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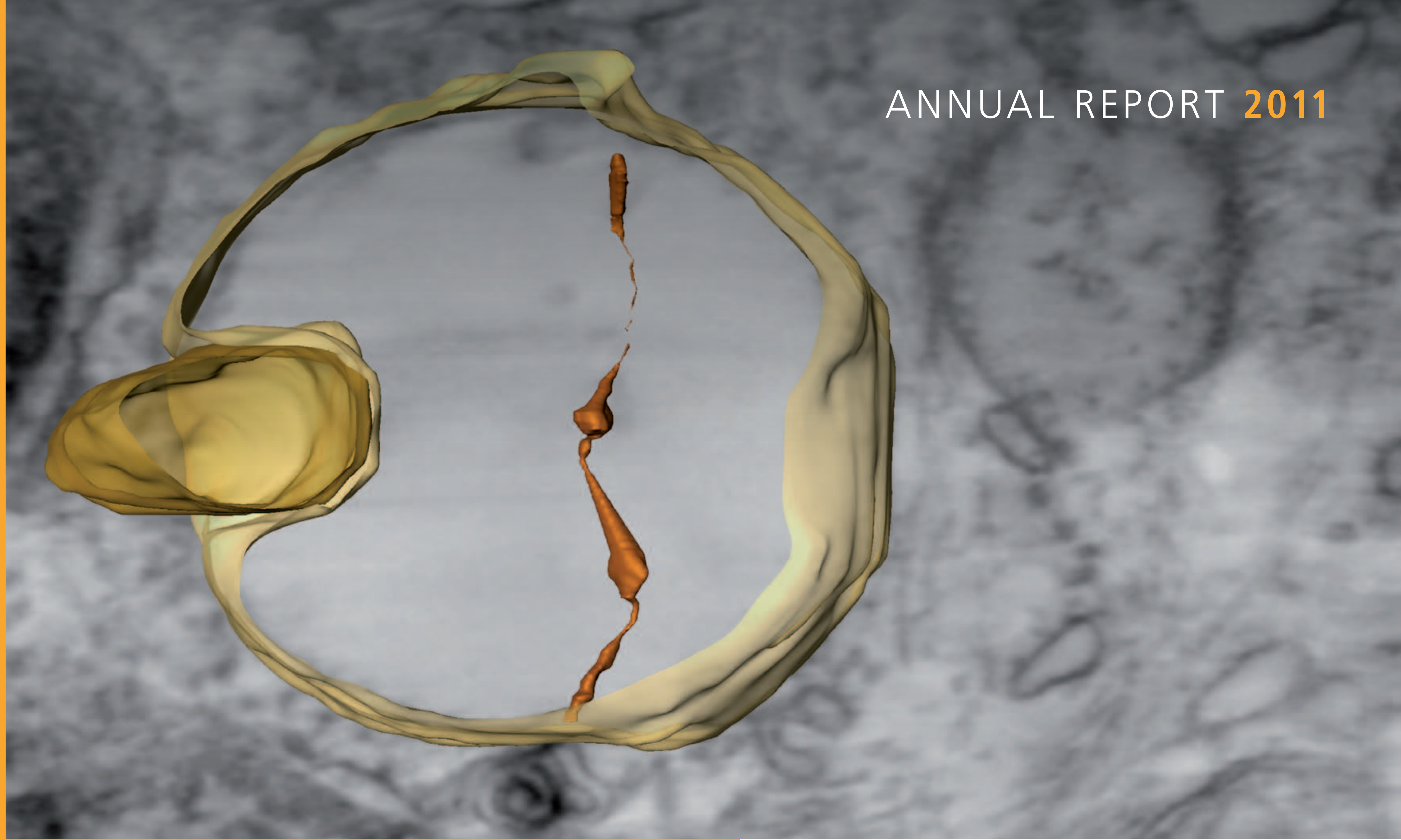


adolphe merkle institute
excellence in pure and applied nanoscience

UNIVERSITY OF FRIBOURG SWITZERLAND

IN MEMORIAM

Dr. Dr. h. c. ADOLPHE MERKLE

(1924 – 2012)

We honour the memory of an innovative entrepreneur, generous patron and cofounder of our institute and will continue to implement his vision of a leading-edge research institute in the field of nanotechnology and materials science here in Fribourg. Dr. Adolphe Merkle has set a new impetus by his foresight and commitment that reaches far beyond the borders of Fribourg. His initiative has sparked a spirit of optimism that is clearly evident in his institute. The Adolphe Merkle Institute is increasingly becoming a magnet for people who wish to participate in this exciting project and we believe that Dr. Adolphe Merkle's vision is just the beginning. We deeply regret that our distinguished patron can no longer accompany us on this path but his dedication stays with us and will continue to light the way ahead.

Summary

Message from the director

Christoph Weder
Director and Professor for Polymer Chemistry and Materials

About fifty of the sixty scientific papers that AMI scientists wrote or published last year feature at least one co-author from another institution. I was surprised myself when I made the tally, but it is a perfect score to make a point about the importance of interdisciplinary interactions in our research field. We collaborated with chemists, chemical engineers, material scientists, physicists, electrical engineers, biologists, biomedical engineers, toxicologists, medical doctors, and members of other disciplines to develop new nanomaterials, characterize their properties, and explore their functionality in a diverse array of applications that range from cortical implants and smart fishing lures to high-density optical data storage systems. In my own experience, collaborations with scientists that offer complementary expertise and interests are not a luxury, but a requirement for the successful and efficient execution of complex research projects in our field. The recognition that the results of our work receive from our peers, partners, funding agencies, and the public (read more in the highlights section on page 12) seems to suggest that this strategy serves us well.

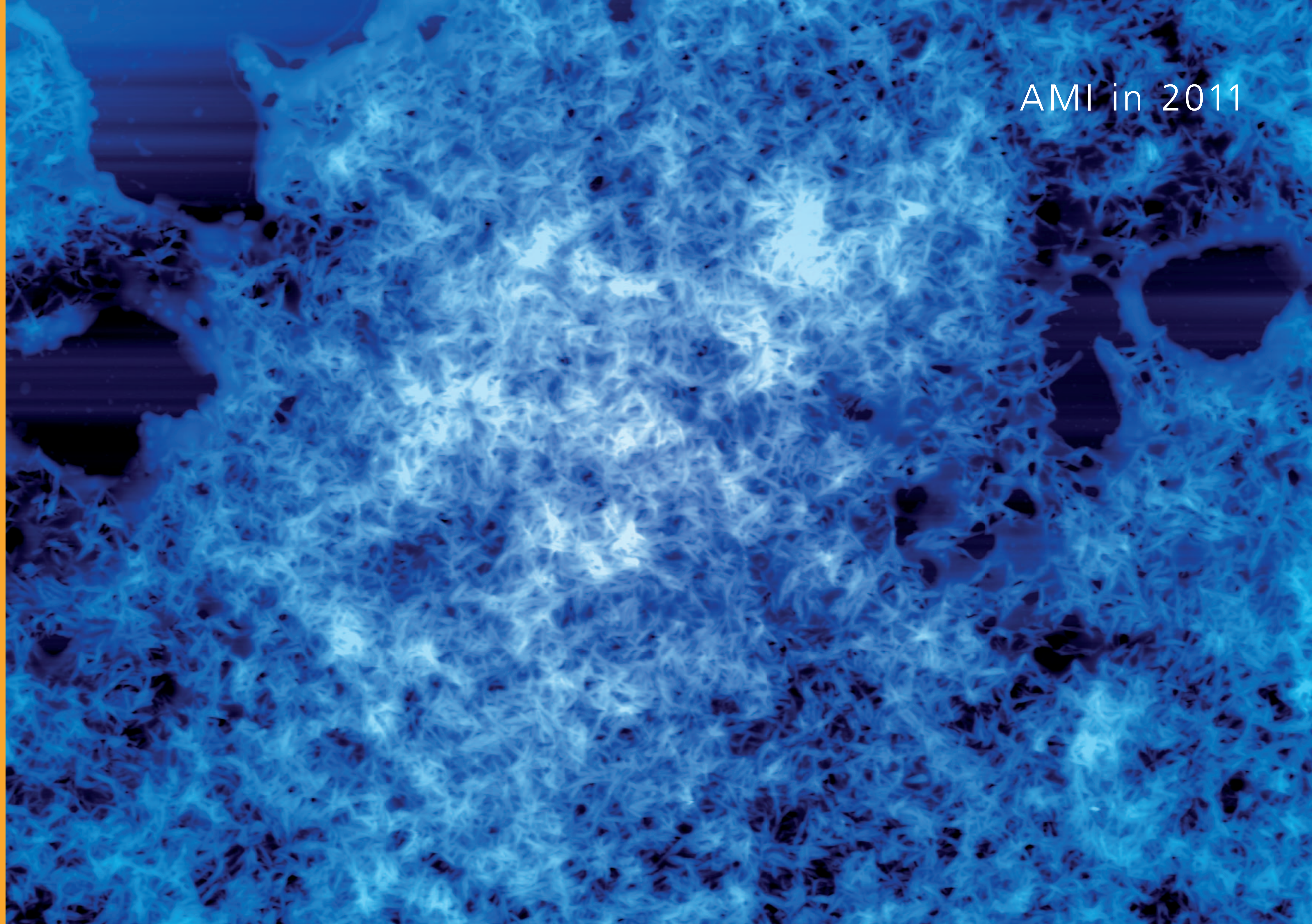
Enabling and nurturing interdisciplinary collaborations within the institute are also key elements of AMI's strategic plan. An important milestone in this context was filling the position of the second AMI chair for bio-nanomaterials. I am thrilled that we have been able to appoint Professors Alke Fink and Barbara Rothen-Rutishauser, who share a professor position and lead the new department for bio-nanomaterials. This unusual arrangement reflects that a multidisciplinary research approach is also a necessity in this area and takes advantage of the opportunity to combine the knowledge of two internationally recognized scientists with complementary expertise in biology and materials science (read more in the «AMI 2011» section on page 10). I am proud that we were also able to recruit Professor Marco Lattuada, who won a Swiss National Science Foundation Professor Award and joined AMI as an Associate Professor for nanoparticle-based materials in January 2012.

