CCMX
Competence Centre for
Materials Science and Technology

CCMX FINAL REPORT

A LEGACY OF ENDURING COLLABORATION AND INNOVATION

EPFL ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE
ETH zürich
EMPA
PAUL SCHERRER INSTITUT PSI
csem

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EXECUTIVE SUMMARY

In 2006, the ETH Board gave CCMX a mandate to facilitate better alignment between the research activities of ETH Domain institutions and the needs of Swiss industry. Over the course of its 10-year engagement, CCMX's Public-Private Partnership (PPP) has evolved into a proven alternative for funding pre-competitive materials science in a pragmatic and productive way. This enabled quite a broad scope of research efforts to be realised and also resulted in increased efficiencies. CCMX's approach has been widely beneficial to ETH Domain and industry stakeholders, while creating a substantial return on investment, with offshoots projects amounting to more than 33 mCHF, 68 theses and 549 reviewed ISI publications.

CCMX introduced a new paradigm for collaborative research in Switzerland.

Industry and academia were able to reach an unprecedented level of cooperation and mutual understanding. Interdisciplinary collaboration was a core requirement at every level of the Centre's activity. From funding to training to networking, CCMX promoted increased interactions among stakeholders. Companies have regarded CCMX projects as an excellent means for attracting highly skilled personnel, thus fueling long term development and innovation in their fields.

CCMX brought value to industry stakeholders through pre-competitive research projects that could not be accomplished internally, and also through wide-ranging training activities and technology transfer events. Since 2006, there have been a total of 76 companies, three federal entities and one foreign government-funded institute involved in CCMX projects. With four new academic chairs, two at EPFL and two at ETH Zurich, along with five ongoing Materials Challenges, CCMX leaves a lasting legacy of interaction between industry and academia.

Education has been, and still is, a core element of the Centre's mission, exemplified by its variety of advanced training events. Courses on recurring themes have established a brand identity—demonstrated by the way students anticipate their occurrence with early registration. Going forward, CCMX will continue supporting the Swiss materials science community through the organisation of courses and networking events in 2017 and beyond.

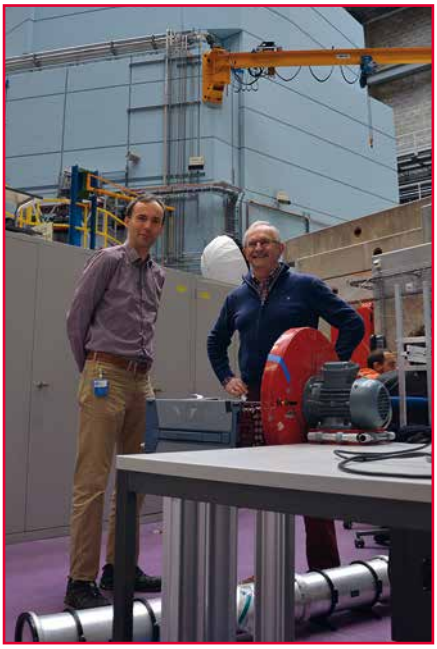
CCMX has secured a lasting legacy of collaboration and engagement between Swiss industry and academia in three concrete ways: by co-funding four new academic chairs charged with doing cutting-edge research, by implementing five Materials Challenges to fuel innovation, and by providing a continuing structure for training and networking events.

Every aspect of the Centre's activities has advanced materials science in Switzerland through productive and innovative collaboration between academic and industry partners. In conclusion, CCMX has achieved and exceeded its mission.

1. HISTORY OF ACTIONS AND EVOLUTION OF STRATEGY

A. Introduction

In this final report we will focus particularly on the strategic relevance of CCMX.



Prior to the initiation of CCMX in 2005, the world leading researchers in materials science affiliated to ETH Domain institutions worked with funding from SNSF, European projects, CTI and bilateral industry contracts. The ETH Board identified the need for better cooperation between the research groups and integration of the mid- and long-term strategic research needs of the industry. Most significantly, there was an important "funding gap" between the fundamental research supported by SNSF, and the applied, "close to market" projects supported by the CTI. There was a deep concern from Swiss industry, highlighted in the CCMX survey undertaken in 2006, about the long-term supply of researchers trained in the fundamental disciplines of materials science.

The mission given to CCMX by the ETH Board was to bridge the innovation gap between the excellent basic and applied research carried out in the ETH Domain and associated institutions, and the needs of Swiss industry in terms of technology transfer, technical support and service. The academic research groups were tasked with achieving better critical mass by working in multidisciplinary teams, and to better understand the long term research themes of importance to industry. Additionally, industry needed to achieve a closer interface with academic research as a source for personnel and ideas to fuel long term development and innovation. Because the industrial application of materials science is very diverse, a decision was made to operate at a thematic or sectoral level, through Education and Research Units (ERUs) to establish an effective interface with industry.

B. Phase 1: 2006–2008

CCMX was formed in 2006 to create new opportunities to link the research capacity of Switzerland's academic institutions and build strong industrial partnerships. Switzerland is a country with excellent academic research, but in order to operate in an increasingly competitive world, synergies and durable collaborations with industry were needed for success. CCMX represented a new model based on the combined research strengths of the ETH institutions and CSEM, working in close collaboration with different industrial sectors that rely on material science innovation.

Education and Research Units (ERUs) were established in materials science industrial sectors. These ERUs offered potential for innovation and were capable of attracting significant interest and active partnership from industrial companies. Three ERUs were initiated: Materials for the Life Sciences (MatLife); Materials for Micro- and Nanosystems (MMNS), later encompassed in the *Nano-Tera* initiative; and Surface, Coatings and Particles Engineering (SPERU). In 2007, following extensive consultation with industry partners, a fourth ERU devoted to metallurgy (MERU) was created with the objective of fostering pre-competitive research projects in leading-edge metallurgy. In addition, the critical role of analytical methods in materials science was recognised with the establishment of the Analytical Platform in Nano- and Microscale Materials Characterisation (NMMC). The aim of this platform was to develop new techniques relevant for industry, as well as encourage its access to and use of state-of-the-art analytical techniques.

This organisational structure was effective in promoting multiple contacts between industry and academia, and in helping identify the long term issues in materials science for different industrial sectors. Open dialogue between academic research groups and industry about long term research needs was promoted through a combination of diverse contacts, "Technology Aperitifs" events, and direct discussions with the ERU directors and industry liaison officers.

A broad array of training events and workshops were established to meet the needs of both the academic and the industrial researchers.

In Phase 1, CCMX allocated funding to 16 Flagship projects involving 9 companies, plus 11 projects funded by the Analytical Platform involving 2 companies.

C. Phase 2: 2008–2011

To reinforce the alignment of industry needs with pre-competitive research in the ETH Domain, the strategy in Phase 2 (2008–2011) shifted to Public-Private Partnerships (PPP). This was achieved by means of the "Research Ticket" programme," in which companies would subscribe a portion of, or a full "Research Ticket," in the value of 75 kCHF. Funding from industry was matched 2-to-1 by funds from CCMX.

