institute are listed in Appendix A.

Within the Center of Competence "Applications of nanotechnology" we envision to position two Centers of Excellence with strongly complementary research foci, though interesting cross-links as well:
1. CoE on Bio-NanoApplications (current action)
2. CoE on Nano-Electronics, Photonics and Spintronics (later stage, additional action)

We stress that within the present call only we only apply for funding of the first CoE, as motivated below.

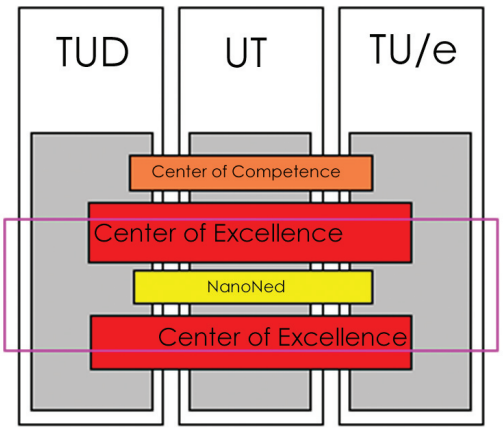
1. CoE on BioNano Applications (BNA)
Aiming at a unification of excellent research at the three TU's, and gaining synergy and critical mass in the fields of biomolecular recognition and manipulation as well as (biomolecular) nanosensing – right at the heart of FOM priority areas "Fysica van levenswetenschappen" and "Nano-fysica/ technologie", as well as the (highest priority) strategic theme "nanomedicine" identified in the NWO strategy document. Within the present call, a coherent 3TU-wide CoE will be implemented in this focused area – which receives presently enormous interest from Dutch and European high-tech companies, and fully in line with nanotechnology activities within a number of open innovation initiatives. We stress that bio-nano related activities have only received a relatively minor attention within the NanoNed program. The present action is considered to be ideally suited to found a number of essential nucleating groups and establish new research lines catalyzing a coherent effort of the three TU's in this important area of research, and optimally exploiting the present excellent expertise in the required enabling technologies.

'Protein Topoisomerase repairs DNA',
Copyright TU Delft / Tremani

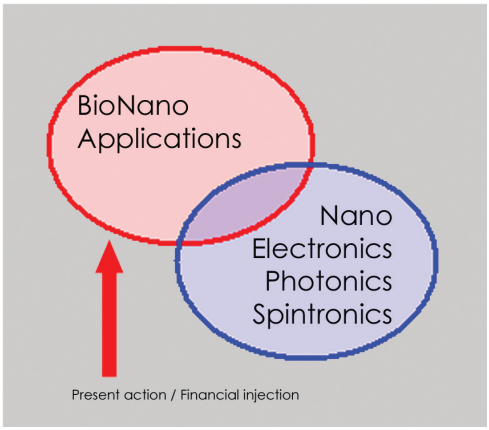


2 Participating chairs

2. CoE on Nano-Electronics, Photonics and Spintronics (EPS)
This second CoE with more emphasis on physical-phenomena related nano-issues will be defined in more detail at a later stage, and implemented with separate funding. We consider it of importance to highlight the excellent research in this field at the three TU's, a position that is internationally extremely well recognized, and led to a sound financial position (e.g., covering over 50% of the NanoNed program, a high number of personal research programs, etc.).



Schematic diagram of the Center of Competence, clustering research from the three TU's, and exploiting the thematic focusing within NanoNed flagships.



Within the present initiative, the CoE on NanoSensing & Bio-NanoApplications will be implemented. A second CoE might be shaped at a later stage.

3 Center of Excellence

The CoE Bio-NanoApplications (BNA) brings together excellent research groups in the area's of (bio)-physics, (bio)chemistry, nanofabrication and (bio)materials and biosensing, and merges their expertise to enable investigation of single molecules and single cells. The challenges are to better understand fundamental processes in biological nanosystems and to utilize this for biomedical and life-sciences applications. The interdisciplinary nature of the CoE, together with the complementary expertise from the Nanosciences, Nanotechnologies and Biomedical applications areas will create an internationally competitive center that will form a fertile and stimulation environment for graduate education and for creative science, technological innovation and relevant applications.