These developments sustained the expected growth of the institute. The number of researchers increased to a total of 45. I am excited to see chemists, physicists, toxicologists, biologists, and biochemists working under one roof to solve interesting and important problems in the field of soft nanomaterials. The emerging collaborations between AMI's different departments have quickly started to bear fruits (read more in the research section starting on page 16) and I am delighted to see that multidisciplinarity is indeed becoming a virtue of our institute.

I trust that the developments and achievements documented in this annual report support our institute's position on the importance of multidisciplinary research. Hopefully, they also reflect the creativity, compassion, motivation, and professionalism of our team members, who have worked relentlessly to keep AMI on its course to realize Adolphe Merkle's vision of becoming a leading competence center for fundamental and applied interdisciplinary research in the field of soft nanomaterials.

At AMI, we recognize the value of partnerships and are once again grateful for the interest, courtesy, and support that we have received throughout the year. We will continue to work hard to be a valuable and reliable partner and to make relevant contributions to science and to society.

Christoph Weder
AMI Director and Professor for Polymer Chemistry and Materials


AMI in 2011

After three years of existence, all indicators show that AMI is still continuing to grow rapidly. The institute's development is following its strategic plan for the years 2010 – 2015, which seeks to position AMI as a leading interdisciplinary research center for soft nanomaterials science and technology.

New chair for bio-nanomaterials

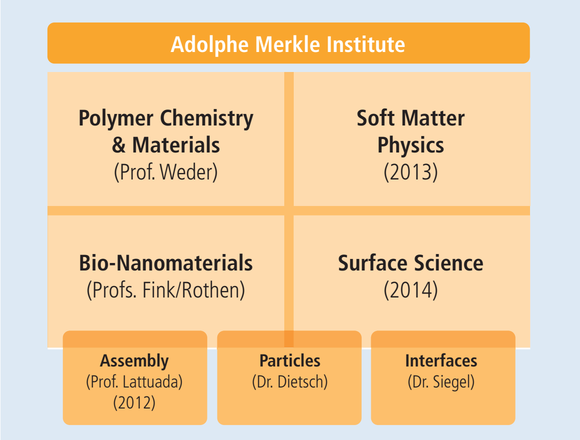
The scope of AMI's research activities broadened considerably with the appointment of Professors Barbara Rothen-Rutishauser and Alke Fink. Since July 2011, the two share the position as chair for bio-nanomaterials and lead AMI's new department for Bio-Nanomaterials.

Prof. B. Rothen-Rutishauser (left) and Prof. A. Fink (right).

Professor Barbara Rothen-Rutishauser joined AMI from the Department of Anatomy of the University of Bern, where she had held the positions of group leader and independent research group leader from 2006 to 2011. The cell biologist was trained at ETH Zurich and has also worked as a researcher at the Centre for Health and Environment of Napier University in Edinburgh (UK). Professor Rothen-Rutishauser's main interests and expertise are nanoparticle-cell interactions, particularly in relation to the lung. Her research seeks to utilize the knowledge generated in fundamental studies to promote the safe use of engineered nanomaterials by considering possible health risks, and for the creation of new drug delivery systems.

Professor Alke Fink joined AMI from the University of Fribourg's chemistry department, where she had directed the advanced particle research group as a Swiss National Science Foundation Professor since 2009. The chemist was trained at the University of Ulm (DE) and has also worked as a researcher at the EPF Lausanne, the Engineering Research Center for Particle Science and Technology of the University of Florida (USA), and at the Department of Materials Science of the University of New South Wales in Sydney (AU). Her research focuses on the synthesis and characterization of novel multifunctional and/or hybrid nanoparticles and the use of these materials in biological and medical applications.

The joint chair for bio-nanomaterials builds on the previous collaboration of the two researchers and allows them to further merge Professor Fink's expertise in materials science with Professor Rothen-Rutishauser's biological competences. The result is a truly multidisciplinary department that is uniquely positioned to address the complex question of how nanomaterials interact with living matter and to utilize this knowledge in biomedical applications.



Research groups at the Adolphe Merkle Institute.

Continuous growth and further development

With the arrival of the Bio-Nanomaterials team and the further growth of the department for polymer chemistry and materials, the institute nearly doubled its size in 2011, and now has more than 50 employees. The expertise of these departments will be complemented by a new group led by Professor Marco Lattuada, who won a Swiss National Science Foundation Professor Award and joined AMI as an associate professor in January 2012. His research efforts are focused on the creation of hierarchically ordered materials using new assembly processes. There is also an ongoing hiring process for a new chair in the area of soft matter physics. It is expected that the position will be filled by 2013.

Fostering multidisciplinary interactions

With the expansion of the institute, a range of mechanisms that actively encourage multidisciplinary research projects between departments and groups have been implemented. The topics of the AMI Seminar Series, which featured in 2011 over 12 external speakers from institutions as far as the Institute Charles Gerhardt Montpellier (F) and the University of North Carolina (USA), were broadened to meet the interests of the new audience. Brainstorming workshops, joint grant proposals, and a scientific retreat are just some examples of how interactions between researchers are stimulated to establish a culture of multidisciplinarity at AMI.

New building takes shape

The planning of AMI's future home on the faculty campus, where the natural science faculty of the University of Fribourg is located, has been completed. The start of construction was imminent when this annual report was printed, after the parliament of the Canton of Fribourg approved the budget of the 50 Mio CHF project in November 2011. The new facility combines two historic buildings of the former Clinic Garcia, which will be gutted and renovated to include a new laboratory complex that will offer state-of-the-art research, office, teaching, and meeting space on a surface of over 7,500 m^2. The project is led by architects from the Atelier Serge Charrière SA and civil engineers from MGI Ingénieurs Conseil SA and Technoservice Engineering SA. Current plans foresee AMI's relocation to the new building in December 2013.

Specialized support is beginning to pay off

In addition to the academic staff, which makes for about 86 %of the personnel, AMI is making a strategic investment in a small but effective support team, whose role goes beyond what is normally found in academic departments. In addition to administrative assistance, AMI researchers can rely on professional in-house resources for technology transfer and industrial collaborations, marketing and communications, and grant writing. These measures seek to relieve researchers from administrative responsibilities so that they can concentrate their energy on what they do best: research. At the same time, these tasks are executed by dedicated specialists, who can also cultivate institutional relationships with external partners, ensure that best-practices are shared throughout the institute, and avoid duplication of certain work. While the effectiveness of these services is still improving, the institute's outstanding success in 2011 in partnering with companies, attracting external funding, and presenting a positive media presence seems to support that this strategy is indeed paying off.

Plans of AMI's new building, formerly known as the Clinic Garcia (courtesy of Atelier Serge Charrière SA).

New Bio-Nanomaterials group

Professors Alke Fink (chemist) and Barbara Rothen-Rutishauser (biologist) joined AMI in July 2011 to build and co-chair a new research department that focuses on the study of bio-nanomaterials. The new bio-nano team rapidly started its activities and has already grown to over twenty scientists.

High impact research

AMI researchers and partners at Case Western Reserve University in Cleveland and the US Army Research Laboratory at the Aberdeen Proving Ground (both USA) developed a polymer-based material that can heal itself when placed under ultraviolet light. These findings were published in the prestigious scientific journal *Nature* in April 2011. Cuts or scratches in films of these new «metallo-supramolecular polymers» can be healed with lamps such as the ones dentists use to cure fillings. The healed films display the same mechanical properties as the original. While the technology is still in a «proof-of-concept» phase, the new approach may be useful for the development of automotive paints, varnishes for floors and furniture, and many other applications where being able to fix damages easily would be of great use.

Papers by Hervé Dietsch and co-workers on ellipsoidal and spherocylindrical-shaped magnetic nanoparticles and Yoan Simon and co-workers on upconverting nanoparticles were selected to be featured on the covers of the journals *Macromolecular Chemistry and Physics, Macromolecular Rapid Communications,* and the *Journal of Physical Chemistry.*

Continued success in attracting external research funding

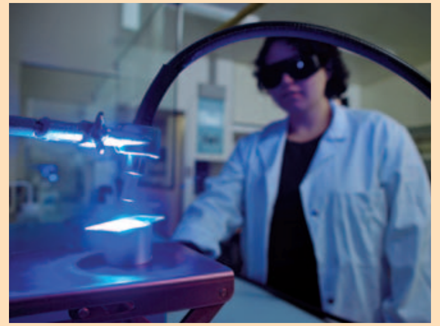
AMI researchers received new research funding of a total of over 6.5 Mio CHF from European and Swiss government agencies, as well as from industry, surpassing expectations by far. After winning two competitive grants from the Swiss National Science Foundation's National Research Program Resource Wood (NRP 66) to research the processing of nanocellulose composites and nanoparticle-based wood treatments, AMI now hosts five research projects that are part of National Research Programs.

