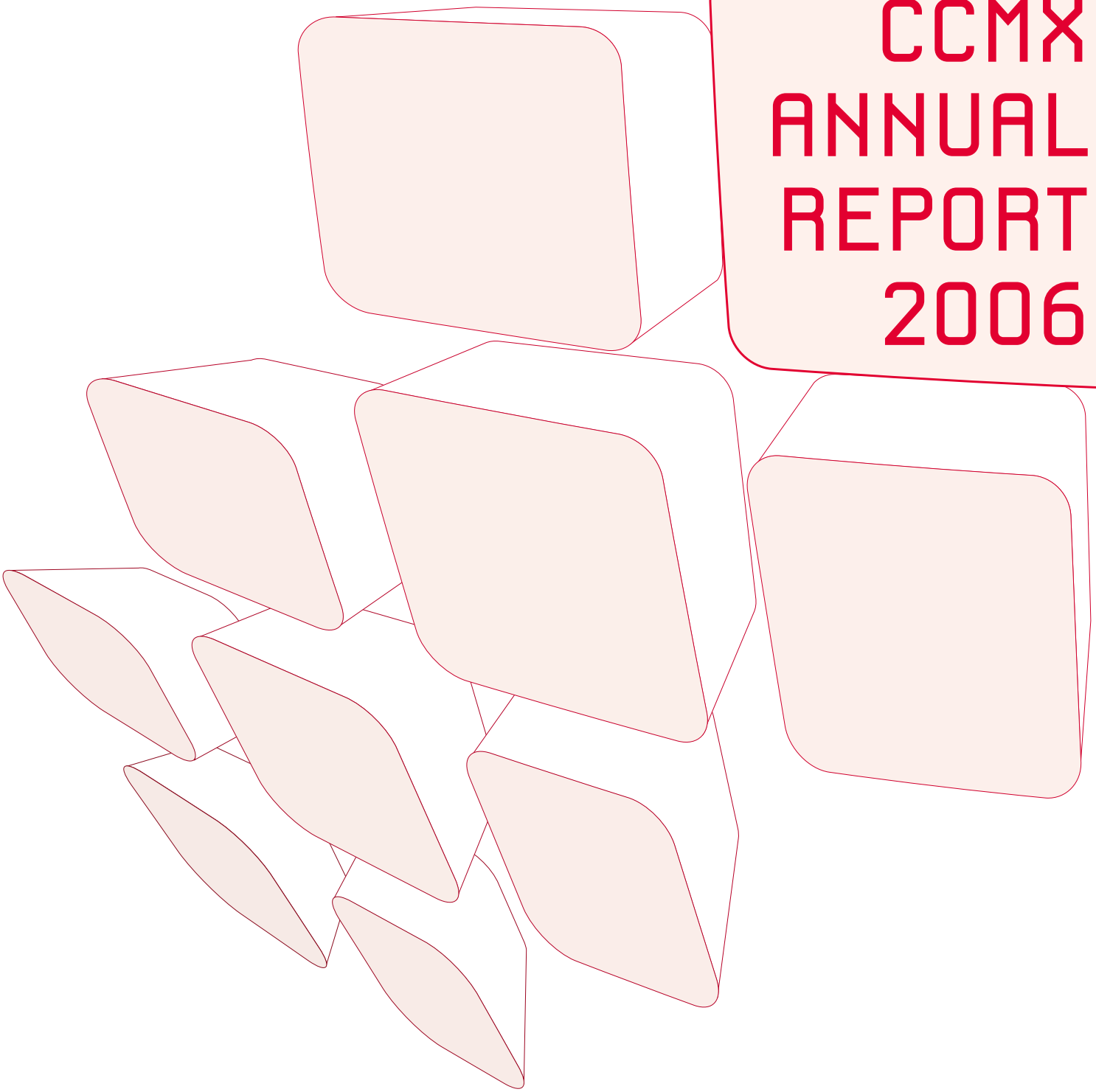
CCMX
Competence Centre for
Materials Science and Technology

CCMX ANNUAL REPORT 2006



EPFL ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

ETH Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

EMPA Materials Science & Technology

PAUL SCHERRER INSTITUT PSI

csem

Foreword

The **Competence Centre for Materials Science and Technology (CCMX)** is about scientific and technological exchange. It works on the premise that effective collaboration between academic and industrial partners is best fostered by close and continuous dialogue on themes of common interest. Created by the ETH Board to reinforce materials science and technology in Switzerland, CCMX actively encourages exploratory and pre-competitive research, application development and education.

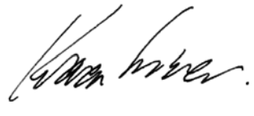
2006 has been the year for getting the Centre up and running. By organising its activities around three Education and Research Units (ERUs) and an analytical platform, on selected priority themes, and by actively involving the ERUs/platform in the process of project selection, the Centre has managed to rapidly establish a range of research consortia. In early summer 2006, twenty-seven projects were approved for funding by the Centre's Steering Committee. Among the criteria for funding were collaboration between ETH Domain institutions and a clear expression of interest from industrial partners.

The structures necessary for the governance of the Centre have also been put in place. A Steering Committee, representing the founding institutions and the world of industry, has met regularly to oversee the Centre's operations. An International Advisory Board will assist the Committee in the regular strategic evaluation of the Centre. Within each ERU/platform, a Scientific and Industrial Advisory Board comprising recognised experts in the field, from both academia and industry, guide the strategic choices of the ERU/platform and advise on its operations.

In addition to the dialogue taking place within the ERUs/platform, the Centre has carried out a wide consultation of external partners on their real needs for R&D in materials. For CCMX this is an important initiative; at the same time as publicising the Centre and making its activities better known, the input of industrial and economic partners is invaluable for refining its operations. This work is continuing: in-depth follow-up with interested companies will continue in 2007.

CCMX is intended to bring new vigour to research activities in the ETH Domain. Although the projects have only been operational for a few months, some initial results are already available, and the Centre is bearing fruit in several ways. We can already see the value obtained by bringing together strengths of ETH-Domain institutions in interdisciplinary projects with application potential. In time this will certainly help the continued participation of Swiss groups in international research programmes, the CCMX project consortia being natural groupings for future collaboration. Novel initiatives in institutional and continuous education are being started by the ERUs/platform. Access to technological resources and know-how is being encouraged. Finally, like the other Competence Centres, CCMX will continue to catalyse coordination between the partner institutions on the management of these innovative, cooperative ventures.

CCMX is now on its feet and much promise is shown by the first wave of projects. In line with its ambition to become a player at the highest level, the Centre will capitalise on this. A new call for proposals is intended for late 2007. The ERUs/platform are open for further collaboration and are considering new topics for this call. In addition, it is being discussed whether other strategic fields should be covered by new ERUs. CCMX will continue to grow and we encourage you to participate.



Prof. Karen Scrivener
Chair, CCMX

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Why a Competence Centre in Materials Science?

Materials science is one of the few universally-recognised enabling technologies. Materials constitute an essential two-way bridge between science and industry: on the one hand, as key elements of technologies, they have an important impact on our economy and our society; on the other hand, they increasingly draw on basic science and fundamental research in other disciplines, so that close interaction between industry and research laboratories can be a significant factor in the success of new developments.