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5 Participating groups and program

The nanoscience and nanotechnology landscape at the Dutch TU's has international top level in several areas. TUD is renowned for its top quality in nanophysics, quantum- and physical electronics and molecular biophysics, with a strong emphasis on basic science. This top quality is illustrated not only by the presence of Spinoza laureate Dekker but also by the very high citation indicators for the entire Kavli institute. The institute enjoys a large number of highly qualified young researchers with academic award. The UT has an excellent reputation in the areas of supramolecular nanochemistry, bio/nanomaterials, sensing and nanofluidics, with a strong emphasis on application and valorisation, as illustrated by over 30 MESA+/BMTI spin-off companies in 15 yr. The international technological top quality of UT is indicated by several VICI and Simon Stevin laureates (Gardeniers, Blank, Reinhoudt, van den Berg) as well as by the large number of European programs such as Nano2Life, Frontiers, etc. TU/e has established leading positions in the field of nanoengineering of functional materials and devices, and has been awarded a multitude of Vici and Pioneer awards in this field (Janssen, Swagten, Schubert, Koopmans, Koenraad) recently. It has a strong reputation in application-oriented fundamental research, traditionally in very close collaboration with the local high-tech industries (multinationals such as Philips Research, ASML, Océ, DSM, etc).

An initial screening of excellent research groups, covering key activities required to implement a coherent and world-leading program on applications of bionanotechnology has led to the following preliminary list. We stress that other high quality, and sometimes just as essential, activities are available within the CoCo. A more final list will be defined while further working out the research topics, but we also aim at a dynamic structure of the CoE that can constantly respond efficiently to future opportunities and strategic choices.

Delft University of Technology

Professor	Chair	Visitation score
Cees Dekker	Molecular Biophysics	5, 5, 5, 5 (2003)
Teun Klapwijk	NanoPhysics	4.5, 4.5, 4.5, 4.5 (2003)
Huub Salemink	Semiconductor Nanophotonics	N.A.
Josef Braat	Optics	5, 4, 5, 5 (2003)
Laurens Siebbeles	Optoelectronic materials	4, 3.5, 4.5, 5 (2003)

University of Twente

Professor	Chair	Visitation score
Albert van den Berg	Biosensors and Lab-on-Chip	5, 4, 5, 5 (1999)
Dave Blank	Inorganic Materials Science	4, 5, 4, 5 (2002)
Vinod Subramaniam	Biophysical Engineering	N.A.
David Reinhoudt	SupraMolecular Chemistry and Technology	5, 5, 5, 5 (2002)
Jan Feijen	Polymer biomaterials	4, 5, 5, 5 (2002)

Eindhoven University of Technology

Professor	Chair	Visitation score
Menno Prins	Molecular Biosensors for Medical diagnostics	N.A.
René Janssen	Molecular Materials & Nanosystems	4, 4, 4, 5 (2002)[1)] 4.5, 4.5, 4.5, 4.5 (2005)[2)]
Bert Koopmans	Physics of Nanostructures	4.5, 4.5, 4.5, 5.0 (2005)[2)]
Thijs Michels	Polymer Physics and Theory	5.0, 4.5, 4.5, 4.5 (2005)[2)]
Ulrich Schubert	Macromolecular Chemistry and Nano Science	N.A.
Andreas Dietzel	Micro- and Nano-Scale Engineering	N.A.

[1)] Department of Chemical Engineering and Chemistry

[2)] Preliminary results, Department of Applied Physics

5 Participating groups and program

Program
The BNA Center of Excellence is formed by relevant high-quality groups selected from the supporting shell of the center of competence, with the aim to create focus and critical mass in the two following areas:

1. Single molecule and single cell studies
Form a high-quality research effort for advanced analysis/recognition, manipulation/repair of biological relevant material (such as DNA, proteins, single cells). We envision very efficient, compact and parallel operating devices based on nanotechnology, including transport, separation, analysis and signal processing of such material. In addition, molecular synthesis of nanostructures is envisaged for bioanalysis and drug delivery purposes. Ultimate users of these technologies are the areas of biochemical/biotechnology industry, medical/pharmaceutical/food (nutriceuticals) users and medical diagnostics including health centers. Such devices will enable radically new ways of doing analysis/diagnosis/screening, early treatment and local medication. This nano4bio technology will fuse the physics, chemistry, biology and engineering at the atomic/molecular scale. Prototypes of simple devices have been demonstrated. The challenge is to design and fabricate such devices for particular purposes, with a combination of 'optimized' functionality in the constituent parts: this is a long-term challenge and will incorporate a wide field of sciences, technologies and industries. It will enable the formation of novel science/technology intensive SME's in relevant application areas.