Recognition for AMI researchers

AMI Professor Christoph Weder was elected to serve as Associate Editor of the new polymer journal *ACS Macro Letters*. He also served as guest editor of a special issue of the *Journal of Materials Chemistry on Mechanoresponsive Materials*. Professor Alke Fink was elected as co-president of the Fribourg Chemical Society, and Professor Barbara Rothen-Rutishauser as board member of the International Society of Aerosol Medicine. Sandro Steiner received an award for highly skilled individuals from a foundation in Liechtenstein. Soo-Hyon Lee won the best poster award at the Swiss Chemical Society's 2011 fall meeting. Professor Christoph Weder was awarded with an Advanced Researcher Award of 2 Mio Euros from the European Research Council to pursue research on «mechanically responsive polymers.» Weder is the first professor at the University of Fribourg to win this prestigious grant.

Front cover of the *Journal of Physical Chemistry* in December 2011 (courtesy of ACS Publications).

The new Bio-nanomaterials department team.



Activating the self-healing process with UV-light.

Some of the numerous clippings on AMI projects in 2011.

Soo-Hyon Lee at the Swiss Chemical Society (SCS) Fall Meeting with Prof. E. Peter Kündig, SCS President and M. Kindermann, Group Leader Process R&D at DSM Nutritional Products, Basel. (Courtesy of SCS)

A german TV crew filming Dr. Gina Fiore in the laboratory.

National and international press coverage for AMI

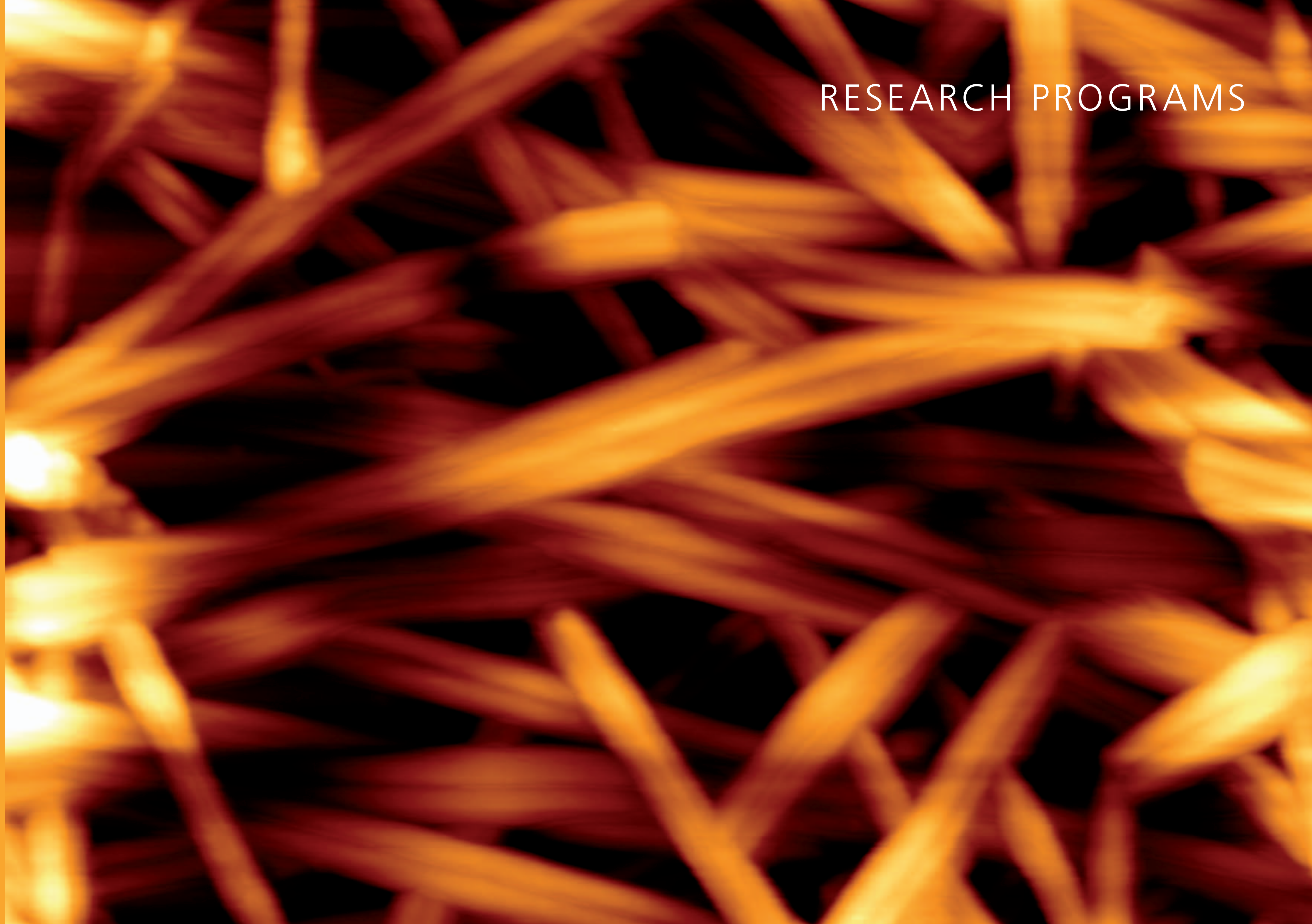
AMI's research programs received significant attention from both national and international media. The polymer department's breakthrough on self-healing polymers was featured in well over a hundred stories that appeared in newspapers such as the *Washington Post* and the *Irish Independent*, German and Swiss public radio stations *SWR2* and *DRS1*, respectively, and TV stations such as *VOX TV* in Germany.

Bio-mimetic shape-memory polymers developed under the Swiss National Science Foundation's National Research Program Smart Materials (NRP 62) were the subject of a press release from the Swiss National Science Foundation. The work was featured on local radio and TV stations *Radio Fribourg* and *La Telé*, as well as national newspapers such as *20 Minuten*, *Tages Anzeiger, Le Temps, La Liberté*, and *Le Matin*. The latter also featured the work in its list of science breakthroughs of the year.

The polymer department's work on smart material was also the subject of a feature story broadcasted by the *Swiss National Television* as part of its science program «Einstein».

Professor Rothen-Rutishauser was featured as an expert, commenting on possible health risks of aerosolized matter – ranging from the debris resulting from the 9/11 attacks to diesel exhaust – in a range of media, such as the nation's largest newspaper, *20 Minuten*, and the consumer magazine *Kassensturz* on national television.

In addition, AMI's governance structure, its role in the Canton of Fribourg, the institute's view on public-private partnerships, its research strategy, the dynamic growth, and the progress of the construction of the institute's new home were the subjects of articles in newspapers and magazines that included *l'Hebdo, La Liberté*, and the *Freiburger Nachrichten*.



RESEARCH PROGRAMS

FROM INNOVATIVE NANOMATERIALS TO LIFE SCIENCE: AN INTERDISCIPLINARY APPROACH

Bio-nanotechnology is a young and rapidly evolving research field at the crossroads of biotechnology and nanoscience, two interdisciplinary areas that combine advances in both science and engineering. This technological revolution promises to provide specifically designed nanomaterials for numerous applications in biology, medicine, and life science. However, to safely and efficiently translate bio-nanotechnology into life science applications, it is crucial to gain a thorough understanding of the interaction between nanomaterials and living matter.

The strength of the interdisciplinary nature within the Bio-Nanomaterials research department, including (bio)chemistry, biology, chemical and biological engineering, and material science brings a unique holistic approach to exploring bio-nanotechnology, from controlled nanomaterial synthesis and novel surface derivatization strategies to nanomaterial-cell interactions.

Motivation

Some important aspects of nanomaterial uptake into cells, intracellular fate, and correlation with the possible toxic mechanism are still not understood. Many factors influence these aspects, such as nanomaterial size, shape, and core and surface coating, as well as the cell culture and test systems that are used (Fig. 1). The complementary research expertise of the group allows a systematic, unbiased, and co-operative research approach that will provide a comprehensive understanding of how nanomaterials interact with cells.