Switzerland has excelled in the field of materials in recent years and they play a particularly important role in Swiss industry. In December 2005 the ETH Board initiated the Competence Centre for Materials Science and Technology (CCMX), one of several centres of excellence at the national level, to serve the interests of Switzerland in research, education and technology transfer.

CCMX will reinforce links between academia, industry and the economy in all regions of Switzerland and provide access to basic and applied know-how in materials science, micro- and nanotechnologies. By targeting pre-competitive research in materials science to benefit industry and the Swiss economy, CCMX aims to have a strong and positive influence on the field of materials science in Switzerland.

The objectives of the Centre are to:

- carry out R&D at the highest level in chosen fields of scientific and technological priority
- group the strengths of ETH-Domain institutions in interdisciplinary projects with application potential
- reinforce links with industry and the economy in all regions of Switzerland
- transfer innovative materials technologies into application
- provide access to basic and applied know-how in materials science, micro- and nanotechnologies
- contribute to the offer of training in materials science and technology at all levels
- prepare well-equipped scientists and engineers to suit the industrial needs of the economy, through continuous education
- provide a platform of scientific and technological exchange
- support the research necessary for ensuring the continued participation of Swiss groups in international research programmes.

The Centre regroups the strengths of four ETH domain institutions (EPFL, ETHZ, EMPA and PSI) and of CSEM, and involves the active participation of partners from industry, from industrial associations and from other Swiss universities. The Centre is headed by a Steering Committee comprising members from EPFL (chair), ETHZ, PSI, EMPA and industry.

At the core of the Centre's activities are ERUs - Education and Research Units - and an Analytical Platform. In targeted domains of scientific and technological priority, the ERUs elaborate and carry out advanced programmes of research, education and technology transfer. The initial focus of the Centre has been placed on three strategic fields: **surface, coatings and particles engineering, materials for the life sciences** and **materials for micro- and nanosystems**. Closely linked to these ERUs is a platform for developing and promoting analytical activities in **nano- and microscale materials characterisation.**

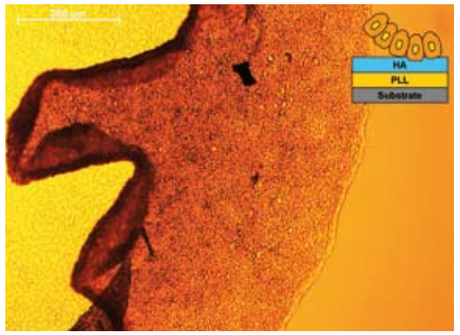
By bringing together R&D teams from several institutions, the Centre aims to improve the coordination of research resources within the ETH Domain. The Centre's activities complement those of CTI and SNSF, and provide an opportunity for collaboration with groups from other Swiss institutions, including the Universities of Applied Sciences. Substantial benefits will be generated in terms of education; the ERUs and platform will contribute to the offer of training at all levels for our students and engineers, in line with the needs of the economy.

The Centre will build on financial resources from the ETH Board. A budget of CHF10 mio. has been allocated for the period 2006-2007 from the Board's «Research area-oriented funding» programme. The Centre aims to attract financial commitment from other participating parties. The contractual conditions for the collaborative projects are aimed at facilitating the implementation of developed technologies into application.

CCMX aims to foster world-class research and development in its selected fields of activity. It will federate materials science activities of the ETH Domain and will provide the critical mass necessary to be a major player at the international level. Within Switzerland, it will constitute a bridge between science and industry, to address needs in numerous sectors, especially those of SMEs.

Summary of activities in 2006

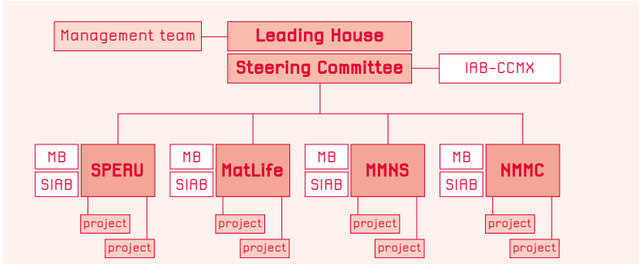
Since its inception in early 2006, the Centre has been hard at work to establish the base for its world-class programme of research, education and technology transfer.



3D designed cell cultures for tissue engineering (ETHZ, USZ, EPFL).

Lab-on-a-chip (EPFL, CSEM, ETHZ)

The **organisational structure** of the Centre is shown below. The roles, responsibilities and competencies of the constituent bodies form part of the Centre's Business Plan, as approved by the ETH Board.



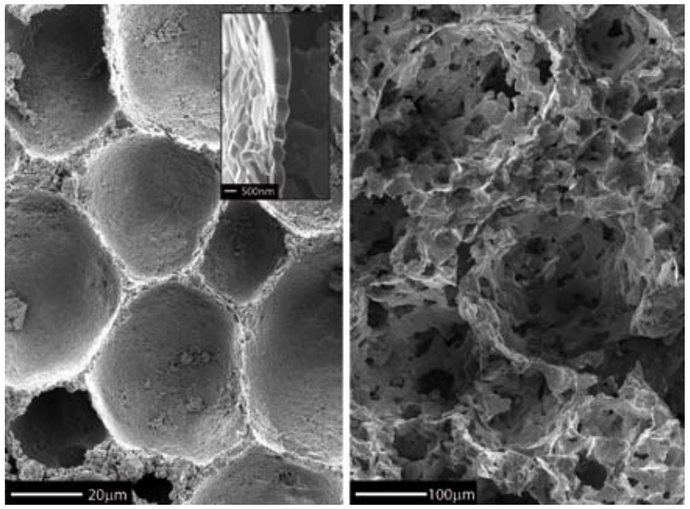
key: **SPERU** Surface, coatings and particles engineering ERU
MatLife Materials for the life sciences ERU
MMNS Materials for micro- and nanosystems ERU
NMMC Nano- and microscale materials characterisation platform

The Leading House and Steering Committee report to the ETH Board. The Steering Committee is composed of eight members; two each from EPFL and ETHZ and one each from EMPA, PSI, CSEM and from industry. As the Leading House, EPFL chairs the Committee. To assist the Committee, an International Advisory Board (IAB) has been constituted, with a mandate covering the appraisal of the Centre's strategy, advising on future direction and initiatives, and evaluating the progress of the projects funded by the Centre.

The **ERUs/platform** were chosen in scientific domains in which the ETH Domain already possesses a critical mass of expertise of international standing, and which also show considerable promise for the economy where downstream developments can benefit from a concerted effort in upstream R&D. The governance of each ERU/platform is ensured by a Director, who is a top scientific leader. He/she reports to the Steering Committee; within the ERU/platform, he/she is supported by a Scientific and Industrial Advisory Board (SIAB) and a Management Board (MB). The thematic foci of each ERU/platform, their education activities and outreach initiatives, were defined by the Directors and MBs in collaboration with the SIABs, before final approval by the Steering Committee.