2. NanoSensing
Form a high-quality research/technology effort on new sensing devices based on nanotechnology: such sensors are purposely designed to function for particular functions, utilizing hybrid combinations and functionalized materials, such that the sensing effects are highly optimized for sensitivity, selectivity and efficiency. More specifically, the aim is to detect, identify and ultimately manipulate individual biomolecules at extremely low concentration (femtomole/liter) and in a quantitative way. It is envisaged to use smart combinations of mechanics, fabrication technology, materials/surface functionalization and nanoelectronics and integrated photonics to perform cost-effective sensing elements for a wide variety of physical, chemical and biological parameters. Particular emphasis will be on the use of functional (e.g. magnetic) nanobeads for manipulating and detection of individual biomolecules, using combinations of magnetic an optical tools, self-assembly and scanning-probe based patterning methods of functionalized, nanostructured surfaces, and including the field of biophotonics. In addition, functionalized nanowires as well as micro/nanostructures using functional materials will be used for ultrasensitive and selective sensing. A high interest from medical/pharmaceutical/lab-on-chip users is expected.

These two focus-fields are chosen based upon excellent available expertise within the participating centers (Kavli, cNM, MESA$^+$/BMTI). We expect that this CoE in the future will be competitive with the (mainly US) international top-level centers. Our current research efforts are highly recognized and close to world-leading in several constituting fields. We intend to utilize this stimulation to create new research groups (professors, staff, equipment, startup funds) and are intending to use our reputation to seek internationally renowned scientist for staffing. We propose to start 4 new groups, and give further opportunities to 3 highly potential researchers to start up activities in bio-nano areas.

Whereas in the BNA center the biophysical, biochemical and technological expertise ("exact"-science) is well represented, supplementary biological and medical expertise is needed besides the participating BMTI; for this, connections with national (Dutch cancer institute (NKI), national genomics/proteomics initiatives, health science technology (HST) initiative, food (WCFS)) as well as international centers of excellence (Harvard Medical School (Toner), Fraunhofer Gesellshaft (Fuhr), St. Jude Children's hospital (Green)) will be exploited/further developed.

6 Key themes covered by CoE

- High Tech Systems and Materials
- NanoTechnologie
- Life Sciences
- Bsik Nanoned
- HST Health Science & Technology
- Nano4Vitality
- Center for Molecular Medicine
- Holst center
- Materials valley

Moreover, we emphasize that the choice for the present CoE is in line with many recent developments and visions as displayed in recent strategy documents:

- The open innovation centers on applications of nanotechnology and biomedical technologies; Holst and CMM
- The two highest priority areas identified within the Strategisch Plan FOM/GBN, viz. Fysica van levenspocessen and nanofysica/technologie.
- The first strategic theme as identified within the NWO strategy document “towards a multidisciplinary national nanoscience programme”, viz. nanomedicine, as well as a strong link with the third theme recognized therein, viz. Functional nanoparticles and nano-patterned surfaces.

7 Sub-themes KP-7 covered by CoE

- NanoSciences
- NanoTechnology
- NanoMedicine
- (molecular) LifeSciences
- Advanced nano-Systems

Further links to:
- EFSRI European Research Infrastructures
- Smartmix (the CoE will position itself for smartmix co-funding)
- NanoNed future and stimulus to form nanoplatform for long term NWO-funding.
- Synergizing nanosciences and –technology into novel areas with high expectations, bio-nanotechnology and photonics (see recent FOM/GBN and NWO reports)

8 Three top groups EU on similar fields

1. The ETH Zurich and EPF Lausanne are participating in the swiss NCCR programs: of interest are the NCCR competence centers in nanotechnology and quantum photonics.
   http://www.nccr-nano.org/nccr/nccr_network

2. The Lund nanoscience consortium has research areas in similar nanoscience/technology fields as our CoCo and the NanoNed consortium: it is active in EU programs.
   http://www.nano.ftf.lth.se/main.html?research.html

3. The Center of NanoScience in München is a broad interdisciplinary group in nanoscale research, centered around the LMU (München) and is active in very similar areas as our CoCo and the NanoNed program.
   http://www.nanoscience.uni-muenchen.de/

9 New groups to be founded within the CoE

Four new 3TU-chairs with basic research groups will be installed, for which absolute top-researchers will be attracted, and will typically be facilitated by 2 M /group, also including (tenure track) staff positions. Some of these new groups are overlapping with current chairs near retirement. Secondly, three new fields of expertise will be developed by young scientists ("potentials"), that may later result in chair positions or will be embedded in existing faculty structures. The chairs and potentials will be focused on the following topics:

1) Single molecule studies
- Nanopore-based DNA sequencing and applications (3TU Chair, TUD)
- Single molecule and information processing (3TU Chair, TUD)

2) Single cell studies ("lab-in-a-cell")
- Supramolecular Chemistry and Technology for Bioapplications (3TU Chair, UT)
- Biofunctionalized polymers and nanosurfaces (3TU Chair, UT)

3) Biosensing and nanosensing
- Nanosensing and biomedical applications (3TU Chair, TU/e)
- Applications of biophotonics (Potential, TU/e)
- Nanomaterials and electrical nanosensing (3TU Potential, UT)

For further details, see the description under 11: connecting R&D agenda.