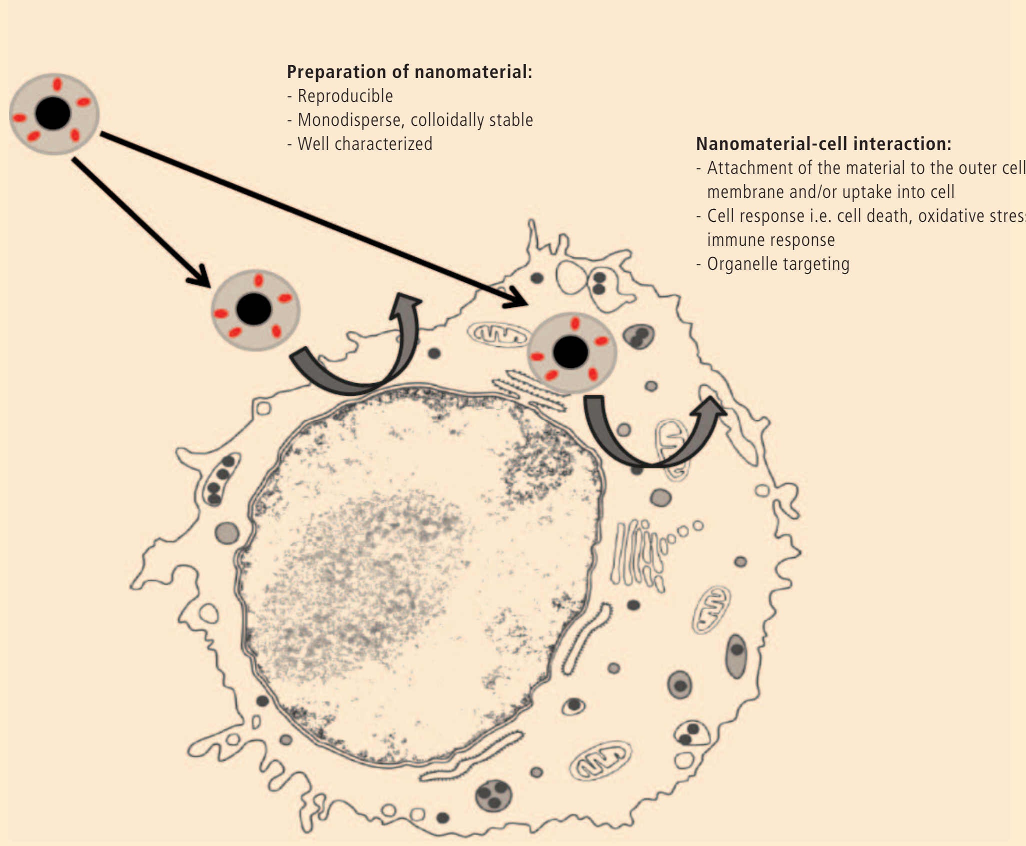


Fig. 1: Overview of the BioNanomaterials department's research vision. All undertaken projects have the aim to address the questions: «What does a particle look like in the cell membrane and/or in the cell?» and «How can a particle cross tissue, as well as cell membranes, intracellular trafficking, and cellular responses?»

State of the art

In collaboration with PD Dr. von Garnier and Dr. Blank from the University Hospital, the AMI research team investigated whether superparamagnetic iron oxide nanoparticles (SPIONS) can modulate the human immune system (Blank et al., 2011). The particles consist of an iron oxide core coated with a hydrophilic polymer shell, to which the fluorescence dye «Oregon green» has been covalently coupled (Fig. 2A). The particle-cell interaction was assessed using dendritic cells, known to be one of the key immune competent cells in the human body. Laser scanning microscopy was performed on the dendritic cells to characterise uptake, intracellular localisation, and the association of SPIONS (yellow) with the endosomal compartment (light blue) (Rothen-Rutishauser et al., 2011). By using a 3D shadow projection mode, AMI researchers were able to show that most of the SPIONS colocalise with the endosomes (surrounded by yellow). However, there are several SPIONS (light blue) that were not found to be associated with the endosomal compartment (Fig. 2B). In addition, it was shown that SPIONS may exert a certain degree of immune-modulation by regulating dendric cell function by reverting them into a more immature-like state (high capacity for antigen uptake, low capacity for T cell stimulation).

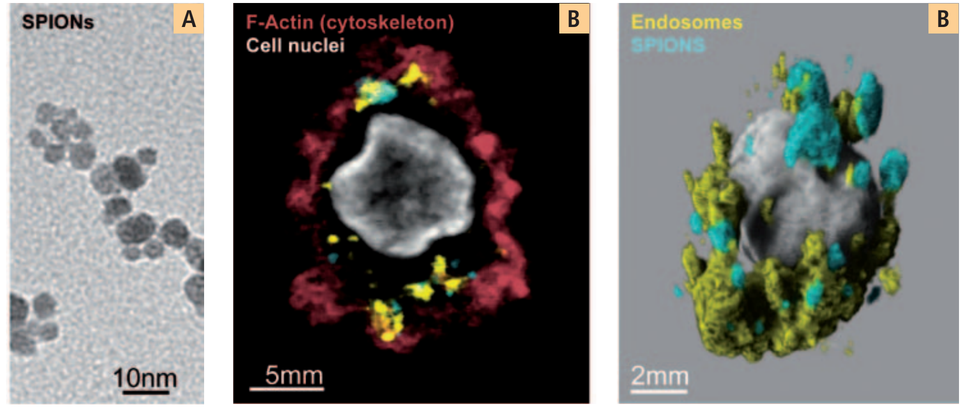


Fig. 2: Visualisation of superparamagnetic iron oxide nanoparticles (SPIONS) by transmission electron and laser scanning microscopy. **A)** Cryo-TEM (transmission electron microscopy) picture of polymer coated SPIONS. **B)** LSM (laser scanning microscope) picture of a dendritic cell treated with Oregon green 488-labelled SPIONS during 4 hours. Micrographs show the localisation of SPIONS (yellow), endosomes (light blue), and nuclei (white). Actin (red) staining facilitated the detection of intracellular SPIONS. The image on the left represents a single xy-layer, the image on the right, a 3D shadow projection.

The recently started NFP64 project, «Biomedical nanoparticles as immune modulators,» will focus on the investigation of possible immune-modulatory effects of SPIONS in the lung in order to harness the unique properties of nanoparticles for novel clinical applications in the treatment of allergic respiratory diseases.

Vision of the Bio-Nanomaterials department

It is the Bio-Nanomaterials department vision to provide a substantial understanding of nanomaterials at the interface to biotechnology and / or medicine. By understanding the underlying mechanism of interactions, we will have the possibility to conceptualize new nanotechnological approaches to nanomaterials for biotechnology and medicine, and to develop them from concept to application.

References: Rothen-Rutishauser B, Blank F, Petri-Fink A, Clift MJD, Geiser T, von Garnier Ch. Laser scanning microscopy combined with image restoration to analyse and quantify the intracellular localisation of fluorescently labelled nanoparticles. G.I.T. Imaging & Microscopy (2011).
Blank F, Gerber P, Rothen-Rutishauser B, Salaklang J, Sakulkhu U, de Peyer K, Gehr P, Gazdhar A, Nicod LP, Hofmann H, Geiser T, Fink A, von Garnier C. Polymer-coated nanoparticles alter dendritic cell-dependent T cell stimulation. Nanotoxicology (2011)

Contact: Prof. A. Fink and Prof. B. Rothen-Rutishauser

INVESTIGATING THE BIOLOGICAL INTERACTIONS OF CELLULOSE NANOFIBERS: AN INTERDISCIPLINARY PROJECT

Funding received from the recent Swiss National Science Foundation National Research Programme 64, «Opportunities and Risks of Nanomaterials,» has provided AMI with the ability to undertake an interdisciplinary landmark project in which the interactions of cellulose nanofibers with the human lung are studied in vitro and new cellulose nanomaterials are developed.

Interesting early results

In a collaborative project between the Bio-Nanomaterials and Polymer Chemistry & Materials departments at AMI, a new investigation was launched that utilizes the core expertise of the two: the production, characterisation, and use of cellulose nanofibers from bio-renewable sources (Polymer Chemistry & Materials) and the utilization of state-of-the-art in-vitro analysis to assess the interactions of nanoparticles with living matter (Bio-Nanomaterials).

The team already published first results of a biological study that probes the effects of cellulose nanofibers in the lung (Clift et al. 2011). In in-vitro experiments, cellulose nanofibers derived from cotton were compared to industrially relevant multi-walled carbon nanotubes and crocidolite asbestos fibers. It was observed that the cellulose nanofibers elicited a significantly lower cytotoxicity and (pro-)inflammatory response than both the carbon nanotubes and asbestos fibers within a sophisticated in vitro model of the human epithelial airway barrier. Cutting-edge microscopy techniques, such as electron microscopic tomography, showed that the intracellular localization of cotton nanofibers (Figure 1) is different from other (nano) fibers types, which could explain the different cell responses measured. The bio-response of nanomaterials has been shown to depend strongly on their physico-chemical characteristics, especially their surface properties. These have proven to be vital for their respective applications. Therefore, many open questions remain concerning the interaction between cellulose nanofibers with different surface chemistries and biological systems during the life-cycle of such nanofibers and nanofiber-based materials.

New promising research areas

The SNF (Swiss National Foundation) grant supports three PhD students who are working to gain answers to such questions. Two of them are manipulating cellulose nanofibers from different biologically renewable sources for a variety of applications. Silvana Müller is creating aerogels with cellulose nanofibers as a bio-based renewable alternative to synthetic insulation foams. Sandra Camarero is seeking to align the nanofibers within polymer matrices to create materials with mechanical properties similar to those of steel. Carola Endes is undertaking an extensive assessment of the biological interaction of a series of cellulose nanofibers with varying physico-chemical characteristics.

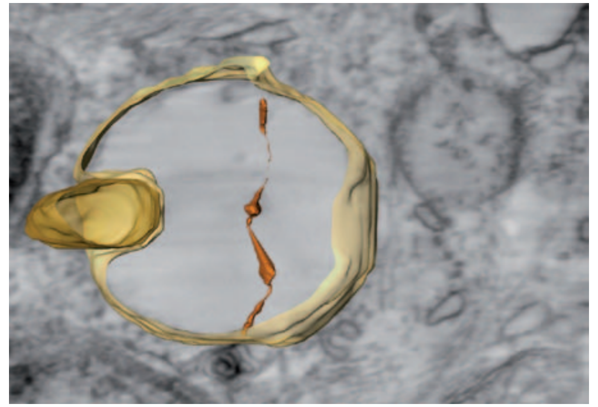


Fig. 1: A 3D reconstructed image of an electron tomogram showing a cellulose nanofiber derived from cotton (orange/red) inside a vesicular body (yellow) within a human blood derived macrophage.