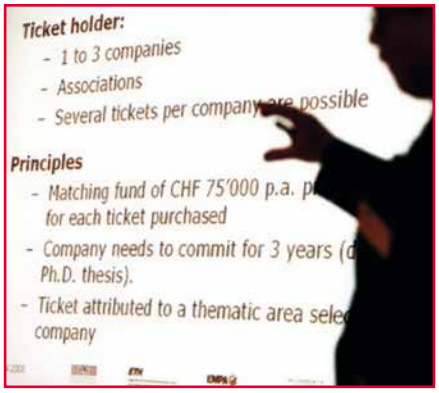
Companies took a lead in identifying priority research topics, which allowed researchers to target the projects within a thematic area to include the needs of the companies. Mutually beneficial value of in-kind support by industrial partners was recognised and considered as a viable complement to the "Research Ticket" programme. An essential criterion for CCMX research projects was the interaction of several research groups.

With this "Research Ticket" programme, CCMX created a new model for bringing together academic research with industry needs, going beyond the traditional boundaries that had existed for such cooperation. The Centre consulted directly with companies to determine their primary concerns and research needs, mainly those that could not be accomplished internally. CCMX's unique Public-Private Partnership (PPP) pre-competitive approach enabled several companies to participate in the same area. This resulted in the implementation of a much broader scope of research. Additionally, this coordinated effort increased efficiency by preventing stakeholders from duplicating work at multiple locations.

In this phase, CCMX offered a significant opportunity to Swiss researchers: medium- to long-term research, conducted by multi-partner and multi-institutional consortia. In 2008, even though the world economy, including Switzerland, at the launch of the "Research Ticket" programme was facing its most dangerous crisis since the 1930s, 23 companies and two federal offices actively participated in 14 PPP projects. As well as the direct benefit to ETH Domain and industry stakeholders, this approach created a substantial return on investment, with offshoot projects amounting to more than 29 million CHF in funding from industry, and from Swiss/international private and public sources for phase 2. For example, the project "Coloured ceramic surfaces for metallic dental implants and prosthetic appliances" launched in 2010 was a catalyst for a successful CTI proposal involving all the original academic (Empa, ETH Zurich) and industry partners in the new project.

In addition to the large collaborative PPP projects under the Education and Research Units (ERUs), calls for equipment-related projects for nano- and micro- scale materials characterisation were launched; support was granted to 20 new projects, involving 15 companies (including one company involved in two projects). Among new instruments established at ETH Domain institutions with CCMX support, was the NanoXAS. Consisting of a scanning transmission X-ray microscope (STXM) in combination with a scanning probe microscope (SPM), it was developed for researching materials on the nanoscale in collaboration with PSI, Empa and University of Erlangen-Nuremberg. CCMX provided start-up funding of 270 kCHF—matched by 1 million CHF from the academic partners—and contributed to adapting the NanoXAS to a dedicated beamline at the Swiss Light Source (SLS).

Two PPP projects successfully evolved into the creation of Materials Challenges funded in Phase 3 (2012–2016). First, the project "V.I.G.O."—A new evaluation tool for determination, description, and comparison of the biological effects of nanoparticles / nanomaterials" by Empa, EPFL, three companies and two federal offices developed into the "NanoScreen" Materials Challenge. NanoScreen brings together expert knowledge in engineered nanomaterials design, production, characterisation, *in vitro* testing and measurement science. This unique combination of expertise enables researchers to correlate the physical-chemical properties of solid inorganic engineered nanomaterials with their potential side effects and, ultimately, to establish predictive power. Second, a project involving Empa, ETH Zurich and one company, developed coatings exhibiting anisotropic thermal conductivities, to effectively protect longer lifetime



cutting tools used for machining strong and wear-resistant modern alloys. This project contributed to the conception of the new Empa Coatings Center, the only location in Switzerland offering high-power impulse magnetron sputtering with Oerlikon Balzers' Ingenia Sp3 coater. The Empa Coatings Center attracted additional partners before opening its doors in 2016.

In 2008, an External Review Committee conducted a scientific audit on CCMX. The resulting evaluation was very good:

> "In many respects, the CCMX has shown to be an excellent initiative and innovative mechanism to help bridge the gap between materials science and technology by creating critical mass of ideas and resources through inter-institutional collaboration. Additionally, one primary objective of CCMX is to form a platform to enable a continuous dialog between academia and industry. The External Review Panel recognizes that CCMX has well succeeded in promoting and achieving increased collaborations between different participating institutes in the CCMX partnership. The CCMX thematic areas have integrated the materials science research of Swiss academia into a complementary network of knowledge. This already is a major achievement since unique, unprecedented team building and an impressive number of new collaborations between different institutions have resulted from the CCMX initiative! Additionally, the well-organized, innovative stream of educational events (technology aperitifs, travelling lab, winter schools, etc.) is further evidence of the CCMX partnership.
>
> Despite some initial start-up challenges, CCMX has given the Swiss materials research scene a new, improved and common visibility both, internal and external to Switzerland, already in its first few years of existence! To build on this, the programme planning, continuation and long term horizon needs to be clearly communicated by the ETH Board in order to provide industrial and academic participants an understanding of the sustainability of the new CCMX mechanism."

D. Phase 3: 2012–2016

Building on the "Research Ticket" programme, the Centre's aim in Phase 3 (funding period 2012–2016) was to leave a lasting legacy of interaction between industry and academia, with these objectives:

1. Structure materials science and engineering in Switzerland for the long term.
2. Reinforce links with a mid- to long-term perspective between the partner institutions and industry.
3. Address the deficiency of professors and research activity in areas important to industry.

At the heart of this strategy was a tandem approach for supporting new Professor Chairs and focused research platforms by means of Materials Challenges.

Four new academic chairs have been co-funded by CCMX, together with EPFL and ETH Zurich, in areas of materials science that industry had identified as critically important (see page 8, 2. Legacy). Beyond 2016, these professors will continue to be fully supported by their home institutions. The four professors focus on areas of key importance to industry that were not being addressed by existing laboratories. They impact the education of future engineers and scientists who will be needed by industry as the field progresses. Co-funding these professors was a deliberate investment in future generations of materials science engineers, within industry and academia. In addition to having their primary research activities supported by CCMX, all of these professors have enthusiastically engaged in the Centre's networking and training events.