A fundamental role of CCMX is to reinforce **links between academic research and industry**. As a first initiative the Centre has canvassed a broad range of external partners to establish the future needs of Swiss industry in materials R&D and in continuing education. This is described in the section «Survey of the demands of Swiss industry in materials R&D». The Centre considers this action to be crucial for the development of its activities in the future and will continue with its policy of dialogue with current and potential partners.

The Centre's **research activities** are now well underway. A first call for proposals was launched in spring 2006 by each of the ERUs/platform for their own domains. The process of selection consisted of several stages, involving both the ERU/platform Management Boards and Scientific and Industrial Advisory Boards,



Porous ceramics prepared from wet particle-stabilised foams (ETHZ, EPFL).

and based on clear and objective guidelines. The flagship projects finally chosen were subject to several reviews by independent experts during the process, to ensure a rigorous standard of selection. Among the criteria weighing heavily on the outcome were: collaboration between academic institutions, quality of research content, trans-disciplinarity and the participation and expressed interest of industrial partners.

As a result of this call for proposals, the Centre's ERUs and analytical platform allocated initial funding to twenty-seven projects offering substantial potential for innovation, based on consortia of partners from ETH Domain institutions, Swiss universities and industry. Emphasis has been placed on developments of interest to applications and on matching industrial needs to available technologies. Many of the projects are application-oriented although at a pre-competitive level, and span the «funding gap» between fundamental science/discovery (typically funded by SNSF) and product-oriented development (typically funded by CTI/KTI).

The first projects started operations in July 2006 and all were underway by 1st January 2007. Some projects have already obtained promising results. These projects will constitute a substantial R&D effort around a large community of skilled young scientists and engineers.

Some of the chosen projects have already attracted **industrial funding**. Projects in MatLife, for example, involve a range of companies: SurfaceSolutionS, Sanofi-Pasteur, Arrayon biotechnology, Biotronik, Ayanda Biosystems, AO Davos and Novartis. The Centre will continue to emphasise this aspect of cooperation in order to increase the financial implication of external partners. The ERUs are currently working closely with potential industrial partners on setting up coordinated long-term industrial liaison programmes and are showing strong commitment to attracting matching funds as an essential factor in their success. CCMX will in part be judged on its success in attracting third-party support.

The management of intellectual property (IP) has been and will continue to be a key consideration in setting up projects. The Centre has so far based the project contracts on models of IP management currently used in the partner institutions and by CTI/KTI; however it will pursue discussions with all the partners concerned with the aim of adapting current practices to the collaborative, trans-institution nature of a Competence Centre.

Education initiatives are another fundamental priority of the Centre. The ERUs/platform have been highly active in this respect, and have all planned courses, seminars and travelling laboratories, among other initiatives for 2007. More details are given in the following pages in the description of each ERU/platform. A coordination of the Master programmes in Materials Science at EPFL and ETHZ is in place and should result in a joint programme.

The Centre will continue to emphasise outreach activities as a central part of its mission; its success will depend on the quality of interactions it can encourage. The First Annual Meeting held in Fribourg on 20th March 2007, will bring together representatives of a broad spectrum of materials-related activities from industry, the economy and academia, to present CCMX activities and opportunities for participation.

Procedure for selection of research projects

The quality of the selection procedure for project funding in each ERU/platform is fundamentally important for the overall excellence of the Centre. For its first call for proposals in spring 2006, the Leading House ensured the involvement of all the Centre's principal actors, in spite of the short time frame available, in order to ensure as complete and fair a review procedure as possible.

	SPERU	MatLife	MMNS	NMMC	Trans-ERU
Pre-proposals submitted	**23**	**20**			**2**
per institution					
EPFL	11	7			1
ETHZ	8	6			1
EMPA	2	3			0
PSI	0	1			0
CSEM	2	1			0
Others	0	2			0
Pre-proposals retained	**19**	**9**			**2**
Full proposals submitted	**10**	**8**	**9**	**18**	**2**
per institution					
EPFL	4	2	4	6	1
ETHZ	5	5	2	1	1
EMPA	0	0	1	10	0
PSI	0	0	2	0	0
CSEM	1	1	0	0	0
Others	0	0	0	1	0
Full proposals retained	**4**	**7**	**4**	**12**	**1**

The Steering Committee based the call for proposals on the ERU/platform programmes as approved in the CCMX Business Plan. It assigned the operational responsibility of the call to the ERUs/platform. With support from the Leading House management team, the calls were launched in the second half of March 2006; each ERU/platform submitted its proposal for projects to be funded to the Leading House by 25th May. The Steering Committee met on 12th June to approve the plans and, in certain cases, impose complements of action or realignment of the proposals.

In SPERU and MatLife, a two-stage process was used. A first expression of interest based on a short pre-proposal was subjected to multiple reviews. In some cases it was suggested to the proposers that several proposals be combined into larger consortia. Retained projects were then invited to submit full proposals.

MMNS and the NMMC analytical platform both used a one-stage process. All the proposals received were reviewed by at least four independant assessors.

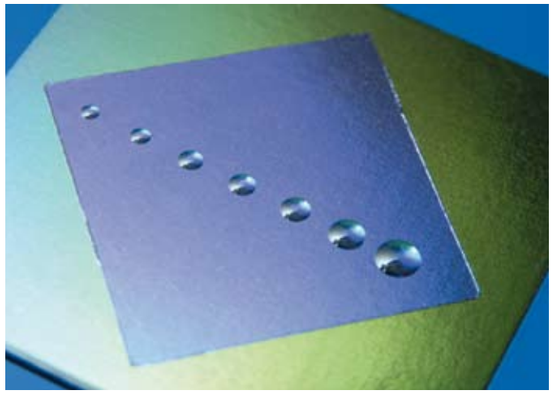
Certain proposals, while received by a particular ERU, were considered to be «trans-ERU» in nature, and were processed differently; the implicated ERUs each evaluated the proposal according to their established procedure, on the basis of which the Leading House submitted a proposal for funding to the Steering Committee. This resulted in the decision to fund one extra project, under the umbrella of MMNS.

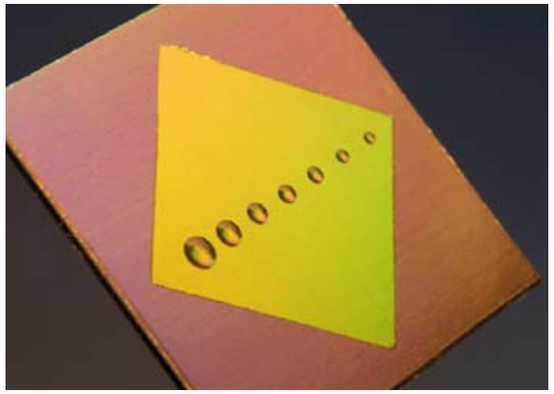
As shown by the figures above, the selection procedure was stringent. Over a very short time span, the procedure mobilised a large number of qualified specialists and entailed several control loops. The involvement of all the principal actors ensured an objective evaluation and the respect of the criteria for funding. In its coordinating role, the Leading House acts as a fair and neutral arbiter of the procedure.