10 Societal drivers

Societal driver:
Recognizing and treating illness well before first symptoms display and irreversible damage to the health and well-being occurs, as well as targeted therapy without undesired side-effects, available for affordable costs to large populations world wide.

Technological dreams:

- (Bio)molecular recognition and manipulation of individual molecules (proteins, DNA) in-vivo and at the ultimately low concentrations against a high background of other species that is present in biological systems requiring the unraveling of the elementary mechanisms of life and acquiring engineering tools operating at the molecular level in living cells. **(single cell DNA sequencer)**
- Evaluation of properties and behavior of small amounts of individual cells (e.g. cancerous cells from a breast microbiopsy) to evaluate drug effectiveness without cultivation leading to personalized-medicine. **(Lab-in-a-Cell)**

Further motivation:
The rapid development of micro- and nano- technology for biological and medical applications holds significant promise for the creation of new diagnostic and therapeutic avenues in the progress towards personalized medicine. In a recent vision paper entitled "Nanotechnology for Health" aimed at establishing an European Technology Platform on Nanomedicine under the auspices of the European Community's 7th Framework program, several disease areas including cancer, diabetes and neurological (especially neurodegenerative) diseases were identified as being expected to benefit from nanotechnology in the next 10 years. Even more spectacular and far-reaching potential is being anticipated for the decades thereafter.

11 Connecting R&D agenda

The new activities as indicated in 9 (3TU-chairs, 3TU Potentials) will be hosted at different institutes – logically fitting in the complementary expertise and specializations:

Single molecule studies
The two new 3TU chairs will be embedded into the expansion of the Kavli nanoscience institute into the biophysics fields as envisaged by the department. In this process it is intended to utilize our cooperation with Leiden University on molecular identification and handling in the joint health science technology initiative (HST) and in the IOP program on photonic devices (Braat). The nanopore position will explore fragment analysis using nanotechnology without relying on amplification processes, thus opening the pathway to radically new analysis technologies (N. Dekker). This work is in competition with actual trends in bio/nano technology in internationally renowned expert centers around the world. The Single Molecule position will enhance and expand our current highly rewarding activity on molecular analysis using electrical and optical technology (Dekker, LeMay). A large fraction of this work is done in cooperation with Leiden University and with the health science initiative in LUMC and Rotterdam. These new groups will aim at challenges as: the protein nanomachinery in cells and exploring the coupling of biological systems to solid-state information processing. The work will focus on the basic sciences and demonstration of concepts and will complement the technology work in UT (cell handling, fluidics) as well as the sensoric work at TU/e. The three institutes have a proven track record in working together via the bsik NanoImpuls and Nanoned and their infrastructure initiatives.

Single cell studies
The Chair on "Supramolecular chemistry and technology for bioapplications" (hosted at UT) will focus on supramolecular synthesis, chemical surface modification and molecular architecture and is intended to replace the existing chair of supramolecular chemistry (group Reinhoudt). This area is thought to be essential to make the link between the extensive expertise in synthetic, supramolecular and (bio)polymer chemistry and bio/single cell applications. In particular, interaction of cell-membrane proteins and surfaces, chemical recognition at cell surfaces and transport through cell membranes are topics that will be investigated within the new chair. Since in several of these cases also single molecule interactions are involved there will be a strong interaction with the existing groups in Leiden, Groningen and Wageningen, as well as with existing (Dekker) and new 3TU chairs on single molecule studies at TUD. Further, a second Chair "Nanostructured biomaterials" (UT) will focus on biofunctionalization of nanobeads and synthesis of functional nano-biopolymers and nanoparticles (groups Subramariam, Feijen); this topic will have great relevance for both single (live) cell imaging as well as the application area of advanced drug delivery and tissue engineering.

Biosensing and nanosensing
Two full chairs (hosted at TU/e and UT) and one Potentials (hosted at TU/e) will be aiming at developing novel biosensor concepts for medical applications, as well as contributing to the understanding and manipulation of biomolecular structures and processes by application thereof. Focus from the new group at TU/e will be on magnetic and optical sensing schemes, complementary to the Chair at UT that is focusing on electrical nanosensing. The potential at TU/e will specifically explore applications of biophotonics.
Further development of the biomagnetic sensing- and manipulation schemes will rely on essential input from the fields of magnetic sensor concepts as well as physics and manipulation of magnetic nanobeads (Koopmans), molecular engineering principles and expertise on (bio)molecule/sensor surface interfaces (Janssen), sensing principles based on self-assembly, ink-jet printing schemes and scanning-probe based chemical modification of sensor surfaces (Schubert) and mechanical and nanofluidic aspects of sensing and actuation schemes, as well as bio-inspired mesoscale assembly (Dietzel). Further progress in this field will also benefit from improved mechanistic understanding (Michels), addressing both the sensing functions, as well as the quantitative modeling of biomolecule and nanoparticle self-assembly – in bulk and at interfaces (providing input to both themes, bio-nano applications (mostly located at UT and TUD) and biosensing (TU/e and UT)). The