The five CCMX Materials Challenges are platforms for pre-competitive research that tackle underlying scientific questions essential to Swiss industry (see page 6, 2. Legacy). Materials Challenges are co-funded by CCMX and industry partners (1:1) for five years, after which time the researchers will have a structure in place for industry to

continue supporting mid-term research in materials sciences and engineering. Rather than several projects running in parallel, each Materials Challenge is a single research platform that:

- tackles underlying scientific questions critical to the future of Swiss industry, addressing long term research needs
- is co-piloted with industrial partners
- prepares and trains the next generation of researchers creating a recruitment base for the industry
- seeds enduring collaborations and strengthens existing collaborations
- promotes scientific interaction within the ETH Domain and CSEM, and, in the case of physical platforms for analysis or testing, promotes access of researchers throughout the ETH Domain and CSEM

CCMX invited proposals from teams (one or more research groups) who wished to propose Materials Challenges according to the following criteria:

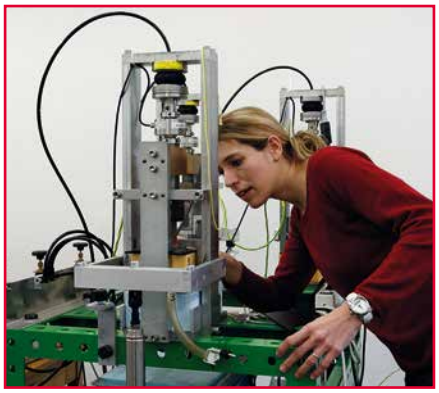
- The Materials Challenges should be led by a professor or a group leader in the ETH Domain (EPFL, ETH Zurich, Empa or PSI) with a contract beyond the funding period.
- Several laboratories or groups from ETH Domain institutions and CSEM should ideally be involved in one Challenge.
- CCMX funds (order of magnitude of 1 million CHF overall for five years) are attributed as matching funds to industrial contributions (1:1).
- The research platform must be established in an area of Materials Science of durable interest in Switzerland where there is a lack of trained PhD students, possibly as a unifying feature between the interests of several companies (though a Challenge may be co-funded by a single company).
- The proposal for a Materials Challenge should include the research themes that will be covered in order to allow for PhD theses developments. An accurate description of the fundamental aspects to be involved should be provided.
- It also should include a plan for training activities that will be accessible to the Challenge stakeholders, and possibly open to ETH Domain, CSEM and industry researchers.
- A Materials Challenge should be made self-sustaining after the 5-year seed funding by CCMX. Plans for achieving self-sustainability should be described.

The proposals were presented by the principal investigators to the CCMX Steering Committee who evaluated whether it fitted the previously identified criteria. Once approved by the Steering Committee, the proposals were sent for evaluation by International Independent Experts. The final decision for funding was made by the CCMX Steering Committee.

To date, the five CCMX Materials Challenges involve 34 companies (5 of them already involved in the "Research Ticket" programme, Phase 2), representing industry funding of 6 mCHF. Some of them already led to offshoot activities such as CTI and bilateral projects with industry.

During Phase 3, the Analytical Platform (NMMC) catalysed the establishment of six cutting-edge materials characterisation methods and/or analytical tools at Empa, EPFL, PSI and ETH Zurich, contributing to durable improvements in the ETH Domain's materials science related analytical facilities.

From 2012, CCMX has continued offering a wide range of continuing education, including advanced courses, seminars and specialised workshops. Topics chosen are targeted to the needs of PhD students, engineers, and scientists from both industry and academia. Lecturers are experts in their respective fields, invited from the Centre's network of partner institutions (see page 16, Annex C for the 2016 offer).



2. LEGACY

CCMX has introduced a new paradigm for collaborative research in Switzerland. In 2006, CCMX was mandated to create closer connections between ETH Domain research institutions and the needs of Swiss industry. Over the past 10 years, CCMX's Public-Private Partnership (PPP) has evolved into a proven alternative for funding pre-competitive materials science in a pragmatic and productive way. The Centre consults directly with Swiss companies to determine research needs, focusing on medium to long-term generic areas not usually dealt with internally. This unique PPP approach permits cooperation among many companies to address scientific questions in the same topic area. This enables a much broader scope of research efforts to be realised and also results in increased efficiency. CCMX's approach has been widely beneficial to ETH Domain and industry stakeholders, and has already created a substantial return on investment with offshoots projects amounting to more than 33 mCHF, 68 theses and 549 reviewed ISI publications.

CCMX has brought value to industry stakeholders through pre-competitive research projects, and also through its wide-ranging training activities and technology transfer events. There have been a total of 76 Companies, 2 federal entities and 1 foreign government-funded institute involved in CCMX projects since 2006 (see page 15, Annex B). Industrial and governmental partners value CCMX's continuing dialog with academic and industry stakeholders.

A. CCMX Materials Challenges

MC1	Coating Competence Center for Sputter Deposition by HiPIMS, **High Performance Coatings** by Empa (with Oerlikon Balzers)
MC2	NanoScreen: Reliable and Rapid in vitro Safety Assessment of Nanomaterials, **Understanding Nanosafety** by Empa, EPFL and University of Basel (with Cetics Healthcare Technologies, Midatech, KRISS, Federal Office of Public Health)
MC3	Additive Manufacturing and Metallic Microstructures (AM^3), **Re-thinking the Materials Science Behind Additive Manufacturing** by EPFL, PSI and Empa (with General Electric [Switzerland] GmbH, Patek Philippe, Rolex, VV [Branch of Richemont International SA], Audemars Piguet & Cie, Swatch Group R & D Ltd, Heraeus Materials SA, Oerlikon Metco AG)
MC4	Self-Care Materials, **Fibre Science for Controlled Release** by Empa and EPFL (with a consortium of 18 companies)
MC5	Large Area Growth of 2D Materials for device integration, **Large Area 2D Materials** by EPFL (with F. Hoffmann-La Roche AG and NanoSurf AG)

A Centre for High Performance Coatings

Switzerland's companies are very competitive in the world market for coatings, comprising more than 70% of this market segment. Despite this remarkable prominence, no academic chair in Switzerland covers this economically important and technologically challenging field. Coating companies have no choice but to recruit from abroad. The Materials Challenge "Coatings Competence Center for Sputter Deposition by HiPIMS" is the response to this situation—Empa and Oerlikon Balzers, the world's largest coating company, have joined forces to develop novel coatings using a state-of-the-art industrial coater. This Materials Challenge has been instrumental to the foundation of Empa's new Coating Competence Center, which had its grand opening in spring 2016 with two events attracting well over 200 attendees from industry, scientific and political communities.

The Center's focus is to ensure knowledge transfer from academia to industry, to continuously supply high-calibre personnel for industry, to provide an academic environment for addressing the needs of industrial production and to facilitate low-volume production series in pre-industrialisation conditions.

This enabling platform has generated follow-up collaborative projects close to applications with industrial companies that are funded through other sources than CCMX, while also using high-end infrastructures. A first such project began in July 2016. A proposal for a second was submitted in autumn 2016 and a third is in preparation, to

begin in 2017. Combining an industrial preparation setup with Empa's analytical capabilities makes the Coatings Center particularly attractive for many industrial partners. Additionally, this Materials Challenge reinforces the practical education of graduate students and postdoctoral researchers best suited for industry's needs.