ERU #1

«Surface, coatings and particles engineering» Education and Research Unit – SPERU

Particulate-based products are found in such diverse fields as transportation, energy, pharmaceuticals, the food industry, medical devices, the watch industry and consumer goods. They may serve in surface structuring and coatings, composites, fluids or bulk materials comprising metals, semi-conducting materials, ceramics, soft matter and polymers. The smart combination of well-known materials with particles, especially nano-sized particles with unique and novel properties, may lead to systems and products with characteristics and functionalities not achievable through classic processing or with standard materials.





Zero-order nano optical pigments (CSEM, PSI)

Sperու

To successfully establish the Education and Research Unit «Surface, Coatings & Particles Engineering» (SPERU) as a Centre of Excellence, an integrated understanding in the fields of colloidal chemistry, surface and interface science, and processing of particulate matter should govern research activities leading to appropriate implementation towards industrial exploitation. Particulate-based products such as coatings/thin films (e.g. for protective layers, electronic devices, batteries or hard disks, packaging), fluidic or solid composites (e.g. for print media, cosmetics, pharmaceuticals, food) are recognised by their functionality, by system design and their handling. Most of their properties rely on a perfect match between materials properties and process technologies. Expert treatment and processing of nano-sized particles with unique magnetic, optic and/or chemical properties may help broaden their scope of applications; however, safety issues must be taken into account. The scientists, engineers and technicians working within SPERU are aware of nanoparticle-related problems and their laboratories are equipped to satisfy the requested safety requirements.

SPERU will investigate and develop new particulate-based systems. The core research team needs to exchange knowledge and technology with industry in order to transfer their know-how from the forefront of research into meaningful applications. Their current competencies in coating technologies, surface engineering and particles technology - including particle-based smart materials, advanced characterisation and testing methods - will facilitate knowledge transition from the bench to products and systems. SPERU's main goals are the development of innovative new particulate materials with unique properties and new economically-interesting processing methods. A network of leading scientists will serve as an active interface between fundamental research and applied development in the framework of pre-competitive research projects.

SPERU is run by a Management Board that includes its Director and by an operational Management Team. Their activities are supported by a Scientific and Industrial Advisory Board with members from industry and academia in Switzerland, Europe and the USA.

The ERU already consists today of a strong network with research units from each of the five ETH Domain institutions. Four flagship projects have been funded and are currently underway:

A) «Development of novel methods for surface modification and investigation of cell-particles interaction for superparamagnetic nanoparticles»
Principal investigator: Prof. P. Renaud (EPFL)
Partners: EPFL, CSEM
Nanosized superparamagnetic particles will be coated with interesting biological molecules and classified regarding their physical and chemical properties using a novel technique based on microfluidics.

B) «Nanocrystalline ceramic thin film coating without sintering»
Principal investigator: Dr. J. Rupp (ETHZ)
Partners: ETHZ, PSI, EMPA
Development of novel fabrication techniques for thin particulate films with high functionality leading to a large range of applications.

C) «Smart functional foams»
Principal investigator: Prof. L. Gauckler (ETHZ)
Partners: ETHZ, EPFL
Further improvement of an innovative new method for the manufacturing of foams stabilised with colloidal particles and their transformation into solid materials based on ceramic, metal or polymer.

D) «Zero-order nano optical pigments»
Principal investigator: Dr. A. Stuck (CSEM)
Partners: CSEM, PSI
Physical colours based on the unique arrangement of non-spherical nanosized particles in an inorganic or organic matrix are under investigation for applications in safety or decorative surfaces.

These flagship projects based around SPERU core research groups emphasise the ERU's knowledge base and will act as seeds for further innovative pre-competitive research projects. They will ensure SPERU's visibility vis-à-vis industry and should encourage future partners to collaborate in similar or new topics based on particles-related and surface technologies.

SPERU aims to be an exemplary interdisciplinary research group transferring with success the research results elaborated in the participating laboratories to industrial applications. It is a clear goal to reinforce the existing high level of academic research and to operate as a «think tank» for future industrial needs and a source for novel advanced particulate materials, including their processing. Therefore SPERU will be organised as a virtual institute specifically devoted to pre-competitive research financed at a high level with third-party funds. An industrial liaison programme will be set up. Industrial members will be offered fast and efficient access to their domain of interest by purchasing a research ticket to be matched with CCMX funding. Industry partners will have the opportunity to participate in the definition of future strategy through the SPERU Industrial Assembly. In addition SPERU, as an integrated research facility, will have an excellent chance to actively participate in projects funded though the 7th EU Framework Programme.

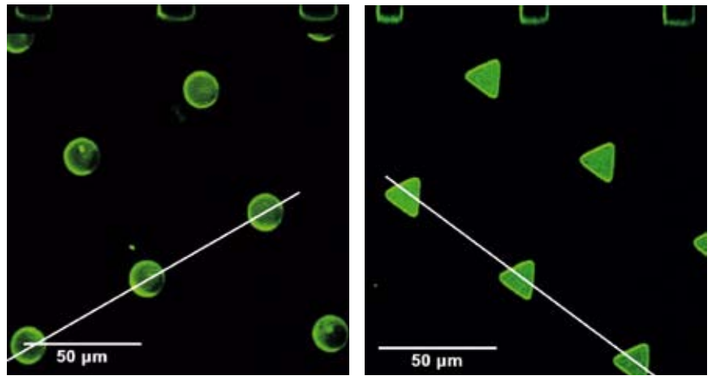
Technology transfer will be actively encouraged through direct contacts between SPERU researchers and industrial researchers. In 2007 SPERU will be implementing several initiatives for promoting pre-competitive research and continuous education activities:

1. **«What is coming next *in a particular field*»** regional events, consisting of plenary talks and short talks followed by a debate, will be organised in late afternoon several times per year. This event will particularly target decision-makers and will aim at promoting SPERU pre-competitive research activities.
2. The **«SPERU Science and Networking Day»** during which industry researchers will have the opportunity to brainstorm with groups of SPERU researchers about foreseen long-term challenges.
3. **Individual training** for company scientists will be offered at a SPERU network location.
4. An **annual five-day course** will be organised in close collaboration with the two other ERUs of CCMX, offering a series of modules opening a broad angle on current and future technical challenges.
5. Specific 1-2 day **short courses** tailored to the technical and scientific needs of companies will be organised several times per year in collaboration with SPERU member laboratories. As an example, EPFL's Powder Technology Laboratory organised a «Particle Size Measurement and Powder Characterisation» course on 19th-20th October 2006, attended by 12 participants, three-quarters of whom came from Swiss industry.
6. Other courses and events will be organised in collaboration with Swiss or European Materials Science and Engineering associations.

ERU #2

«Materials for the life sciences» Education and Research Unit – MatLife

MatLife's vision is to establish within three to five years a complete educational and research network integrating research groups throughout Switzerland and focusing on new breakthrough technologies.



Studying single cells in engineered 3D microenvironments (ETHZ, EMPA, AO Davos, Novartis)

MatLife has already several clear research foci: scaffolds for tissue engineering, materials for regenerative medicine, drug and gene delivery systems, materials and surfaces that derive from bioengineering, anti-microbial and anti-inflammatory surfaces as well as biosensors to detect especially protein and carbohydrate molecules. In all these projects, MatLife tries to combine enabling technologies and functional design to produce optimal devices. Improved performance, reliability and cost-effectiveness of applications will result. A particular focus is on soft materials with molecular structure designed in consideration of their biological interactions and in the integration of novel enabling technologies in devices and systems; applications are in fields such as implantology, tissue engineering, drug delivery and biosensing/diagnostics.