11 Connecting R&D agenda

work on electrical nanosensing at UT will cover the exploration of functional nanomaterials and nanostructures (nanowires) for biochemical sensing (group Blank, van den Berg). This also includes nanosensors that enable intracellular sensing and nanoarrays for electrical cell imaging. Finally, the program on biophotonics at TU/e will be aiming at concepts for integrated photonics for nanosensing, e.g. for 'high-parallel single-molecule detection', and will greatly benefit from work in several existing groups (Janssen, Koopmans, Salemink) as well as a new group on Photonics and semiconductor nanoscience, as presently being founded at TU/e.

12 Masters course with specific strength per location

Present situation
At present, acknowledged MSc courses in the field of Nano-Science & Technology (with croho accreditation) are situated at MESA+ (nanotechnology) and at TUD, together with Leiden University (Nanosciences, now in 3rd year with 20+ students). Moreover, a masterprogram on NanoEngineering has started recently at TU/e, as a joint initiative with the Radboud University (Nijmegen). Interestingly, while inherently complementary, all three programs are strongly aiming at interdisciplinary activities, bridging traditional courses on (applied) physics, chemistry and biology. Thereby, they are considered as a particular appropriate seed for establishing a joint 3TU master on Nano-Science & Technology, allied to the Center of Competence on Applications of NanoTechnology, and more specifically the CoE on Bio-NanoApplications.

Joint 3TU Master
Currently a joint MSc course is being arranged, based on the programs located at the three locations and with particular highlights for each institute, representing the local expertise. Within this program, students will follow basic lectures on NS&T at their home university (served partially by joint staff), while specialized top-courses will be offered at the centers with specific expertise. Moreover, mobility of students for specialized research projects will be strongly stimulated. It is anticipated that we will connect to the KNAW accredited Casimir Research School on Physics (since mid 2005). Concrete plans for this 3TU master curriculum are actively being worked out at present, and the procedure for the final 3TU-wide croho accreditation will be started up early 2006. Within this CoE proposal we furthermore apply for a specific budget to establish 3TU top-master classes. (see 17.)

13 Large infrastructure

The list of large infrastructure will be attached at a later stage. It will be augmented with the infrastructure supplied under NanoNed's Nanolab facilities, run as a shared facility center under the NanoNed partners – including the 3TU's. New investments from the BSIK program NanoNed amount to 66 M euro at the main partners, including e-beam lithography, plasma etching an ion-beam processing.

14 Novel equipment

Our plans to achieve a world-leading position for the joint 3TU-initiative in bio-nano applications and nanosensing, will inevitably require a strong impulse in generally accessible novel experimental infrastructure. Recent investments within the NanoNed program (NanoLab) have been mostly focused on the "hard" nanosciences, including clean room facilities for novel devices in the fields of nano-electronics, photonics and spintronics. Whereas the present CoE will certainly profit from the new infrastructure, the present center certainly needs an additional infrastructural impulse more dedicated to the bionano-related sciences. Some of the required equipment will be covered by the present program.

Part of the required investments is linked to the new 3TU chairs, will be defined by them and is budgeted under the new chair positions. Another part is directly defined by the choices of topics and has already been identified for the greater part as indicated below:

- State of the art optical tweezers systems with laser cutter
- Novel laser systems, such as 355 nm 3f laser system
- E-SEM (environmental SEM)
- Confocal microscopy
- Scanning probe microscopy

The novel equipment from the CoE budget will be scheduled to fit in with local expertise and in consideration of 13 above.

15 Added Value of 3TU cooperation

We extend our internationally ISI acknowledged reputation, built over >10 years, in our specialized fields, nanoscience, nanotechnology and its applications. As already emphasized in part A, bio-nano related activities have only received a relatively minor attention within the NanoNed program. Through this Center of Excellence BioNano Applications, the actual top level reputations in fundamental and applied science of the individual locations (e.g. biophysics, bionanoscience, supramolecular chemistry, functional (bio)materials, Lab-on-a-Chip, biophotonics, biosensors) will be combined to give international excellence and impact over the whole range from basic science, via applied research to high-knowledge content business activity. Nanotechnology has been recognized in the Netherlands as a topic of crucial importance, as illustrated by the national BSIK program Nanoned. However, the particular topic BioNanoapplications does not play a major role in this program, and light of the recent international focus on this area this CoE BNA offers a unique opportunity to be a world leader in this area. We emphasis the strong activity in adjacent fields of genomics/proteomics in the Netherlands.
National and international contacts and exchange of knowledge and sharing of local expertises are strongly intensified through the newly formed "3TU chairs". The quality of fundamental and applied research strongly benefits from the concentration of excellence, and students at all locations receive top level education from each individual TU site, including the international top-scientists that will be attracted to give the master classes. The focus of the individual locations on specific topics also implies that these topics will be excluded from the agenda at other locations.