Nanoscreen: Understanding Nanosafety

Only safe and sustainable products will be accepted by consumers and provide the revenue expected by their manufacturers. This also applies to new products and methods based on nanotechnology. However, despite much excitement in the scientific community, translation of nanotechnology-based developments has suffered from significant translational gaps, particular in the field of biomedicine. Safety concerns and associated socioeconomic uncertainties are undoubtedly imposing significant hurdles. Most of the tools to overcome these challenges —like standardised methodology, tools for prediction of the behaviour of nanoparticles in the environment or in contact with humans—are not yet sufficiently developed.

The NanoScreen Materials Challenge is a unique consortium in Switzerland headed by Empa and EPFL. NanoScreen aims for in-depth understanding of solid nanomaterials' potential side effects, contributes to and triggers international harmonisation activities together with institutions in the USA, Europe and Asia, as well as provides training for young researchers. The consortium is interdisciplinary, covering expertise in material synthesis, characterisation, biological assessment, simulation, and standardisation. It includes academia, industry and a regulatory body providing a unique connection point for Swiss industry implementing safe-by-design-strategies early in the innovation process, with the goal of increased global competitiveness.

AM³: Re-thinking the Materials Science Behind Additive Manufacturing

The AM³ Materials Challenge addresses the fundamental materials science issues underlying the transition from traditional manufacturing techniques to additive manufacturing (AM), with a specific focus on metallic alloys, and the relation between process, microstructure and properties. The relevance of this theme for the Swiss industry is evident from the fact this Challenge attracted support from eight companies, spanning a range of interests—from precious metals for jewellery to metallic powder fabrication, to materials for medicine and for energy. The peculiar processing conditions in additive manufacturing—where metals are heated and cooled at rates an order of magnitude faster than typically encountered in metallurgy—requires a broad investigative approach covering different aspects of AM's materials science. The academic team encompasses expertise from multi-scale modelling, to *in situ* and *ex situ* microstructure characterisation, and thermo-mechanical treatments that may be used to enhance material properties, and spans a similarly broad section of the ETH Domain.

By focusing on the fundamental scientific aspects of out-of-equilibrium processing, while at the same time having constant feedback from a diverse array of high-added-value manufacturers, AM³ will create foundations for an interdisciplinary platform to tackle more targeted aspects of this emerging technology, and to guarantee that stronger synergies between academic and industrial partners will develop over the course of the Challenge. With four doctoral students dedicated to the project, along with summer and winter schools devoted to the different aspects of additive manufacturing, the education effort within AM³ will ensure that a new generation of researchers, familiar with advanced manufacturing technology, will bring innovation to Swiss companies and research centres.

Self-Care Materials: Fibre Science for Controlled Release

The Self-Care Material Challenge will foster development of highly advanced fibres and fabrics for self-powered, sensing, monitoring, and ultimately substance delivery fibrous systems. Recently, there have been significant breakthroughs in fibre-based devices—in the materials and architectures that can be processed, as well as the novel functionalities that they can exhibit. Fibre processing methods are uniquely scalable, low cost, and enable tailoring of the fibre's micro and molecular structures with high precision, which provide several degrees of freedom to tune properties. Moreover,

fibres can be integrated in a variety of supports such as textiles, scaffold, tissues and even thin packaging films. This facilitates great opportunities in several fields within the Swiss scientific and technological landscape, including health care and food industries, sensing, energy harvesting and storage, and smart textiles. To date, advanced functional fibres research has primarily been conducted by end users—such as optics, chemical, medical and textile scientists and engineers. Very little materials science and processing oriented research has been performed in this field, which accounts for the limited transfer of promising laboratory results to industrial applications.

The Self-Care Material Challenge bridges the gap between functional fibre conception and large-scale industrial applications by addressing a series of scientific questions intimately linked with the materials science of fibre materials and processing. Companies from the textile, chemical, agrochemical, medical, pharmaceutical, and even fashion industries have expressed strong interest in being associated with an initiative that could help develop innovative fibre-based systems to monitor and release substances, preserve products or treat individuals. Both principal investigators are leaders in their field of fibrous materials. Their state-of-the-art facilities and complementary expertise will advance productive collaboration in the ETH Domain. Their collaborations in the broader ETH Domain, as well as with health care institutes, will insure a wide range of expertise for this multidisciplinary project. Finally, this Challenge will also be a great opportunity to train PhD students and engineers in a solid and broad background in materials science, but also in the critical relationship between processing conditions and performance, which is a key aspect for future engineers.

Large Area 2D Materials

A platform is being developed for large-area (wafer-scale) growth of electronics-grade 2D semiconductors. The unique combination of atomic-scale thickness, direct band gap, and favourable electronic and mechanical properties makes the selected class of materials interesting for numerous applications, including high-end electronics, flexible electronics, optoelectronics, spintronics, biosensing, NEMS and MEMS devices.

This platform is based on in-house developed hardware for metalorganic chemical vapour deposition (MOCVD) growth on wafer substrates as well as on the development of fabrication protocols for transfer and integration in electronic devices. Three areas of potential interest to the Swiss industry will be explored, with one large and one small size company initially supporting the Materials Challenge. The first application consists of nanopore-based sensors for the detection of DNA translocation using picoampere-level electrical current measurements. The second application consists of integrating MoS_2 as a strain-sensing layer for self-sensing Atomic Force Microscopy probes—it is based on the recent finding of a high piezoresistive gauge factor in MoS_2. The third area studies the thermoelectric properties of 2D transition metal dichalcogenides, predicted to be at the state of the art. This application could target energy harvesting in wearable electronic devices and is of potential interest to the Swiss watch industry.

In addition, the platform will be available to all interested researchers in Switzerland, including the ETH Domain, to develop their own manufacturing processes. One immediate goal is to make electronic grade (2D) semiconductors transition metal dichalcogenides available to the ETH Domain research community, either through pilot projects (enabled with allocated seed funds) or through simple material requests. MOCVD will be the method of choice for industrial-scale production of 2D transition metal dichalcogenides. This Materials Challenge will give Swiss industry, the ETH Domain and CSEM easy access to this class of materials, and enable development of new high-margin products, while also using these materials for further fundamental and applied research.

B. Academic Chairs co-funded by CCMX

EPFL

Fabien Sorin—Synthesis of multimaterials fibers and photonic devices using a unique custom draw tower

Michele Ceriotti—Atomistic simulation of complex compounds and their application in chemistry and materials science

ETHZ

Pietro Gambardella—Synthesis and characterisation of magnetic systems with novel structural and electronic properties

Eric Dufresne—Understanding, controlling and exploiting the structure and dynamics of soft and living materials

Fabien Sorin

After joining the EPFL Institute of Materials at EPFL in 2013, Fabien Sorin successfully established his vision of a research group working at the frontiers between fundamental research, innovation, and applications. The investigation of the materials science behind novel and scalable nano-fabrication techniques is at the heart of his scientific work. His group investigates, in particular, two seemingly different approaches to materials self-assembly at the nanoscale over unconventional substrates, such as large-area, flexible, stretchable 2D films or 1D functional fibres—the template dewetting of thin films and the thermal drawing of multi-material fibres. Both approaches are an interplay between viscosity, surface tension and time scale (metastability) that, if well understood, could lead to breakthroughs in how to approach materials processing.