Projects funded within MatLife are of two types:

(i) **enabling technology development**, addressing major issues that limit progress in the field, combined with a deeper understanding of the fundamental mechanistic phenomena involved;

(ii) **integrated projects** with the aim of developing devices based on new concepts/enabling techniques and demonstrating their performance in first applications.

There are seven ongoing flagship projects. Each project has at least one industrial partner or hospital collaborator. Those which started in 2006 have already generated significant and promising results.

A) «Three-dimensionally engineered cell culture substrates as nanofibrous, glycofunctionalised, electrospun scaffolds for directed growth of cells and nerve regeneration»
Principal investigator: Dr. C. Hinderling (CSEM)
Partners: CSEM, ETHZ, Arrayon biotechnology
The aim of the project is to generate a novel nanofibrous material to be used as three-dimensional scaffolds for the directed growth of cells, such as in nerve regeneration and nerve guiding. The material will be produced in the form of a non-woven mat of nanofibres produced by electrospinning.

B) «Targeted drug delivery: novel polymeric, nanoscale carrier systems for vaccine delivery (antigen delivery to immune system cells)»
Principal investigator: Prof. J. Hubbell (EPFL)
Partners: ETHZ, SurfaceSolutionS, Sanofi-Pasteur
This proposal describes a novel approach to target dendritic cells (DCs) and consequently control T-cell mediated immunity for vaccine applications. Polymer nanoparticle systems will be designed that specifically target and deliver antigen to DCs.

C) «Generic analytical, diagnostic and drug screening platforms, for highly parallel, array-type detection of glycosylated proteins/drugs and food components»
Principal investigator: Prof. P. Seeberger (ETHZ)
Partners: ETHZ, Arrayon biotechnology
The goal of the proposed project is to explore the feasibility of assembling lectins, to test the assemblies' binding efficiency and binding kinetics with multivalent target glycoproteins, and to establish generic analytical means for assaying natural or designed glycosylated (protein) drugs and/or food complements.

D) «Implantable devices: biofunctionalised, drug-eluting magnesium implants as bioresorbable cardiovascular stents»
Principal investigator: Dr. S. Tosatti (ETHZ)
Partners: ETHZ, EMPA, Biotronik
This project aims at the cooperative development of a completely new stent system, which combines the advantages of both drug-eluting stents (DES) and absorbable metal stents (AMS). Specifically, a coated AMS with tailored degradation characteristics, and biofunctionalised layers that enable medical cargo will be developed.

E) «A versatile platform for screening drugs and measuring signal transduction using transmembrane protein receptors on chip»
Principal investigator: Prof. H. Vogel (EPFL)
Partners: EPFL, CSEM, ETHZ, Ayanda Biosystems
The aim is to develop a versatile platform for screening of transmembrane receptor function and signalling pathways. A self-assembly technique using block-copolymers will be employed to produce patterns for etching nanoporous SiNx supports with defined density, feature size and chemical cues.

F) «Three-dimensionally engineered cell culture substrates, for investigating how cellular microenvironments regulate cell function and as a single-cell-based in-vitro sensor platform for drug discovery and screening with more predictive data sets»
Principal investigator: Prof. V. Vogel (ETHZ)
Partners: ETHZ, EMPA, AO Davos, Novartis
The goal of this project is to develop a platform technology where single cells can be studied in engineered quasi-3D microwells. The physical aspects of the cellular environments will be further tuned to learn how cell shape and the rigidity of the microwell walls differentially regulate diverse cell functions.

G) «Three-dimensionally designed cell cultures consisting of microstructured cell-sheets and polymer layers for tissue engineering»
Principal investigator: Prof. J. Vörös (ETHZ)
Partners: ETHZ, EPFL, University Hospital Zurich
The project aims at developing a new method for harvesting of cell sheets by electrochemical means. The project team proposes to develop a 3D composite material consisting of alternating layers of 2D engineered, heterotypic cell sheets and microstructured biodegradable natural and artificial polymeric thin film hydrogels.

In addition to running research projects in high-priority areas of materials for the life sciences, MatLife is also dedicated to advancing educational opportunities, particularly for PhD students and postdoctoral fellows, through two types of educational workshops, as well as encouraging Master students from abroad to join CCMX projects by providing financial assistance. Furthermore, to enhance the relationship between academia and industry, we are proposing an industrial liaison programme for the ERU of which companies can become members, for a fee, and in return will have access to technology developed within MatLife as well as access to the educational workshops.

Workshops

Two types of educational workshops have been devised to provide specific training across the relevant disciplines of the field while also fostering personal contacts between students of different organisations. The first is a Tutorial Type (TuT) Workshop, in which block sessions on high-priority areas of materials for the life sciences will be presented in a tutorial fashion by leaders in the respective fields. Both national and international speakers will be invited to present these topics. The first TuT workshop is being organised for August 2007; it will consist of a one-day workshop preceding the international Biosurf VII conference being held in Zurich from 29th to 31st August 2007 (http://www.biosurf.ch). We also plan to organise, together with the other ERUs, a cross-ERU annual Tutorial Type workshop.
The second type of workshop will be a Travelling Lab (TLab) Workshop in which participants will spend one week travelling from industrial to clinical to academic settings and participating in hands-on problem solving in each of these settings. The first TLab workshop is tentatively scheduled for January 2008.

Master thesis student support

Another aspect of the programme covers the financial support of Master Theses conducted by students from abroad. The motivation for this support is to encourage and allow more students from foreign countries to take part in the master programmes of ETH Zurich and EPF Lausanne, who otherwise, without financial support, would not be able to do so. It is envisaged that this support will make our schools more international on the level of master education, positively contribute to a lively, international research group culture and strengthen the educational and research links between our institutions and top foreign universities worldwide. For further information, please contact liaison-officer-matlife@mat.ethz.ch.

Industrial liaison programme

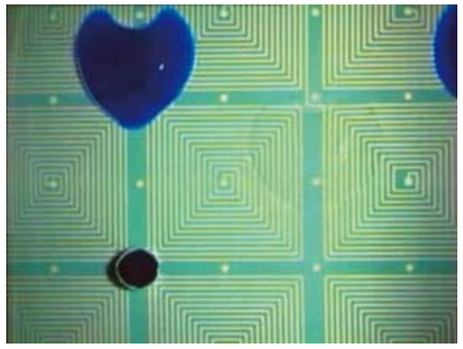
The aim of the MatLife Industrial Liaison Programme (ILP) is to develop a long-term partnership between academia and industry. In addition to industries being encouraged to take part as partners in either pre-competitive or competitive research projects, they will also be invited to become members in the MatLife consortium by joining the ILP. In exchange for a fee, both small and large companies will gain preferred access to technology developed in the ERU Research Programme as well as gaining access to the educational programmes offered by the ERU. The income received from the members will help fund MatLife activities such as the Educational Programme workshops. In autumn 2007, a one-day meeting with interested industrial partners will be organised with the aim of informing and getting feedback on the planned further development of the ILP.