The results of this project will provide essential information as to the potential uses and opportunities of cellulose nanofibers in the context of possible applications by developing an understanding for the structure-property relationships of new nanomaterials and which characteristics limit adverse biological reactions.

References: Clift, M. J. D.; Foster, E. J.; Vanhecke, D.; Studer, D.; Wick, P.; Gehr, P.; Rothen-Rutishauser, B.; Weder, C.; Investigating the interaction of cellulose nanofibers derived from cotton with a sophisticated 3D human lung cell co-culture; *Biomacromolecules* **2011**, *12*, 3666–3673.

Contact: Dr. M.J.D. Clift and Dr. E.J. Foster

DEVELOPMENT OF A NOVEL HUMAN AIR-BLOOD BARRIER MODEL ON AN ULTRATHIN POROUS MEMBRANE

Every day, new products containing nanoparticles (NPs) come onto the market and influence our daily life. The distinct physicochemical characteristics of nanosized materials have, for example, been used to develop new inhalable NPs for local drug targeting. However, the effect of many NPs on living organisms is still poorly understood and needs to be further investigated. To understand the effects brought forth by NPs in the human lung, the group of Prof. Rothen-Rutishauser and Prof. Fink aims to establish and optimize an epithelial-endothelial co-culture system including two types of immune cells (i.e. macrophages and dendritic cells) by using a newly developed ultrathin porous membrane. This project is being done in collaboration with Dr. Silvia Angeloni and Dr. Martha Liley from CSEM* in Neuchâtel and is being financed by «Lunge Zürich».**

The lung is a portal of entry for NPs

Stretching out all the alveoli of a human lung, one ends up with an area as large as a tennis court (140 m^2). With each breath, this vast lung surface can be exposed to millions of unintended (e.g. combustion-derived) and intended (i.e. biomedical) inhaled nanosized particles (<100 nm). Inhaled NPs are distributed all over the respiratory tract in a size-dependent manner. The smaller the particles are, the deeper they can penetrate into the lung. It has been shown that NPs can reach the alveolar region where they can induce the formation of reactive oxygen species and inflammation.

Cell culture model of the human airway barrier

Currently, the possible effects of inhaled NPs are mainly being investigated using invasive animal tests. Over the last few years, Prof. Rothen-Rutishauser's research group has established and evaluated a 3D cell culture model of the human airway barrier consisting of macrophages and epithelial and dendritic cells. The goal of this group's present study is to refine this existing model to also include endothelial cells. Moreover, the new cell culture model will take advantage of novel ultrathin porous membranes, which are developed at the CSEM (Fig. 1). The conventional inserts, which are used in the existing model, are typically about 10 μm thick. This is quite different from the human air-blood barrier, which has a thickness of less than 1 μm. The new membranes have a thickness of only about 500 nm, and feature pores of equal size and even distribution, which is not the case for the conventional track-etched membranes.

Researchers' first results show that both epithelial cells, which are seeded on the upper side of the membrane, and endothelial cells, which are on the lower side, can be co-cultured on the new ultrathin membrane, and that both cells form confluent

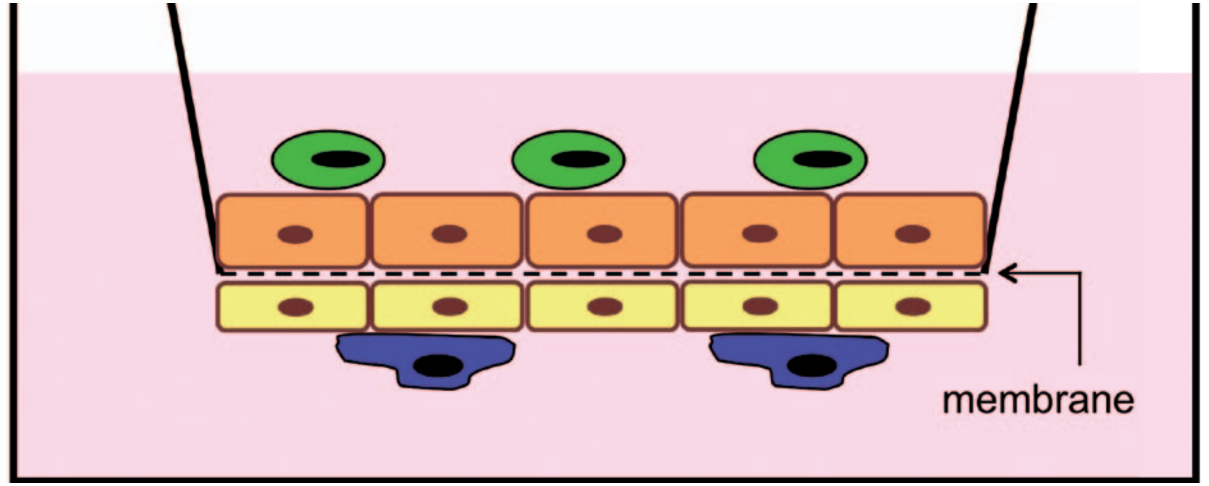


Fig. 1: Quadruple cell co-culture model of the human air-liquid barrier consisting of macrophages (green), epithelial (orange), endothelial (yellow), and dendritic (blue) cells.

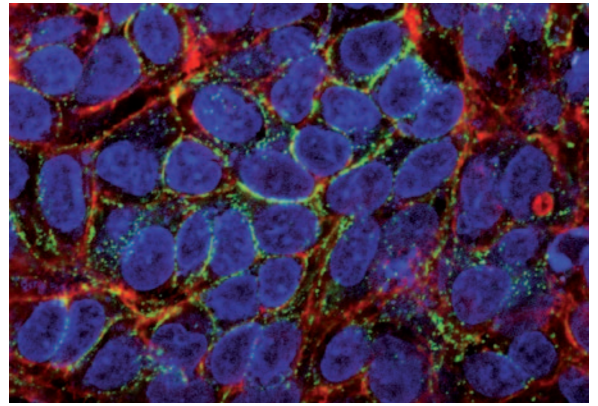


Fig. 2: Human epithelial cells stained for actin filaments (red), cell nuclei (blue), and E-cadherin (green) under a confocal laser scanning microscope.

layers (Fig. 2). Furthermore, measuring the passage of blue dextran from the upper to the lower chamber shows that the cells form a tight bilayer (Fig. 3).

Future applications

Once the development of this new system is completed, it will offer an advanced cell culture model of the human airway barrier. AMI researchers are convinced that thanks to this model, the number of animals used to assess inhalation toxicology will be significantly reduced. In addition, it will not only allow scientists to study the effects of NPs on the human air-liquid barrier, but also help to evaluate possible risks or benefits of any substance that can be inhaled.

* CSEM: Swiss Center for Electronics and Microtechnology
** «Lunge Zürich» is a Swiss non-profit organization active in the field of lungs, air, and respiration.

Fig. 3: The passage of blue dextran from the upper to the lower chamber is used to assess epithelial-endothelial bilayer integrity.

Contact: Dr. C. Jud

SMART BRAIN IMPLANTS

As part of the Swiss National Science Foundation's National Research Program 62, «Smart Materials», AMI researchers are developing mechanically-adaptable materials for biomedical applications.

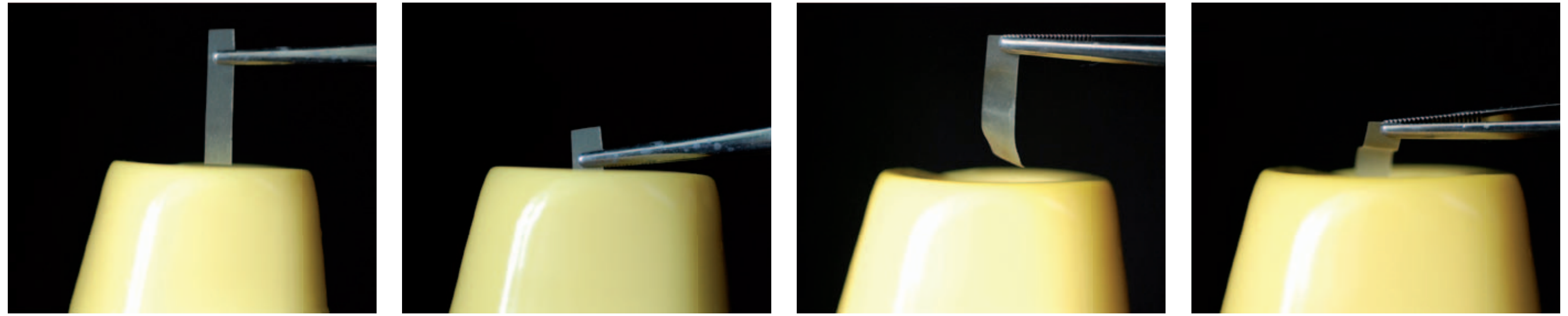
Mechanically adaptive materials for biomedical applications

Materials whose properties change in response to an external stimulus in a desirable manner are often referred to as «smart» or «intelligent». AMI researchers are investigating several types of stimuli-responsive nanomaterials that change their mechanical properties on command. One international, interdisciplinary collaboration pursues the development of such mechanically adaptive materials for use as a «smart» structural component in intracortical microelectrodes. These biomedical devices serve to record neural signals and/or provide neural stimulation and are potentially useful in clinical applications that require (re-)connecting the brain with the outside world For example, they could be used for the treatment of Parkinson's disease, strokes, and spinal cord injuries.