Thanks to preliminary scientific results, Sorin secured further funding from the European Research Council (ERC starting grant) and from the CCMX Materials Challenge funding scheme. This has enabled him to expand his group, and to work on exciting ideas with potential impact in both fundamental and applied materials research. Because of the environment fostered by CCMX and its network, he was also able to establish joint projects with industrial partners on compelling aspects of innovative materials processing. He has filed several patents and has developed on-going collaborations that could lead to concrete applications of his research.

One of the motivations that led Sorin to leave industry and return to academia was that he missed the opportunity for teaching and interacting with students. He enjoys working with and mentoring his PhD students and post-docs, and feels that via the CCMX co-funded Chair, he has built a healthy group with shared values of hard work, scientific excellence and team spirit. Sorin has also been able to experience the two extremes of the teaching spectrum — he took over the Introduction to Materials Science class for first year Bachelor students with 350 participants, and he teaches a Doctoral School class on optical properties of Materials to 10-15 PhD students. The EPFL professor considers teaching a variety of fundamental materials science concepts to different audiences levels is an enriching personal and professional experience that ultimately impacts the research and innovation in his laboratory.

Michele Ceriotti

Research at the laboratory of Computational Science and Modelling (COSMO), led by Michele Ceriotti, focuses on the development and applications of atomistic computer simulations techniques—ranging from the statistical mechanics of quantum fluctuations in materials, to the extension of the time scale of phenomena amenable to modelling (the so-called rare-events problem) to the use of machine-learning techniques for predicting and interpreting the behaviour of complex materials.

More specifically, simulations at COSMO shed light on the behaviour of water within both bulk and confined environments (such as those encountered in fuel cells), as well as on the stability of hydrogen-bonded crystals, including pharmaceutical compounds such as paracetamol. By making it possible to investigate processes that occur on a longer time scale, simulations could delve into the out-of-equilibrium processes that underlie advanced manufacturing techniques — a line of research that garnered support from several Swiss industrial partners in the framework of the CCMX Materials Challenge AM^3 — in addition to solid-state precipitation processes, in collaboration with the aluminium manufacturer Constellium.

Scientific research activities have been complemented by educational engagement at both undergraduate and graduate levels, to produce a new generation of materials scientists familiar with the latest developments in the field. These efforts included the development of a statistical mechanics class for EPFL's Materials Science Master programme that is characterised by hands-on sessions where students perform atomistic simulations of materials to see classical statistical mechanical concepts in action.

At a higher level, lectures on accelerated sampling and machine learning techniques have been delivered to several CCMX advanced training events, as well as to international materials science graduate programmes, such as the Thomas Young Centre in London.

Pietro Gambardella

Magnets possess both strength and memory. These two properties make them useful for a variety of technologies that involve action at a distance, or for information retention. A key aspect of Pietro Gambardella's research is controlling the magnetic configurations in nanostructured materials for data storage, memory, energy, and sensor applications. Reinforcing this endeavour is his group's expertise in the creating tailor-made systems using top-down (thin films and multilayers, lithography) and bottom-up (self-assembly) nanofabrication strategies, and, the synthesis of novel magnetic compounds. Through careful design of the materials, components and interactions, robust control can be achieved with an applied external stimulus, such as magnetic fields and electric currents. Recent investigations target ultrafast magnetic switching, novel magnetoresistance effects, spin-transfer systems, and single-atom magnets.

Pietro Gambardella's educational mission is to train students in areas at the intersection between materials science and applied physics, providing the tools and competencies required for understanding and characterising heterogeneous solid-state material systems. His research group provides advanced laboratory training in thin film deposition and nanofabrication tools, magnetisation measurements, scanning probe microscopy and x-ray spectroscopy, and additionally supports student participation in team-based research projects across ETH Zurich, industry, and at large scale facilities (Paul Scherrer Institute, Swiss Light Source, and European Synchrotron Radiation Facility).

Eric Dufresne

Today's engineers strive to make devices that are energy efficient and sustainable. Living organisms meet these criteria beautifully. Yet the soft materials used in living systems are very different than the steel, silicon and plastic preferred by engineers. Why aren't more devices built out of soft materials? One reason is that many of the physical principles that govern the structure and properties of soft materials are simply not understood. A second reason is that a powerful cohort of design principles that could exploit their novel properties has not yet been assembled. When comparing engineered and biological soft materials, there are two essential differences. First, they are "active," driven far from equilibrium due to a distributed consumption of energy. Secondly, they are self-regulating. Networks of signalling molecules, called "regulatory pathways," process information and interact with structural components to change material properties. Thus, living materials are infused with control systems that enable them to dynamically change their structure and properties in response to external stimuli.

Eric Dufresne's research programme at ETH Zurich aims to elucidate the physics and design principles of soft and living materials. His team attacks the problem from two

ends. Firstly, by studying the basic physics of simple soft-matter systems—typically polymers or colloids, because these systems are ideal for their tractability and clear demonstration of the essential phenomena. Additionally, by collaborating with biologists studying the physiology of living systems. His laboratory is driven by experiments and its core expertise lies in the development of new optical and mechanical approaches to investigate the structure and dynamics of materials on length scales from 100 nm to 1mm and force scales from 10 fN to 10 mN.

C. Analytical Platform

The Analytical Platform uses the combined expertise available at the different ETH Domain institutions for the development and implementation of new and unique analytical methods, and then makes these analytical resources available to researchers of the ETH Domain institutions, partners from other universities and the industry.

The availability of these instruments has created a sustainable resource for the Swiss scientific community that will last beyond 2016. Examples of the unique instruments implemented with support from platform projects are: the Nano-XAS (a combined x-ray/scanning force microscope), the OMNY (a high-resolution scanning x-ray tomography instrument), a Neutron Microscope System with highest spatial resolution at PSI, a He-ion microscope, a scanning force microscopy centre including world-wide unique quantitative Magnetic Force Microscopy techniques at Empa, a Plasma FIB-SEM at ETHZ, and a Near-field digital holographic microscope at EPFL. These instruments have been used for basic and applied research projects supporting the continued development of materials science in Switzerland. The instruments are available for research, for high-level services provided to industry, and to train the next generation of scientists. An example of this is a Scanning Force Microscopy advanced course that includes practical training sessions with experts on various microscope systems.

Various other basic and applied projects based on the available analytical instrumentation generated additional finances for continued scientific research, and provided diverse opportunities for young scientists. This has created an exceptional return on investment of the CCMX analytical platform, providing sustained value for future collaborative projects and education.