ERU #3

«Materials for micro- and nanosystems» Education and Research Unit – MMNS

The Educational and Research Unit «Materials for Micro- and Nanosystems» MMNS focuses on materials that create new micro- and nanoscale electrical and mechanical devices for computing, embedded control and biomedical data acquisition. The ERU will study the characterisation and patterning of these materials from a systems engineering point-of-view.

Silicon and some other materials should be patterned in such a way that nanoscale devices for computation and storage are produced. New materials for integrated ultrasmall peripherals that complement the computational and storage core of information technology systems will be developed (thematic focus i). A «laboratory-on-a-chip» with sensors for biological and inorganic materials integrated at a very small scale and transport mechanisms for micro- and nanosamples on the chip and on microarrays will be studied (thematic focus ii).



Lab-on-a-chip (EPFL, CSEM, ETHZ, Microsens)

Building a bridge between materials- and systems-oriented approaches is seen as a great opportunity. The ERU is uniquely placed to play a major integrative role between EPFL and CSEM, a leader in the creation of micro-devices with strong ties to local industry. MMNS will contribute to the growth of local enterprises by providing a network of teaching, research and contacts. A yearly symposium and several workshops will be organised.

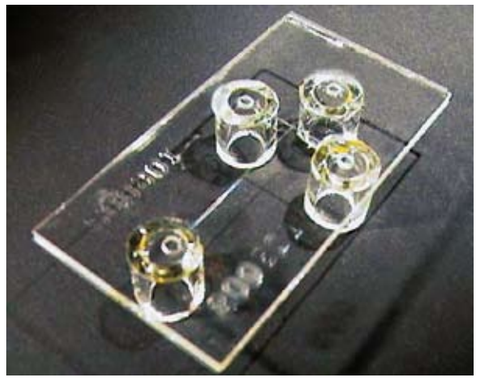
Four projects started operations in summer 2006. Two teams, led by Prof. Y. Leblebici (EPFL) and Prof. J. Vörös (ETHZ) respectively operate within the thematic focus of *materials technologies and design for micro and nanosystems*, whereas the two other teams, led by Prof. M. Gijs (EPFL) and Dr. Q. Ren (EMPA) respectively are active within the second focus area of *laboratory-on-a-chip*. All four teams include participants from two or more institutions of the ETH Domain.

A) «Materials, devices and design technologies for nanoelectronic systems beyond ultimately scaled CMOS»
Principal investigator: Prof. Y. Leblebici (EPFL)
Partners: EPFL, ETHZ, CSEM

Two separate project sub-groups concentrate on the «technology-materials-devices» area and on the «nanosystems and circuits» area, in parallel. Key research themes have been identified as (i) the exploration of novel materials that will be suitable for very high-density memory and logic applications (especially concentrating on ferro-electric materials), (ii) growth and manipulation of CNTs for the creation of novel cross-bar switch arrays, (iii) exploration of gate-all-around (GAA) transistors as viable candidates for novel logic array applications, and (iv) development of fault- tolerant design techniques to be used in conjunction with failure-prone device structures and technologies.
As a first key result, the GAA transistors have been successfully produced in the EPFL micro-nano fabrication facility (CMI) and their correct operation has been experimentally demonstrated. The second fabrication round to produce simple logic functionality (AND/OR) using this device structure is currently underway. The near-term goal is to demonstrate PLA-like array structures for implementation of Boolean functions using matrices of silicon nanowires, fabricated with conventional lithography techniques (a series of isotropic etching and sacrificial oxidation steps). In parallel to this development, experiments are continuing for the process and characterisation of specific ferroelectric materials (polymer dielectrics) for the fabrication of FETs to be used in very dense non-volatile memory arrays.

B) «Development and characterisation of nanowires for applications in bio-electronics»
Principal investigator: Prof. J. Vörös (ETHZ)
Partners: ETHZ, PSI

The large scale production of nanowires is being addressed in this project. Key limiting factors are being addressed; initial experiments on the electronic and



Lab-on-a-chip set-up (EPFL, CSEM, ETHZ, Microsens)

mechanical characterisation of the nanowires have been performed and based on these results the first designs for interfacing the nanowires with micron-size structures have been created. Since the interfacing requires precise positioning of the prefabricated micron-size features and the nanopatterns, preliminary studies for the aligned exposure of samples are being performed at the Swiss Light Source, PSI.
The team is developing an in-situ method for selective manipulation of surface immobilised DNA-tagged nano-scale objects, such as gold colloids in aqueous solution at neutral pH. This will allow the team to adapt the structures produced at PSI to the needs of the biosensing experiments as well as to model the expected sensing behaviour of the nanowires in order to optimise the geometry and the interface design, and to compare the performance of nanowires made of different materials, such as conductive (gold), semiconductive (ITO, doped Si), and nanoparticle-based. The tensile testing of nanowires arrays with systematic variations in height (25-50 nm) and width (30-70 nm) for monitoring scale effects is also on the way. The team plans to perform the characterisation of the electrical conductivity as a function of nanowire dimensions (variations in height and width) and applied strain as well as the microstructural characterisation of the nanowires (grain size, roughness, and defect densities).

C) «Lab-on-a-chip for analysis and diagnostics»
Principal investigator: Prof. M. Gijs (EPFL)
Partners: EPFL, CSEM, ETHZ, Microsens

The objective of the Lab-on-a-Chip (LoC) research project is to explore various research aspects of the LoC concept, focusing on materials, design, microfabrication and experimentation of novel types of miniaturised analysis systems in the following application domains: *in vitro diagnostics* with focus on the detection of malaria, *food analysis* with focus on the detection of antibiotics in milk and *monitoring of the environment* with focus of the detection of pH and ionic strength in water.

The team has developed a CMOS system enabling manipulation of magnetic micro-particles through a magnetic field and in-situ optical detection, and showed that the combination of magnetic actuation and miniaturised optical detection diodes presents an interesting platform for future on-chip bio-analysis applications. Also, a biological receptor immobilization protocol for a wavelength interrogated optical system (WIOS) was developed. WIOS detects the refractive index changes in the evanescent wave of a straight waveguide grating using a wavelength sweep. Molecular recognition reactions can be monitored in real-time without the use of labels.
An AlN shear-mode acousto-gravimetric resonator was processed in the clean room on top of an acoustic reflector structure. This resonator structure will be covered by photolithographically patterned poly(methacrylic acid) brushes grown by surface-initiated atom-transfer radical polymerization. These brushes function as ionotropic matrices and the changing ionicity of an aqueous solution can be directly probed via a resonance frequency change of the resonator.