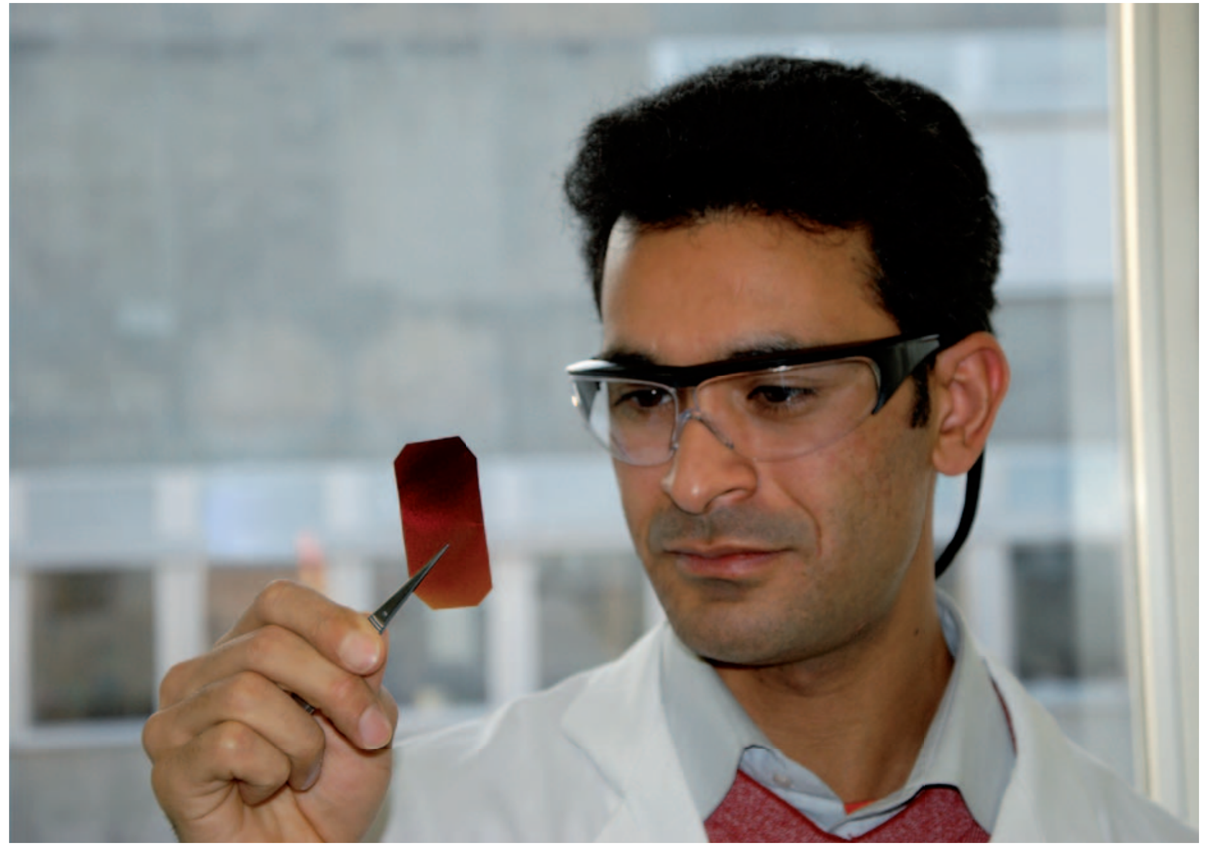
Unfortunately, broad clinical implementation of neural interface technology is stifled by the fact that current electrodes don't normally permit long-term recording of neural activity. It has been suggested that the mechanical mismatch between these devices, which are traditionally made from stiff materials such as tungsten, silicon, and stainless steel, and the soft cortical tissue is a significant contributor to the progressive decrease in neuron density around the electrodes. To alleviate this problem, AMI researchers, inspired by the architecture of the sea cucumber dermis, were able to engineer a new class of mechanically adaptive materials as substrates for «smart» intracortical electrodes. These originally rigid polymer nanocomposites soften considerably upon exposure to certain physiological conditions. The adaptive nature of these materials makes them useful as a basis for electrodes which are sufficiently stiff to easily penetrate the membranes of the brain during implantation, but soften after insertion in response to the chemical environment of the tissue and more closely match the stiffness of the cortex.

Smart implants

After demonstrating the general feasibility of the design concept and exploring several generations of physiologically responsive materials, it became recently possible to create the first generation of smart implants based on the new materials. Initial histological evaluations conducted in collaboration with partners at Case Western Reserve University (USA) showed through an in vivo study with rodents that mechanically adap-



In vivo mechanical switching. Implantation of cortical substrates into the brain model reduced the storage modulus from stiff (easily implantable materials – left) to soft (tissue-matching materials – right) by using water as a chemical switch.



Mehdi Jorfi looking at a material for medical implant.

tive, intracortical neural prosthetics can indeed stabilize neural cell populations at the interface more rapidly than rigid systems, which bodes well for improving the functionality of intracortical devices. However, before such devices become clinically viable, significant further efforts are needed to better understand the molecular and cellular events that govern the effects at the device-tissue interface. At AMI, researchers are continuing to further optimize the switching characteristics of the new nanomaterials and to explore new approaches to bestow them with anti-inflammatory characteristics.

Reference: Capadona, J.R.; Tyler, D. T.; Zorman, C.A.; Rowan, S.J.; Weder, C.; Mechanically Adaptive Nanocomposites for Neural Interfacing; *MRS Bulletin* **2012**, in press.

Collaboration: This project is a collaboration with the groups of Profs. J. Capadona, D. Tyler, S.J. Rowan, and C. Zorman at Case Western Reserve University in Cleveland, OH (USA).

Contact: Dr. E.J. Foster and Prof. C. Weder

MAGNETIC SHAPE MEMORY POLYMERS

Materials that are capable of changing their mechanical properties and/or shape upon the application of an external stimulus are highly suitable for many applications, such as actuators and valves. Relying on the combined expertise of researchers at AMI, a collaborative project was initiated with the objective of fabricating organic as well as inorganic hybrid polymers whose shapes can be remotely controlled by an oscillating magnetic field.

Shape-memory materials are capable of switching between two or more predefined mechanical states and shapes in response to external stimuli, such as heat, electrical current, light, chemicals, or other commands. Shape memory polymers can be classified according to the thermal transition that is exploited (glass transition or melting) and the nature of the cross-links imparting elasticity (covalent or physical cross-linking). The AMI team utilizes superparamagnetic iron oxide nanoparticles as the active component that will respond to an external trigger and integrates them into an elastic polymer matrix. By applying a high-frequency oscillating magnetic field, the nanoparticles act as «hot spots» that locally heat the material above the transition temperature of the polymeric matrix.

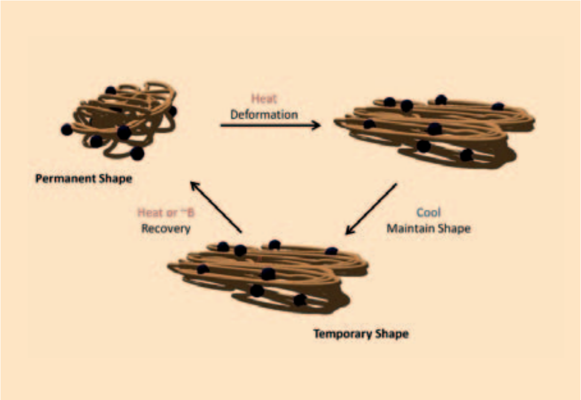
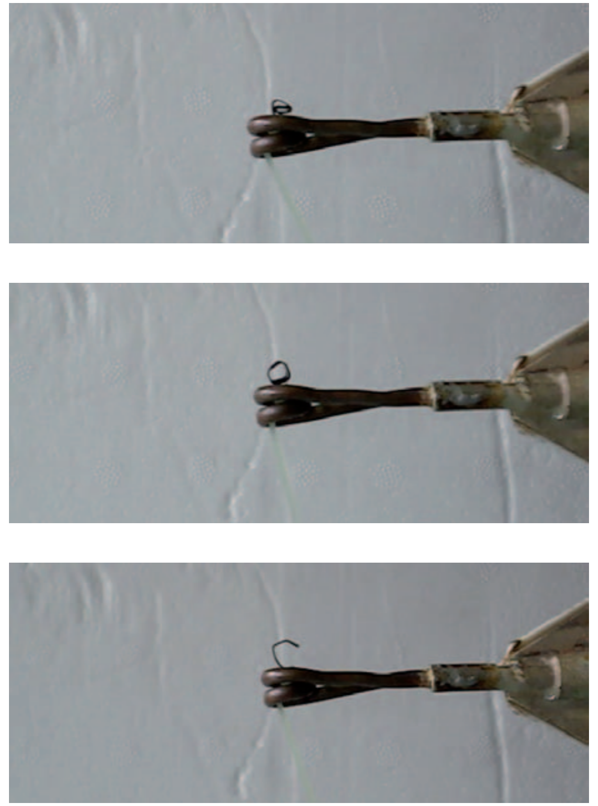


Illustration of the mechanism of shape-memory in polymer nanocomposites.