16 Valorization

a. Spin-offs
The area of bio-nanoapplications is very well suited as nucleus for new start-up companies. The application area is wide and diverse and requires a lot of application-specific knowledge, while the product area is low-medium volume/high value, and the generation of spin-offs is a clear indication of the dynamics of this field. All three TU's have an excellent track record with the formation of spin-offs (Micronit, Cytocentrix, MediMate, Medspray, Nanomi, Lionix, etc.)

b. Collaborative/contract research with small/medium size industries
Knowledge generated within the CoE can also be brought to industry via direct collaboration projects with small-medium size companies. In the past, there have been several research contracts e.g. with medium-size pharma- chemical- and instrumentation companies (e.g. Avantium, Vertex, GSK, Texas Instruments, R&R Mechatronics, Diosynth, WCFS, etc.)

c. Strategic alliances with large multinationals and research institutions
It is the explicit aim of the CoE to create strategic alliancies and collaborations with internationally leading multinationals and research institutes. Through these, ambitious projects can be defined and realized, and optimal utilization of knowledge (and IP) generated in the CoE will be obtained. Potential partners are Philips, FEI, IMEC, Texas Instruments, Glaxo SmithKline, Unilever, NKI, etc. Furthermore, activities of the CoE are particularly well fitted to the scope of the open innovation centers Holst and CMM. The CoE will aim at a continuous supply of novel device concepts and basic understanding, as input to the somewhat shorter-term research programs at those centers.

17 Budget CoE

Requested budget for CoE activities (under 9 and 14)

Overall		
• 5 new 3TU-chairs	* 1.05 M euro	5.25 M euro
• 2 3TU-"potentials"	* 0.9 M euro	1.8 M euro
• Start-up funds		1.25 M euro
• 3 Top-master classes	* 40 k euro/yr	0.2 M euro
• Visiting scientists		p.m.
• Equipment		1.5 M euro
Total		**10.0 M euro**

Budget specification:

1. Single Molecule studies		
• 3TU Chair TUD (nanopores)		
HL	5 years x 210 k euro =	1050 k euro
Start-up funds	=	450 k euro
• 3TU Chair TUD (single molecules)		
HL	5 years x 210 k euro =	1050 k euro
Start-up funds	=	450 k euro
2. Single Cell studies		
• 3TU Chair UT		
HL	5 years x 210 k euro =	1050 k euro
• 3TU Potential UT		
HL	5 years x 210 k euro =	1050 k euro
3. Biosensing and Nanosensing		
• 3TU Chair TU/e:		
HL	5 years x 210 k euro =	1050 k euro
Start-up funds	=	350 k euro
• 3TU Potential TU/e		
UHD	5 years x 180 k euro =	900 k euro
• 3TU Potential UT		
UHD	5 years x 180 k euro =	900 k euro

(N.B. The responsible department provided commitments as to transforming this position to a full chair during the course of the present program, with the associated long-term commitment.)

18 Accompanying research program

The CoE will develop a dedicated STW program “BioNano” for PhD, Postdocs and visitors, amounting to about ~ 60 positions over 10 years, leading to a budget request of 20 M. We envisage that this focused “BioNano” program is managed by STW and open to other participation. Apart from this, similar programs within the framework of FOM and SON are anticipated.

Delft University of Technology

Kavli Institute of Nanoscience

	Professor	Chair
	Hans Mooij	Quantum Computation
	Leo Kouwenhoven	Quantum transport
CoE	Teun Klapwijk	NanoPhysics
CoE	Cees Dekker	Molecular Biophysics
	Gerrit Bauer / Yuli Nazarov	Theoretical Physics
	Henny Zandbergen	Microscopy & Materials
CoE	Huub Salemink	Semiconductor Nanophotonics