D) «Biopolymer PHA as surface materials for micropatterning proteins on microarrays»
Principal investigator: Dr. Q. Ren (EMPA)
Partners: EMPA, PSI, ETHZ, Preentec

The aim of this project is to develop a novel technology for directly immobilising proteins on surfaces, for example for the fabrication of protein microarrays. Medium chain length (mcl) PHA are biopolyesters that are exceptionally well-suited for surface coating. By using gene technology the team will construct PHA-immobilisable fusion proteins that combine the binding domain of extracellular mclPHA depolymerase (PhaZ, from *Pseudomonas fluorescens* GK13) with a protein of interest. For the proof of concept the easily detectable green fluorescent protein (GFP) will be used. We expect the fusion protein to bind mclPHA surfaces with high specificity, high affinity and without denaturation. Furthermore, due to PhaZ being oriented toward the PHA surface, the protein of interest is exposed towards the outside, resulting in an enhanced interaction with target molecules. With its tight financial frame, the project has the character of a feasibility study.
The following tasks have so far been accomplished: (i) PCR amplification of the complete *phaZ* wild-type gene, of an inactivated PhaZ variant gene (S172A) and a *gfp* gene that has been optimised for expression in prokaryotes (GFPuv), (ii) PCR amplification of the supposed substrate binding domain (SBD) and cloning of *phaZ* SBD in an *E. coli* cloning vector, (iii) production and purification of various types of mclPHA, (iv), development of a coating method yielding homogeneous, bubble-free mclPHA coatings.

Analytical platform

«Nano- and microscale materials characterisation for industry and academia» – NMMC

The analytical platform brings together broad analytical resources from all the participating institutions, and is clearly a trans-institutional offer. It will provide nano- and microscale materials characterisation for parties interested in this service. In a first stage, projects will be focused on *scanning* and *beam-related methods*. Sophisticated tools such as the scanning probe microscopies but also beam-related methods such as electron microscopy, focused ion beam techniques, secondary ion mass spectroscopy and synchrotron techniques, enable surface and interfacial characterisation of materials, partially allowing individual atoms and molecules to be observed.

Within the platform strong emphasis is put on the installation of new user/service laboratories including expert operation staff by improving existing structures/laboratories and by virtually combining laboratories existing in the ETH Domain. Analytical tools, methods or instrumentation for the analysis of physical, chemical, or biological properties on the scale below 100 nm will be developed first, by using existing instrumentation and research projects between different ETH Domain institutions or other non-profit organisations.

The use of the already-existing excellent analytical instrumentation in the ETH Domain institutions is facilitated for members of the ERUs of all Competence Centres, for other non-profit research institutions and also for industry. In addition, the platform aims to develop instruments/methods that are or will become of added value for more than one partner of the ETH Domain and of industry.

Several broad types of projects are funded:

- projects of *type 1a* which consider the development of new analytical tools, methods or instrumentation for the analysis of physical, chemical, or biological properties on the scale below 100 nm
- projects of *type 1b*, which consider the purchase of such instrumentation or components to complete user & service laboratory equipment, if a continued further development of the instrumentation is envisioned, preferably with an industrial partner, and if matching funds from the home-institution are available
- projects of *type 2* which consider research projects between different institutions of the ETH Domain or other non-profit organisations that require the use of already existing instrumentation for nanoscale analysis.

As an example of a type 1a project, a novel type of scanning X-ray microscope is currently under construction in a joint effort between EMPA and PSI. The instrument will combine the chemical specificity of x-ray absorption spectroscopy with the spatial resolution (< 5nm) of a scanning force microscope. It will be permanently installed at a beamline at the Swiss Light Source (SLS) at PSI.

In an example of a type 1b project, a Swiss Scanning Probe Microscope User Laboratory has been opened at EMPA. Several multi-purpose and highly specialised scanning probe microscopes are installed in a dedicated user laboratory. The laboratory provides sophisticated analytical services, as well as a platform for research and development projects at the forefront of scanning probe microscopy, for both industry and academia. The instruments are also available for education and technical training courses.

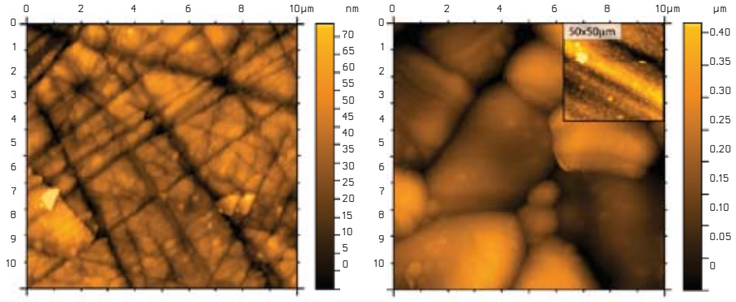
With this funding strategy, the platform caters for a wide range of demands concerning nano- and microscale analysis. Analysis of both specific, well-defined problems as well as less well-defined, riskier problems (where success or suitability of the method is unsure) is covered. The development of new analytical instrumentation and the furthering of education in specific areas of analysis is ensured.

Twelve projects are currently being funded:

TYPE 1a:

A) «Development of self-sensing and-actuating probe for dynamic mode AFM at cryogenic temperature»
Principal investigator: Prof. N. De Rooij (EPFL)
Partners: EPFL, ETHZ
The project aims at the development of a mass-producible and easy-to-use self-sensing and self-actuating probe for dynamic mode atomic force microscopy at cryogenic temperatures.

B) «Nanoscale resolution optical microscopy for material imaging and spectroscopy»
Principal investigator: Prof. C. Depeursinge (EPFL)
Partners: EPFL
In this project, optical digital holographic microscopy for fast imaging and spectroscopy for nanomaterials investigation will be further developed and implemented.



Swiss SPM user laboratory (EMPA)

C) «New generation scanning anode field emission microscope at EMPA Thun»
Principal investigator: Dr. O. Gröning (EMPA)
Partners: EMPA
The project aims at the construction and implementation of new generation scanning anode field emission microscope (SAFEM) for the analysis of planar field emission cathodes.

D) «Nano-XAS»
Principal investigator: Dr. I. Schmid (EMPA)
Partners: EMPA, PSI
The project develops a novel type of scanning x-ray microscope that combines chemical specificity of x-ray absorption spectroscopy with the spatial resolution of scanning force microscopy.

E) «Efficient double-passage SNOMs»
Principal investigator: Dr. U. Sennhauser (EMPA)
Partners: EMPA, ETHZ
The project proposes the development of a new «double passage» SNOM type that is expected to have higher resolution than «single passage» SNOMs.

TYPE 1b:

F) «Correlated energy electron loss and cathodoluminescence spectrometry in SPTEM»
Principal investigator: Prof. P. Stadelmann (EPFL)
Partners: EPFL
The project aims to provide on a scanning probe transmission electron microscopy system (SPTEM) the spectroscopy equipment required to analyse the light emitted by non-conducting materials resulting of its interaction with the electron probe, i.e. cathodoluminescence spectrometry.

G) «Scanning probe microscopy of cytoskeletal proteins in living cells»
Principal investigator: Dr. B. Hinz (EPFL)
Partners: EPFL
The project concerns a life science scanning force microscope package for the study of the nano-mechanical properties of cytoskeletal proteins simultaneously with fluorescence microscopy.

H) «Swiss SPM user laboratory»
Principal investigator: Dr. P. Kappenberger (EMPA)
Partners: EMPA
The project proposes the founding of a Swiss Scanning Probe Microscope User Laboratory with several multi-purpose and some sophisticated scanning probe instrumentations installed in a dedicated user laboratory.