Tough challenges, big opportunities

A number of challenges had to be overcome to create these smart materials. For example, one of the critical aspects lies in carefully controlling the surface chemistry of the nanoparticles, which is important for the distribution and dispersion of these «nanomagnets» within the polymer. A classical method to ensure good compatibilization relies on the post-treatment of the particles with organic or polymeric solubilizing agents. AMI researchers used this and other approaches to integrate the nanoparticles into the polymer. A wide variety of polymeric matrices can be used such that the thermal transition temperature can be tailored at will.

This approach to shape-memory materials opens up new avenues for smart materials that can be triggered remotely by an external magnetic field. Furthermore, this project aims to answer some more fundamental questions such as those regarding heat transfer at the nanoscale and the influence of the detailed architecture on internal heat generation and the therewith magnetically-triggered response. These materials are anticipated to be useful for a wide range of purposes, such as panel unfolding in satellites and magnetically mendable vehicle parts that can be repaired after a minor fender-bender.



Shape recovery of a polymer nanocomposite strip upon application of an oscillating magnetic field.

Contact: Dr. H. Dietsch and Dr. Y. Simon

PROJECTS FINANCED BY THE SWISS NATIONAL SCIENCE FOUNDATION

Responsive colloids with soft and tunable potentials, 01.10.2009 – 30.09.2012, P. Schurtenberger, A. Stradner

This project concentrates on the use of an active control of the interaction potential between particles to reversibly cycle through different phase transitions and thus to explore not only the rich variety of structures that can form in these suspensions, but also to take advantage of this feature of responsive particles in order to create advanced materials with switchable functionality.

Interactions and phase behavior of colloid-polymer mixtures and the influence of charges, 01.04.2008 – 31.03.2011, A. Stradner

This project pursued the creation and characterization of a new aqueous model system with the objective of answering several of the open questions concerning the phase behavior of colloid-polymer mixtures, such as the influence of charges.

Fluctuations in colloidal coronas revealed by dynamic ellipsometric light scattering, 01.10.2009 – 30.09.2011, R. Sigel

This project aimed to establish a new experimental technique to determine the softness and the rheological properties of polymers around colloidal particles. Polymers anchored to the surface are commonly used to stabilize colloidal materials and to protect them from aggregation and precipitation. There is a high interest from industry for prediction tools for the long-term stability of colloidal systems, since stability affects shelf lifetimes and concentration limits of products.

Antifreeze proteins in solution and at interfaces, 01.10.2010 – 28.02.2011, I. Voets

The goal of this project was to gain a deepened understanding of how antifreeze proteins function in vivo and to find links between functionality, solution, and adsorption behavior.

Bio-inspired mechanically responsive polymer nanocomposites, 01.01.2010 – 31.12.2012, C. Weder

This experimental research program targets the design, synthesis, processing, investigation, and application of a new family of bio-inspired polymer nanocomposites with stimuli-responsive mechanical properties. The program focuses on the fundamental aspects of materials which contains cellulose nanowhiskers and change their mechanical properties on command. Such materials are of interest for potential use in biomedical and other applications.

Smart materials: magneto-responsive polymer nanocomposite actuators, 17.03.2010 – 30.11.2011, H. Dietsch

This project involved the development and integration of new iron oxide magnetic nanoparticles in a liquid-crystalline elastomeric matrix. This work was a collaborative effort between researchers at ETH Zürich and AMI, who are responsible for the liquid crystal monomer synthesis and the particle synthesis and integration strategy, respectively.

Cellulose-based nanocomposite building materials: solutions and toxicity, 01.12.2010 – 30.11.2013, C. Weder, J. Foster, M. Clift

This proposal outlines a research program that seeks (i) to develop new high-performance polymer nanocomposites containing rigid cellulose nanofibers and (ii) to investigate the potential health risks associated with these materials. These novel, value-added nanocomposites are designed for use in construction material applications. The investigation of the potential health risks of nanomaterials is an up-and-coming research focus at AMI.

Metal containing polymers, 01.04.2011 – 31.03.2014, C. Weder

This projct focuses on the synthesis and characterization of metal-containing polymers, namely metallosupramolecular polymers with photo-healable properties and metal-containing materials that undergo low-power upconversion.

Spatially resolved magneto-relaxation of in vitro magnetic nanoparticles using atomic magnetometry, 01.09.2010 – 31.08.2012, A. Fink

This exploratory interdisciplinary project aims to develop a novel imaging method for specific in vitro biological entities, such as organs or tumor cells. These objects will be tagged by attached or embodied magnetizable nanoparticles (MNP), whose spatial magnetic field distribution, recorded by arrays of atomic magnetometers, yields images of the biological entities.

Smart vesicles for drug delivery 01.05.2010 – 30.04.2013, A. Fink

The goal of this project is to develop double-walled nanocontainers, so-called vesicles, whose outer wall mimics cell membranes. Equipped with functionalized surface features for targeting selectively particular mammalian cells (e.g. cancer cells), these vesicles are designed to dock the cells or even merge with the cell membranes.

Advances in nanoparticle engineering with a focus on stability, surface, and particle-cell interaction 01.10.2009 – 30.09.2013, A. Fink

This project deals with model particle synthesis, colloidal property investigations, and protein profiling in environments of varying complexity. It seems that one possible and useful classification of nanoparticles is according to the manner in which they interact with proteins, an approach that has not yet been undertaken by nanoscientists. This project seeks to develop the fundamental knowledge required to address this significant limitation.

NCCR-nanoscale science 01.06.2010 – 31.05.2013, B. Rothen-Rutishauser

The aim of this work is to correlate the different surface properties (functionalization, surfactant coating) of multi-walled carbon nanotubes (MWCNTs) to their potential adverse effects in lung cell cultures. Different surface functionalizations of the MWCNTs, for example with positively and negatively charged groups or biosurfactant coatings, are being explored.

Biomedical nanoparticles as immune-modulators 01.09.2011 – 31.08.2014, B. Rothen-Rutishauser

In order to harness the unique properties of nanoparticles for novel clinical applications in the treatment of allergic respiratory diseases, AMI researchers propose developing and testing specifically designed nanoparticles in order to investigate their immune-modulatory effects in the lung.

PROJECTS FINANCED BY THE EUROPEAN RESEARCH COUNCIL

Cost: Self-assembled photonic crystals from highly charged anisotropic core-shell particles, 01.02.2008 – 31.01.2011, P. Schurtenberger

The overall aim of this project was to develop a strategy for the synthesis of electrosterically stabilized rod-like magnetic nanoparticles and to investigate their self-assembly into nanocomposites and highly ordered photonic crystals.

NanoModel: multi-scale modeling of nano-structured polymeric materials: from chemistry to materials performance, 07.11.2008 – 31.12.2011, P. Schurtenberger, H. Dietsch

As part of this EU project in which FIAT, Bosch, and FZ Jülich participated as AMI's partners, AMI researchers developed strategies for the integration of silica and silica-coated nanoparticles synthesized by wet chemistry techniques into a set of polymeric matrices using different approaches, such as in-situ and solvent integration.

Promix: cluster, glass, and crystal formation in concentrated protein mixtures of opposite charges, 01.03.2009 – 28.02.2011, I. Voets

AMI researchers examined similarities and differences between the phase behavior of concentrated protein mixtures, single-component protein solutions and classical colloid model systems.

NanoDiaRa 01.03.2010 – 28.02.2013, A. Fink

This project is part of a large-scale international, interdisciplinary program entitled «Nanosciences, Nanotechnologies, Materials, and new Production Technologies,» which involves a consortium of 15 partners. The main objective of this project is to develop modified superparamagnetic nanoparticles as a diagnostic tool for the detection of early stages of arthritis. In addition to research, the project will consider the social, ethical, and legal aspects of applying nanotechnology for medical purposes.

PROJECTS FINANCED BY OTHER PUBLIC FUNDING AGENCIES

Photo-healable supramolecular polymers, US-Army, 01.07.2009 – 30.06.2012, C. Weder, G. Fiore

The goal of this project is to develop and characterize a novel class of metallosupramolecular polymeric materials that can be healed by exposure to light of an appropriate wavelength and intensity.

Biological responses to nanoscale particles, Deutsche Forschungsgemeinschaft, 01.01.2011 – 31.12.2013, B. Rothen-Rutishauser

This project aims to advance the understanding of the interactions of nanoparticles with proteins, tissue, and cells of the respiratory tract. A special focus lies on the interaction of proteins and other biomolecules of the body fluids with nanoparticles and the influence of these bindings on cell interaction – i.e. uptake and intracellular trafficking.

Assessing the toxicity of Ag nanoparticles at the air-liquid interface using a 3D model of the epithelial airway barrier in vitro, Bundesamt für Gesundheit 01.02.2010 – 31.03.2013, B. Rothen-Rutishauser

Silver nanoparticles are currently being used for a wide range of consumer, industrial, and technological applications. Despite this, the effects of silver nanoparticles on the environment and human health are not fully understood. This project aims to use the in vitro human epithelial airway model combined with a valuable battery of experimental tests to determine the different toxicological endpoints that might be involved in xenobiotic-induced toxicity, specifically in connection with silver nanoparticles.

Modeling an in vitro air-blood barrier by using a novel quadruple co-culture system hosted onto an ultrathin porous membrane, Lunge Zürich 01.07.2011 – 30.06.2012, B. Rothen-Rutishauser

Up until now, only thick porous membranes (several µm in thickness) have been available on the market. This was not optimal for the development of an air-blood barrier with a thickness of less than 1µm. The aim of this project is to establish and characterize an in vitro human air-blood barrier model by using a novel co-culture system hosted onto a new ultrathin porous membrane.