D. Training and Networking Offer

Education is a core element of the CCMX mission. A broad range of advanced training events have attracted nearly 1'200 participants since 2006. Courses on recurring themes have established a brand identity—demonstrated by the way students anticipate their occurrence with early registration. With an emphasis on practical application, the advanced courses maximise hands-on experience and interaction with subject matter experts. This blend of theory and practice is greatly valued by course participants. CCMX's educational programme will be aligned with the Materials Challenges as these evolve, contributing to curriculum development and to opportunities for Master and PhD students to intensify their training through practical application. CCMX courses deliver value acknowledged for ECTS credits by the EPFL Doctoral Programmes and by ETH Zurich. These courses are also available to industry and institutional researchers, enriching the networking potential of these training events.

Creating opportunities for networking has been a key component of CCMX's educational and outreach programme. When giving feedback about these events, participants continually cite networking as a valuable feature. Designed to bring industry and academic researchers together in both structured and informal ways, the Centre's outreach events introduce companies to research potential within the ETH Domain, while sensitising academic researchers to industry's current needs. Since 2006, CCMX's outreach events have attracted more than 2'200 participants.

The e-newsletter and website (www.ccmx.ch) have been integral assets in our communication strategy, serving to support and supplement CCMX's event schedule. The e-newsletter is distributed 10 times a year to nearly 1'900 subscribers. It is an effective and cost-efficient channel for promoting the Centre's training and outreach activities, for sharing news and success stories from project researchers, for publishing profiles on PhD students involved in current projects, and for publicising materials science related courses and events at our partner institutions. The newsletter also serves to direct readers to the CCMX website, which is updated regularly to include information about CCMX courses and events, and about courses and events at partner institutions.

In May 2016, the CCMX Steering Committee agreed to allocate 369 kCHF remaining from the 2012–2016 ETH Board budget to extend its support for the Swiss materials science community it helped establish over the past ten years. This will fund the continued organisation of courses and networking events, such as technology aperitifs (see page 16, Annex C for the current 2017 programme).

The reasons for deciding to continue CCMX training and networking activities are:

1. To offer PhD students and researchers access to courses of recognised quality.
2. To benefit from various networking opportunities among ETH Domain institutions, thanks to the participation of speakers and attendees from all over Switzerland.
3. To facilitate better communication and information transfer about training, seminars, events, conferences, funding and job offers within Switzerland's materials science community through continued publication of the e-newsletter.

E. Conclusion

By co-funding four new professors, implementing the Materials Challenges initiative, and providing a continuing structure courses and technology aperitifs, CCMX has secured its legacy beyond its funding by the ETH Board.

Every aspect of the Centre's activities has advanced materials science in Switzerland through productive and innovative partnerships between academic and industry partners.

3. ANNEXES TO THE REPORT

A. Projects

67 concluded projects (see pages 13–15)

67 Concluded Projects

No.	Project Title	Principal Investigator (PI)	PI's Institution	Other Institutions	End Year	ERU/Platform
1	Development of novel methods for surface modification and investigation of cell-particles interaction for superparamagnetic nanoparticles (PAPAMOD)	Philippe Renaud	EPFL	CSEM	2009	SPERU
2	Nanocrystalline ceramic thin film coating without sintering (NANCER)	Jennifer Rupp	ETHZ	PSI, Empa	2009	SPERU
3	Smart functional foams	Ludwig Gauckler	ETHZ	EPFL	2009	SPERU
4	Zero order nano optical pigments (ZONOP)	Alexander Stuck	CSEM	EPFL	2009	SPERU
5	Photochemically functionalisable scaffolds for Tissue Engineering and Nerve Regeneration	Christian Hinderling & Martha Liley	CSEM	ETHZ	2009	MatLife
6	Immunofunctional Nanoparticles	Jeffrey Hubbell	EPFL	ETHZ	2009	MatLife
7	Multivalent Lectin Array: A Combinatorial Approach	Peter Seeberger	ETHZ		2008	MatLife
8	Bio-functionalized, biodegradable nanostructured magnesium implant for biomedical applications	Samuele Tosatti	ETHZ	Empa	2009	MatLife
9	Three-Dimensionally Designed Cell Cultures Consisting of Microstructured Cell-Sheets and Polymer Layers for Tissue Engineering	Janos Vörös	ETHZ	UZH	2009	MatLife
10	Platform for high-density parallel screening of membrane receptor function	Horst Vogel	EPFL	CSEM, ETHZ	2009	MatLife
11	Studying Single Cells in Engineered 3D Microenvironments	Viola Vogel	ETHZ	Empa	2010	MatLife
12	Lab-on-a-chip for analysis and diagnostics	Martin Gijs	EPFL	CSEM	2008	MMNS
13	Materials, devices and design technologies for nanoelectronic systems beyond ultimately scaled CMOS	Yusuf Leblebici	EPFL	CSEM, ETHZ	2008	MMNS
14	Development and characterisation of nanowires for applications in bio-electronics	Janos Vörös	ETHZ	PSI	2009	MMNS
15	Biopolymer PHA as surface material for micropatterning proteins on microarrays	Qun Ren	Empa	PSI, ETHZ	2008	MatLife
16	Biochemical nanofactory	René-Paul Salathé	EPFL	CSEM	2007	MMNS
17	Development of Self-Sensing and -Actuating Probe for Dynamic Mode AFM at Cryogenic Temperature	Nico De Rooij	EPFL	ETHZ	2007	NMMC
19	New Generation Scanning Anode Field Emission Microscope at Empa Thun	Oliver Gröning	Empa	-	2007	NMMC
20	Nano-XAS	Iris Schmid	Empa	PSI	2007	NMMC
21	Efficient double-passage SNOMs	Urs Sennhauser	Empa	ETHZ	2007	NMMC
22	Correlated Energy Electron Loss and Cathodoluminescene spectrometry in SPTEM	Pierre Stadelmann	EPFL	-	2007	NMMC
23	Scanning Probe Microscopy of Cytoskeletal Proteins in Living Cells	Boris Hinz	EPFL	-	2007	NMMC
24	Swiss SPM User laboratory	Rowena Crockett	Empa	-	2007	NMMC
25	Nanometric level investigations of Aluminum Nitride/Silicon Nitride hard coatings using High Resolution TEM and Energy Dispersive X-Ray analysis	Jörg Patscheider	Empa	-	2007	NMMC
26	Subattonewton force sensors with hard magnetic tips for magnetic resonance force microscopy	Simon Rast	Uni. Basel	Empa	2007	NMMC
27	Stress voiding and electromigration as reliability indicator in nanoscaled interconnects	Urs Sennhauser	Empa	-	2007	NMMC
28	AMORTEM:FIB Preparation of TEM-Specimens with Minimised Defects	Urs Sennhauser	Empa	ETHZ	2007	NMMC
29	Evolution of microstructure and mechanical response due to cyclic deformation at elevated temperatures	Stuart Holdsworth	Empa	ETHZ, PSI	2012	MERU
30	In-situ mechanical testing	Helena Van Swygenhoven	PSI	Empa	2012	MERU
31	Modelling of defect formation in solidification processes using granular dynamics and phase field approaches	Michel Rappaz/Alain Jacot	EPFL	Empa, PSI	2012	MERU
32	Combinatorial study and modelling of optical properties of gold alloys	Ralph Spolenak	ETH Zurich	PSI	2012	MERU
33	Label-free Imaging of Molecular Absorption on in situ Surface-Functional Patterns	Nicholas Spencer	ETHZ	Empa	2010	NMMC
34	Study of complex interfacial properties with nanoscale resolution optical microscopy	Christian Depeursinge	EPFL	CSEM	2011	NMMC
35	Vibrational spectroscopy of nanostructured surface systems	Davide Ferri	Empa	ETHZ	2010	NMMC
36	Time-resolved cathodoluminescence (TRCL)	Jean-Daniel Ganière	EPFL	-	2010	NMMC
37	Microtome4SIMS: Chemical tomography of biological material with 100 nm resolution	Beat Keller	Empa	Uni. Basel	2014	NMMC
38	Adaptation of the Nano-XAS instrument to a dedicated beamline at the SLS	Christoph Quitmann	PSI	Empa	2011	NMMC