TYPE 2:

I) «Nanometric level investigations of aluminium nitride/silicon nitride hard coatings using high resolution TEM and energy dispersive X-Ray analysis»
Principal investigator: Dr. J. Patscheider (EMPA)
Partners: EMPA
The project aims at the investigation of the Al-Si-N system by TEM and EDY to obtain structural and chemical properties.

J) «Subattonewton force sensors with hard magnetic tips for magnetic resonance force microscopy»
Principal investigator: Dr. S. Rast (UniBasel)
Partners: UniBasel, EMPA
The project aims to shrink the dimension of micrometer sized hard magnetic tips glued on a force sensor with attonewton sensitivity in order to enhance magnetic field sensitivity by several orders of magnitude.

K) «Stress voiding and electromigration as reliability indicator in nanoscaled interconnects»
Principal investigator: Dr. U. Sennhauser (EMPA)
Partners: EMPA, Philips Semiconductors
The project proposes to perform 3D TEM to investigate weak mode failures in semiconductor devices.

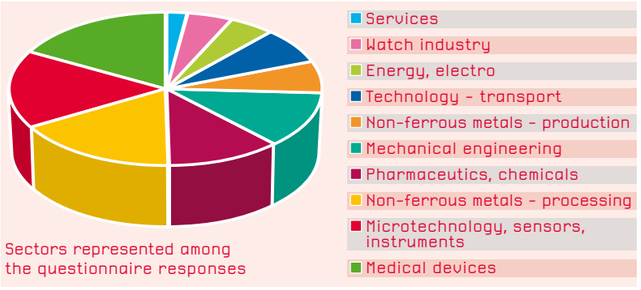
L) «FIB preparation of TEM-specimens with minimised defects»
Principal investigator: Dr. U. Sennhauser (EMPA)
Partners: EMPA, ETHZ
The project aims to implement a method to minimise Ga implantation and to reduce amorphisation close to the thickness of naturally-grown oxide layers during FIB preparation of TEM lamella.

Funding for additional type 2 projects has been reserved by the platform Management Board.

In addition to analytical services an academic education and technical training will be offered to industrial and public sector partners.

Survey of the demands of Swiss industry in materials R&D

Why a survey? In a rapidly-evolving industrial environment, targeting needs in research and development can be a difficult task. Technologies may evolve in unexpected directions; the perspectives of research laboratories and of applications developers may differ significantly. By implicating current and future partners in the formulation of the Centre's activities, the aim is to ensure suitable choices of thematic foci of the ERUs/platform and to optimise the use of the allocated resources.



Sectors represented among the questionnaire responses

In a first initiative, the Centre launched a consultation with three primary goals: to better relate the demands of Swiss industry in research and education to the activities in materials science and technology in academia, to improve networking in the field of materials and to inform on the current and future activities of CCMX.

Instead of opting for a purely statistical analysis with a standardised narrow questionnaire, a broad range of partners were canvassed with a lengthy questionnaire comprising a balanced mixture of closed and open-style questions, in the hope of acquiring in-depth qualitative feedback. The questionnaire was addressed to more than 400 companies, with the help of several professional and industrial associations. All industry sectors touched by materials science and technology were included; these sectors ultimately represent more than a quarter of Switzerland's gross national product, according to the latest statistics from the Swiss Federal Statistical Office.

All participants were assured of the strictest confidentiality, and data will not be given to any third party, nor will reverse engineering of the data be possible. The relevance of their detailed opinions cannot be stressed enough and they will be among the first to benefit from the results of the study. A full report of the findings of the survey will be distributed.

A return rate of just over 10% was achieved (42 companies). Together, these companies employ 6.5% of the entire workforce in the Swiss secondary (manufacturing) sector. The respondents came from across the whole manufacturing industry with the exception of the leather, wood and refinery sectors, which are in any case not primary foci of CCMX. There was a clear participation of the chemical, metals and electronics/fine mechanics sectors. All company sizes from SMEs to large multinational corporations were represented.

The respondents are at present principally active in semi-finished to finished goods, but in the future they intend to focus more on final products and complete systems. With an average R&D spending rate of 4 per cent relative to turnover, the respondents have a slightly higher commitment to research and development than an average Swiss company. Their main expressed needs are, in order of priority: new or improved material properties, cost savings, new or improved process technology, quality improvement, new intellectual property (IP), cooperation with R&D facilities and cooperation with other companies.

All respondents are interested in collaborating with at least one ERU. They favour a bottom-up approach for collaborative research rather than being driven by academia initiatives (top-down). As a model for collaboration, half would opt for CTI-like cooperation rather than any other (SNSF-like or EU-like, for example). Applied research over a limited time-frame and pre-competitive research are preferred to fundamental research; the possibility of working in consortia with other industrial partners is welcomed.

The use of intellectual property resulting from collaborative projects, whether in the form of filed patents or published results, is a crucial preoccupation. There is overall agreement that ETH Domain funding should not be used to subsidise testing and direct services, for which direct industrial funding is seen as more appropriate.

The willingness of industry partners to commit time and resources to CCMX can be seen in the fact that twenty-five industry respondents met under the umbrella of CCMX on 11th January 2007 in Berne. In this kick-off workshop, partners clearly expressed their interest in the various ERUs/platform, as well as in several potential themes for future interaction.

With this precious input, CCMX can thus further fine-tune current and future activities. The continuous search for feed-back from its partners will be an important part of the Centre's tasks.

Perspectives

CCMX is a stimulating new initiative that will work with a long-term vision to reinforce transfer of research ideas out into products and systems. The existing ERUs/platform are seen as pioneers and further areas for close networking will be identified. New themes of research will be added within the existing ERUs and platform; the creation of new ERUs can be envisaged, should their need be demonstrated. The Centre's activities will soon be supplemented through an upcoming call for proposals.

What does CCMX represent for potential partners, and why should they get involved? The Centre

- provides the opportunity to work in consortia, to exchange knowledge and to access resources, especially the people behind the research
- is a privileged forum for pre-competitive research
- opens up access to analytical resources
- offers specialised training and education focussed on materials science and technology
- and finally, is a partner for industry's future needs in research.

The Centre's success will depend largely on the quality of the interactions it can encourage. It will continue to emphasise outreach activities as a central part of its mission. The Centre aims to provide many varied possibilities for interaction: an Annual Meeting, research forums, education initiatives, ERU-sponsored conferences, seminars and workshops and, of course, direct contact with the Centre or the ERUs/platform. It is now up to the materials community, whether managers, researchers, developers, external partners or students, to participate.

2006 data

Planned funding over the period 2006-2007 by ERU/platform, in kCHF

SPERU	MatLife	MMNS	NMMC	Centre	**Total**
2'000	2'600	2'800	2'000	600	**10'000**

Leverage of projects funded by CCMX

	SPERU	MatLife	MMNS	NMMC
Number of projects funded	4	7	4	12
Personnel funded by CCMX (FTE)*	14.7	21	8.65	4.5
Personnel support provided by partners (FTE)*	6.8	17.8	5.85	1

**FTE = full-time equivalent positions (status on 31st December 2006)*

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