Imaging Science & Technology

	Professor	Chair
	Ted Young	Quantitative Imaging
CoE	Josef Braat	Optics

Nanochemical Engineering

	Professor	Chair
CoE	Laurens Siebbeles	Optoelectronic materials

DIMES

	Professor	Chair
	Lina Sarro	Microdevices
	Paddy French	Microsystems

The Kavli Institute of Nanoscience Delft has the following key performance indicators:
Funding From the university: 4.0 M euro + 2.0 M euro for the Nanofacility (cleanroom)
Funding From NWO/FOM/STW: 3.5 M,
Funding From EU& Industry: 1.5 M
The institute employs 8 full professors, 18 ass.professors, 27 postdoc/non-tenured staff, 51 phD students and 30 technical and management staff. The institute runs a state-of-art nanofabrication facility (incl. a new 100kV Ebeam lithograph, 3 new ICP plasma etchers). A new joint high tech laboratory with TNO is under construction (delivery 3Q2006) and this joint facility will invest 27 M euro from Bsik NanoNed.
Industrial partners include: FEI, SRON/Astron, Carl-Zeiss, Leica, TNO, Mapper lithography, Alcatel and Philips Research.
With the Leiden University the institute operates a Croho-licensed Masters program NanoSciences with 20+ international students. A KNAW research school (Casimir) is jointly operated with Leiden since 2004, (two one-week special courses on chemistry and biology and a biannual three-day symposium). A special FOM group on quantum electronics & photonics is operating jointly with Leiden and with extensions in Philips research.
New professor appointments are expected in 2006 (molecular materials), based on own investments and from the endowment of the Kavli foundation, and 2 related chairs in the chemistry department
The Institute is member of the IDEA league (Imperial College, ETH Zurich and Aachen) and in the Kavli network linked with UCSB and Cornell University in USA.

Delft University of Technology

A joint program with IBM research in NY is established. Further joint appointments exist with MIT, Harvard and Princeton. These links allow easy exchange of staff and students into top-rated universities.
The institute is a co-founder and investment partner of the NanoNed consortium and participates in the new IOP Photonics and in 11 EU projects (EpiX, Frontiers, Biomach, SINANO, Radionet, Node, Hyswitch, Canel, Biosense, Spinsqued, EuroSqip).

The institute Nanosciences output was 435 ISI cited papers in 2000-2003 (105/year), now increasing to >135/year, with an average cpp/jcsm = 1,83 and cpp/fcsm= 3.34.
The recent visitation evaluation (with Leiden) yielded for the institute Nanoscience the figures 5,5,5,4.5 with 2 groups all 5's.

University of Twente

MESA+ Institute of Nanotechnology UT / BMTI

	Professor	Chair
	Brenny van Groesen	Applied Analysis and Mathematical Physics
CoE	Albert van den Berg	Lab-on-a-chip
	Markus Pollnau	Integrated Opt ical MicroSystems
	Jurriaan Schmitz	Semiconductor Components
	Ronnie Jansen	Systems and Materials for Information Storage
	Hans Kerkhoff	Testable Design and Test of Microsystems
	Miko Elwenspoek	Transducers Science and Technology
	Uwe Karst	Chemical Analysis
	Paul Kelly	Computational Materials Science
	Willem Vos	Complex Photonic Systems
CoE	Dave Blank	Inorganic Materials Science
	Vinod Subramaniam	Biophysical Engineering
	Horst Rogalla	Low Temperature Division
	Matthias Wessling	Membrane Technology
	Julius Vancso	Materials Science and Technology of Polymers
	Jurriaan Huskens	NanoFabrication
	Niek van Hulst	Optical Techniques
	Frieder Mugele	Physics of Complex Fluids
	Detlef Lohse	Physics of Fluids
CoE	David Reinhoudt	SupraMolecular Chemistry and Technology
	Bene Poelsema	Solid State Physics
	Henk Grootenboer (em) / Bart Koopman	Biomechanical engineering
CoE	Jan Feijen	Polymer Chemistry and Materials

MESA+ is a full business unit of the University of Twente. It encompasses approximately 450 person, which translates into approximately 400 fte's. Its budget in 2006 is 46 M euro (1G = 17 M euro, 2G = ** M euro, 3G = ** M euro).

MESA+ has 18 full professors, 12 associate professors, 31 assistant professors and 5 personal professorships. Another 9 professors joined MESA+ on a part-time basis from industry or strategically related institutions. Within MESA+, 200 PhD students and 50 post docs are active in various projects.

MESA+ runs a full 1500 m2 lab facility with extensive cleanrooms, materials and surface analysis systems, and equipment for production of materials and devices. It cooperates intensively with its 30 spin-offs and has a strong commercialization policy with a production of 3 to 4 new businesses per year. Its spin-offs together have shown a growth of 15% annually in jobs and revenue on average, over the past 12 years. This number is increasing strongly.