Green text in table above signifies project partner is neither ETH Domain nor CSEM.

67 Concluded Projects (continued)

No.	Project Title	Principal Investigator (PI)	PI's Institution	Other Institutions	End Year	ERU/Platform
39	Development of an X-ray phase contrast instrument for the characterisation of materials with low atomic mass	Claus Urban	CSEM	Empa	2010	NMMC
40	Rapid Analytical Project: "FIB investigation of Ge-Si heterojunction photo diodes"	Rolf Kaufmann	CSEM	-	2011	NMMC
41	Rapid Analytical Project: "Protein labelling for TOF-SIMS imaging of hydrophobicity gradients"	Rowena Crockett	Empa	-	2011	NMMC
42	MaCH2 – The Analytical Equipment Database	Susan Meuwly	EPFL	-	2011	NMMC
43	Colored ceramic surfaces for metallic dental implants and prosthetic appliances	Ralph Spolenak	ETH Zurich	Empa, UZH	2014	MatLife
44	Structural evolution and rheological properties in gel carrier	Christopher Plummer	EPFL	ETH Zurich	2014	MatLife
45	Low wear articulating implants employing DLC coatings on CoCrMo and TiAlNb with predictable, long-lasting coating adhesion lifetime	Roland Hauert	Empa	ETH Zurich	2014	Matlife
46	Fibroblast Growth Factor 2 delivery for tissue repair: From Natural Concepts to Engineered Systems	Viola Vogel	ETH Zurich	PSI	2014	Matlife
47	Liquid repellent wear resistant coatings (LIRE-WERE-CO)	Patrik Hoffmann	Empa	EPFL	2015	SPERU
48	Serrulatane-based antimicrobial surface platforms	Harm-Anton Klok	EPFL	ETH Zurich Uni. Basel	2014	MatLife
49	VIGO: A new evaluation tool for determination, description, and comparison of the biological effects of nanoparticles / nanomaterials	Harald Krug	Empa	EPFL	2014	MatLife
51	Synchrotron phase-contrast nanotomography of fresh and hardened cementitious materials	Pietro Lura	Empa	EPFL, PSI	2013	NMMC
52	Development of computational tools for molecular modeling and X-ray spectroscopy, with application to the understanding and design of molecular alignment technology in commercial LCDs	Daniele Passerone	Empa	PSI, UZH	2012	NMMC
53	Equipment for in-situ mechanical testing of nanostructured alloys under service-type loading	Helena van Swygenhoven	PSI	EPFL, Empa	2013	NMMC
54	Measurements and modelling of residual stresses in aluminium components in relation to their microstructure	Jean-Marie Drezet	EPFL	PSI	2015	MERU
55	Arc erosion processes in contact materials: modelling and model experiments	Ralph Spolenak	ETH Zurich	Empa	2015	MERU
56	Protective coatings with managed thermal conductivity for machining difficult-to-cut materials	Valery Shklover	ETH Zurich	Empa	2014	SPERU
57	Quantitative Magnetic Force Microscopy platform (qMFM)	Miguel Marioni	Empa	ETH Zurich	2013	NMMC
58	OMNY (tOMography, Nano, crYo stage)	Mirko Holler	PSI	CSEM	2014	NMMC
59	Development of a He-Ion Beam Induced Charge scanning system (He-IBIC)	Urs Sennhauser	Empa	ETH Zurich	2014	NMMC
60	Ultrasensitive sensing transducer based on Fano interferences in plasmonic metamaterials: FANOSENSE	Olivier Martin	EPFL	CSEM	2014	NMMC
61	Gantry-based X-ray Phase Contrast Scanner for MicroCT Applications	Marco Stampanoni	PSI	ETH Zurich, CSEM	2014	NMMC
62	Study of biological processes in cell membranes at nanoscale by Near Field Digital Holographic Microscopy	Pierre Magistretti	EPFL	CSEM	2012	NMMC
63	NanoAi: Online coupling of a scanning mobility particle sizer SMPS to an inductively coupled plasma mass spectrometer ICP-MS for size fractionated, elemental analysis of nanoparticles in aerosols	Heinz Vonmont	Empa	EPFL, PSI, FHNW	2014	NMMC
64	Argon-cluster as primary ion source in time-of-flight secondary ion mass spectrometry (ToF-SIMS: method development by ToF-SIMS and atomic force microscopy (AFM)	Laetitia Bernard	Empa	-	2015	NMMC
65	Failure and defect analysis of fibre composite materials by means of X-ray interferometry	Rolf Kaufmann	CSEM	-	2013	NMMC
66	Structure-activity relationships of metal oxide nanoparticles-based gas sensors for non-invasive medical diagnosis by time- and surface-resolved XAS-IR	Davide Ferri	Empa	PSI	2013	NMMC
67	Optical Detection and Investigation of Subsurface Features and Defects in Unpolished Transparent Materials and Films	Patrik Hoffmann, Yury Kuzminykh	Empa	-	2013	NMMC
73	QuadProbe FIB: an analytical FIBSEM microscope integrating ion, electron, x-ray, and laser beams for microanalysis in materials research	Johann Michler	Empa	-	2015	NMMC
75	Inductively Coupled Plasma Focused Ion Beam (PFIB) System at ETH Zurich	Roger Wepf	ETH Zurich	-	2015	NMMC

Five grants (with ID numbers 68–72) were allocated in 2013 to upgrade existing analytical equipment development within CCMX projects, in a total amount of 247 kCHF. Because of a change in strategy, one of these grants, amounting to 50 kCHF, was returned to CCMX.

Green text in table above signifies project partner is neither ETH Domain nor CSEM.

4 Projects and 5 Materials Challenges Funded in 2016

No.	Project Title	Principal Investigator (PI)	PI's Institution	Other Institutions	End Year	ERU/Platform
74	Neutron Microscope	Eberhard Lehmann	PSI	-	2018	NMMC
76	Analytical Scanning electron microscope to help tackling current materials sciences challenges	Cécile Hébert	EPFL	-	2017	NMMC
77	Establishing a Correlative Cryo X-ray-Electron Microscopy Workflow: Acquisition of Specialized Cryo-Preparation Equipment at the Paul Scherrer Institute	Sarah Shahmoradian	PSI	-	2019	NMMC
78	Nanoscale Scanning Diamond Magnetometer	Pietro Gambardella	ETH Zurich	-	2019	NMMC
MC1	Coatings Competence Center for Sputter Deposition by HiPIMS	Joerg Patscheider	Empa	-	2019	N/A
MC2	NanoScreen: Reliable and rapid in vitro safety assessment of nanomaterials	Peter Wick	Empa	EPFL, Uni. Basel	2019	N/A
MC3	Additive Manufacturing and Metallic Microstructures (AM^3)	Roland Logé, Michele Ceriotti	EPFL	Empa, PSI	2020	N/A
MC4	Self-Care Materials	René Rossi	Empa	EPFL	2020	N/A
MC5	Large Area Growth of 2D Materials for Device Integration	Aleksandra Radenovic	EPFL	-	2021	N/A

All projects and Materials Challenges continue in 2017. Although CCMX will cease receiving funding from the ETH Board by 31.12.2016, the Steering Committee will continue to supervise progress of the ongoing projects and Materials Challenges in 2017–2021.

Green text in table above signifies project partner is neither ETH Domain nor CSEM.

B. Partners

76 Companies and 2 Federal Offices and 1 Foreign Government-funded Institute Involved Since 2006

ABB Turbo Systems (2)
Alstom (2)
AO Foundation Davos
Armasuisse
Arrayon Biotechnology SA
Asulab (2)
Attolight Sàrl
Audemars Piguet & Cie
Ayanda Biosystems SA
BASF (2)
Biotronik AG
Bobst
Bruker Optics GmbH
Cetics HT GmbH
Cilander AG
Constellium (2)
Crolles R&D
DECTRIS Ltd.
E. Schellenberg Textildruck AG
Färberei Kronbühl AG
F. Hoffmann-La Roche
Flawa AG
General Electric (Switzerland) GmbH
Gessner AG
HeiQ Materials AG
Heraeus Materials SA
IG DHS
ION-TOF Technologies (2)
KonMed
Korean Research Institute of Standards and Science (KRISS)
Kugler Bimetal
Lantal AG
Lyncée Tec (3)
Mammut
Matter Aerosol
Meister + Cie AG
Métalor
Meyer Burger Group
Microsens SA
Midatech
Monosuisse
NanoScan AG
Nanosys GmbH
NanoSurf
Nestec Ltd
Novartis (2)
Novelis
OC Oerlikon Balzers (2)
Oerlikon Metco AG
Patek Philippe
Philips Semiconductors ZH
Plansee Powerplant
PreenTec AG
RMS Foundation
Rolex (3)
Rolic Technologies
SCANCO Medical AG
Scientific Visual Sàrl
Schoeller Textil AG
Sefar
Sika
Stettler Sapphire AG
Straumann (2)
Sanofi-Pasteur
SurfaceSolutionS
Swissatest
swissnuclear
Swiss Textiles
Syngenta
Synthes GmbH (2)
Tischhauser AG
TSB GmbH
TSI GmbH
VV, Branch of Richemont International SA (2)
Wessling GmbH
Zeiss
Federal Office for Public Health (2)
Federal office for the Environment

(2) or (3) signifies the company has contributed two or three times to CCMX Projects / Materials Challenges

3 HES and Universities Involved Since 2006

University Hospital Basel (4)
University of Zurich (3)
FHNW-Fachhochschule Nordwestschweiz

(3) or (4) signifies the institution is involved in three or four projects

C. Courses and Events

CCMX Outreach and Networking Activities in 2016

11 May	Annual Meeting	Bern
6 October	Technology Aperitif: Soft Interfaces in Industry: Current Challenges and New Directions Organised with new ETH Zurich professor Eric Dufresne and ETH's Competence Center	ETH Zurich

CCMX Education Events in 2016

Date	Course	Location
31 January– 5 February	Winter School, Nanoparticles: from Fundamentals to Applications in Life Sciences	Kandersteg
10–11 February	Course co-sponsor, Introduction to Scanning Electron Microscopy Microanalysis Techniques	Empa, Thun
21–23 March	Inorganic Particle Synthesis by Precipitation: From Nanoparticles to Self-organised Mesocrystals and from Theory to Practice	EPFL, Lausanne
4–6 July	Advanced Course, Powder Characterisation and Dispersion: From Nanometers to Millimeters and from Theory to Practice	EPFL, Lausanne
29–31 August	Summer School, Multiscale Modelling of Materials	EPFL, Lausanne
28–30 September	Advanced Course, Instrumented Nanoindentation, In partnership with Anton Paar GmbH and Queen Mary University of London	EPFL, Lausanne
14–17 November	Advanced Course, Combining Structural & Analytical Investigations of Matter at the Micro-, Nano and Atomic Scale	ETH Zurich

CCMX Education Events programmed for 2017

29 January– 3 February	Winter School, Additive Manufacturing in Metals and the Materials Science Behind It	Kandersteg
7 March	Technology Aperitif, Bio-inspired Materials In partnership with EPFL Bio-inspired Projects Platform	EPFL, Lausanne
27–29 March	Advanced Course, Inorganic Particle Synthesis by Precipitation: From Nanoparticles to Self-organised Mesocrystals and from Theory to Practice	EPFL, Lausanne
12–14 June	Advanced Course, Field and Pressure Assisted Sintering	EPFL, Lausanne
26–28 June	Advanced Course, Powder Characterisation and Dispersion: From Nanometers to Millimeters and from Theory to Practice	EPFL, Lausanne
28–30 August	Summer School, Characterisation of Materials	EPFL, Lausanne
27–29 September	Advanced Course, Instrumented Nanoindentation In partnership with Anton Paar GmbH and Queen Mary University of London	EPFL, Lausanne
5 October	CCMX General Meeting	Empa, Dübendorf
27–29 November	Advanced Course, Advanced X-Ray Diffraction Methods for Coatings: Strain, Defects and Deformation Analysis of Thin Films	Empa, Dübendorf

06.04.2017

CCMX

A Legacy of Enduring
Collaboration and Innovation

CCMX FINAL REPORT

EPFL ECOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

ETH zürich

EMPA

PAUL SCHERRER INSTITUT PSI

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