MESA+ is the largest participant and coordinator in NanoNed, and coordinator of the European Network of Excellence Frontiers, with Delft, Cambridge, Münster, Max Planck, Chalmers, Aarhus, Basel, Toulouse, IMEC and Karlsruhe.

The Institute for Biomedical Technology (BMTI) is an interdepartmental research institute of the University of Twente, focusing its efforts at Biomedical Engineering, a multi disciplinary field of science employing engineering principles, methods and know-how to study and understand medical and biological questions and problems.

University of Twente

The 2006 budget of the institute is close to 12.5 M euro, involving contributions of some 200 researchers and representing a total work force of almost 125 FTE. BMTI is supported by 15 full professors, 24 associate and assistant professors and three personal professorships. Additionally, 9 professors joined BMTI on a part-time basis, sharing their research efforts with their "donor-organizations" in industry, (academic) hospitals and/or partner research institutions. On average, about 80 PhD students and 25 Post Doctoral researchers are active in BMTI projects.

BMTI groups run lab facilities in a multi-use environment, combining different disciplinary backgrounds, from cell biology tot biomaterials, from bio-optics, bio sensors and other biophysical techniques to biomechanics and biomedical signals and systems with an electrical engineering background. At the moment, a complete new facility is under construction at the campus of the university. Mid 2006, BMTI will move the larger part of its activities to this two-story building where almost 2000 m^2 of biological, physical and chemical laboratories will be combined into one multidisciplinary research environment.

BMTI has a long history in the valorization and exploitation of research results. To this end, BMTI is actively involved in various business oriented networks to scout and coach potential spin out companies and to stimulate innovation together with partner institutes and private enterprises. Many recent examples are found in the field of tissue engineering and regenerative medicine. BMTI holds unique positions in this emerging area of activities. In 2003, the R&D group of a private enterprise under the name Isotis, headed by Prof. Van Blitterswijk, joined BMTI and was de-facto acquired by the University of Twente to merge with the already existing activities of prof. Feijen in Polymer Chemistry and Biomaterials.
A business accelerator for Tissue Engineering and Technical Life Sciences underlines the promising combination of a market oriented approach and challenging medium-to-long term explorative research. Rehabilitation technology is another area where BMTI's business and engineering approach meets with clinical practice to develop innovative concepts for improvements in medical health care.

BMTI is the initiator and coordinator of the only national research school on integrated Biomedical Engineering (iBME). BMTI also initiated the Dutch National Platform fore Tissue Engineering (DPTE) a joint enterprise of industries, academia and hospitals for the development and use of know-how and infrastructure to implement tissue engineering solutions in medical healthcare.

Eindhoven University of Technology

Eindhoven University of Technology

	Professor	Chair
CoE	Prins	Molecular Biosensors for Medical diagnostics
CoE	Janssen	Molecular materials & nanosystems
CoE	Koopmans / Swagten	Physics of Nanostuctures Spintronics
	Vacancy / Koenraad	Photonics and Semiconductor NanoScience
CoE	Michels	Theory & Polymer Physics
	Beijerinck / Van Leeuwen	Experimental Atomic Physics and Quantum Electronics
	Van de Sanden	Equilibrium and Transport in Plasmas
CoE	Schubert	Macromolecular Chemistry and Nano Science
	Vogt / Niemantsverdriet	Homogeneous Catalysis and Coordination Chemistry
	Meijer	Macromolecular and Organic Chemistry
CoE	Dietzel	Micro- and Nano-Scale Engineering
	Geerts	Micron and SubMicron Mechanics
	Baaijens	Material Technology, Biomechanics and Tissue Engineering
	Smit	Opto-Electronic Devices

Research on NS&T at Eindhoven is clustered in the "center for NanoMaterials" (cNM), a platform for research and education on NS&T, as well as the cross-department research priority "NanoEngineering of functional materials and devices". Thereby, a cluster of research groups, in total covering ~ 250 persons, over the departments TN, ST, WTB, BMT and E has been formed.

This field has evolved in Eindhoven as the logical consequence of the mission of the materials science related top research schools and TTI at TU/e: Dutch Polymer Institute, Catalysis, and Photonics (COBRA). In all these areas nano- engineering has appeared as a necessary future route to meet the ever increasing needs of the technologies that drive the next generation of devices and applications in magneto-electronics, photonics, organic devices, biotechnology etc.

The infrastructure encompasses the Spectrum cleanroom, with extensive facilities for thin film deposition, nanostructuring and -analysis, state-of-the-art facilities for synthesis and (epitaxial) deposition of semiconductors, (magnetic) metals, oxides, organic and polymeric structures and devices, a suit of scanning-probe microscopy tools and low vibration laboratories, a wide range of specialized laser spectroscopies, and several facilities for electron and ion beam fabrication and analysis.