Engineering carbon black nanoparticles for toxicology and human health, Scientific & Technological Cooperation Programme Switzerland-Russia 15.05.2011 – 15.12.2011, B. Rothen-Rutishauser

This project aimed to develop an approach for engineering carbon black nanoparticles with the purpose of implying it for improvement of data quality in toxicological studies. The significance of the project will be to correlate the well-defined physical and chemical properties of carbon black particles, simulating the key properties of original combustion diesel emission, with the identification of hazardous substances responsible for most adverse health effects.

PROJECTS FINANCED BY THE ADOLPHE MERKLE FOUNDATION

Mechano-chemistry, Adolphe Merkle Foundation, C. Weder, Y. Simon

This proposed experimental research program targets the design, synthesis, processing, exploration, and exploitation of a radically new family of bio-inspired, mechanically responsive polymers in which mechanical stress provides the activation energy to trigger specific pre-programmed chemical reactions. These can be used to bestow polymers with unusual functionalities that were unavailable up until now, such as the mechanically-induced generation of light, heat, and electricity, auto-lubricating behavior, the ability to release small molecules (e.g. drugs, fragrances, and antiseptics), or even the capability to cause self-degradation.

Structure, dynamics, and assembly of core-shell microgels, Adolphe Merkle Foundation, H. Dietsch

Spherical colloidal core-shell microgels as well as novel ellipsoidal, hollow hemispheroidal, and facetted analogues, which are responsive to temperature, are being studied. In addition, the structure, dynamics, and supracolloidal assembly of this new class of materials are explored.

Eye lens proteins and cataract formation, Adolphe Merkle Foundation, A. Stradner

The goal of this project is to better understand eye lens transparency and cataract formation. AMI researchers are investigating the structural, dynamic, and viscoelastic properties of eye lens proteins at concentrations corresponding to those found in the lens. Small-angle X-ray scattering experiments, light scattering experiments, and phase behavior studies are being used by researchers in order to study the behavior of eye lens crystalline as a function of various solvent parameters.

Effect of electrostatic interactions on the casein-poly(ethylene oxide) phase diagram in the colloid limit, Adolphe Merkle Foundation, A. Stradner

As most food systems contain food colloids with residual charges, such as caseins, the relevant interparticle interactions that drive phase separation and arrest are not only dominated by hard core repulsion and a short range attraction, but also contain an additional contribution from a screened Coulomb repulsion that can also result in additional phenomena, such as the formation of equilibrium clusters. AMI researchers are working on the phase diagram of casein-poly(ethylene oxide) mixtures and the resulting equilibrium and non-equilibrium structures with a special emphasis on the effect of electrostatic interactions on phase separation and gelation using diffusing wave spectroscopy and confocal laser scanning microscopy.

Light scattering at interfaces, Adolphe Merkle Foundation, R. Sigel

Many processes in technical applications, biology, and even everyday life involve aqueous interfaces. Soft matter, such as polymers, surfactants, or colloids adsorbed to such interfaces, can improve their properties (e.g. corrosion protection at metal/water interfaces). The combination of ellipsometry and static and dynamic light scattering at interfaces is being used to study structure/property relations at the interface and allows a better understanding and tuning of soft matter at interfaces.

PROJECTS FINANCED BY INDUSTRY

Five projects with industry partners were carried out in 2011.

AMI AS A PARTNER

Technology transfer: fostering innovation through partnerships with industry

Predicting the impact that fundamental research results may have on our daily lives is usually very difficult. However, the significant interest from innovative companies in working with AMI suggests that the research conducted at the institute is indeed relevant for future practical applications.

Competitive advantage through open innovation

The exchange of ideas, observations, and experimental results between researchers is the basis for scientific and technological progress. Based on this paradigm, AMI researchers constantly seek to create synergies between different research projects, leverage the complementary expertise of the different research departments, and develop new ideas based on interactions with external scientists. The resulting knowledge and expertise are the basis of AMI's emerging technology platforms (see figure on the right), which are beginning to attract significant interest from industrial partners around the world.

Based on the idea of «open innovation», many technology-based companies rely on collaborations with academic partners. Merging fundamental with application-oriented research, AMI has quickly established itself as a valuable partner for innovative companies. In 2011, the institute continued to expand its interactions with industry to several independent research projects. The figure on the right gives an overview of the interconnection between AMI's technology platforms and possible application areas in various industry sectors.

Technology platforms		Application fields
Smart polymer nanocomposites	• Change properties on command: mechanical properties, shape, color • Release of components on command • Triggers: light, heat, mechanical deformation, humidity	Adhesives Automotive parts Biomedical implants Dental materials Drug development Drug testing Flavor and fragrances Mining equipment Oil production equipment Product security Packaging materials Rapid prototyping
Supramolecular polymers	• Self-healing under UV-light	
Low energy optical upconversion materials	• Radiation curing of polymers	
Polymer nanocomposites	• Enhance mechanical properties of polymers	
Biocompatible nanoparticle carriers	• Target specific cells for drug administration, diagnosis	
Lung cell culture models	• Test interaction between lung cells and aerosols containing drugs, particles	
Characterization methods for nanoparticles	• Visualize structures on the nanoscale: size distribution, surface potential	

Firmenich building in Geneva. (Courtesy of Firmenich)

Controlled fragrance release

One illustrative example of such an open innovation project is the partnership with Firmenich, a leading company in the flavor and fragrance industry. The interaction of fragrances with cellulosic materials significantly influences their performance in laundry applications. One of AMI's research programs focuses on fundamental studies that aim to develop an understanding of fragrance performance as influenced by the structure of cellulose at the mesoscale, i.e. at length scales of a few nanometers to a few micrometers. AMI's expertise with cellulose nanofibers isolated from renewable resources is leveraged to enhance fragrance performance in a partnership with Firmenich.

The concept of «open innovation» involves the use of internal and external ideas to innovate and secure a competitive advantage. Originally implemented by large companies, the concept is now also being used by Small and Medium Enterprises (SMEs).

Firmenich was founded in 1895 in Geneva, Switzerland. Today, it is the world's largest privately owned company in the fragrance and flavor industry. Its clients are the world's leading multinational manufacturers of beauty, household, and fabric care products, as well as pharmaceuticals, food, and beverages.

Contact: Dr. M. Pauchard

National and international research collaborations: exploiting complementary expertise

Interdisciplinary collaborations within the institute and with research groups inside and outside the University are two of AMI's most important strategies to conduct cutting-edge research.

To further develop its own capabilities, in 2011, AMI participated injoint research projects with scientists from various institutions including:

- Case Western Reserve University (Cleveland, USA)
- Chulalongkorn University (Bangkok, Thailand)
- EMPA (Dübendorf, CH)
- Lucerne University (Horw, CH)
- Purdue University (West Lafayette, USA)
- University of Essex (Essex, UK)
- University of Marburg (Marburg, Germany)
- US Army Research Laboratory (Aberdeen Proving Ground, USA)
- US Forest Service (Madison, USA)
- University of Applied Sciences (Bern, CH)
- German Research Center for Environmental Health (Munich, D)
- Helmholtz-Institute for Pharmaceutical Research Saarland (Saarbrücken, D)
- ETH (Lausanne and Zurich, CH)
- University of Edinburgh (Edinburgh, GB)
- Lund University (Lund, S)

Strategic local partnership with the Fribourg College of Engineering

With the objective to bridge the gap between materials research at the laboratory-scale and industrial-scale processes, AMI launched two collaborative projects with the College of Engineering in Fribourg, both of which revolve around nanoparticle-filled polymers. One project is focused on the extraction of cellulose nanofibers from natural sources, and leverages AMI's experience in this area with the College's expertise to scale-up chemical processes. The second project connects polymer processors from the two institutions and aims to explore how laboratory-scale fabrication methods for creating nanoparticle-reinforced polymers can be translated into commercially viable processes.

Fribourg College of Engineering. (Courtesy of EIA-FR)

Contact: Dr. M. Pauchard

Networking & Public relations

AMI understands the importance of creating and leveraging opportunities to stimulate dialogues with its partners and stakeholders. The institute is a member of several research and nanotechnology networks, such as NanoImpactNet, Swiss MNT Network – Micro & Nanotechnology, Nanotechnologie Netzwerk, Nanomodel, and Softcomp. In 2011, AMI also initiated a series of special events to interface with various constituents.

Impressions from the «Goûters scientifiques» in Fribourg.

«Open house» for materials science students

In March, AMI hosted the annual «student day» of the Swiss Association for Materials Science and Technology. The event introduced over 80 students from all over Switzerland to ongoing research at the institute and the Fribourg Center for Nanomaterials (Frimat).

Multidisciplinarity in research and education

In September, Professor Christoph Weder spoke at the teacher's kick-off meeting at Collège St. Croix, in Fribourg, where he shared his views on the importance of interdisciplinarity in education with over 100 high school teachers.

«Open house» for interested collaboration partners

In November about 60 participants from industry and academic institutions met at AMI for the kick-off meeting of a new Innovation Circle on the topic of «Nanopolymers and Surfaces». This event was organized in collaboration with i-net Basel Nano and the Fribourg Nanotechnologie Netzwerk. The Innovation Circle seeks to bring together participants that want to benefit from a direct access to current information and findings on a specific subject.

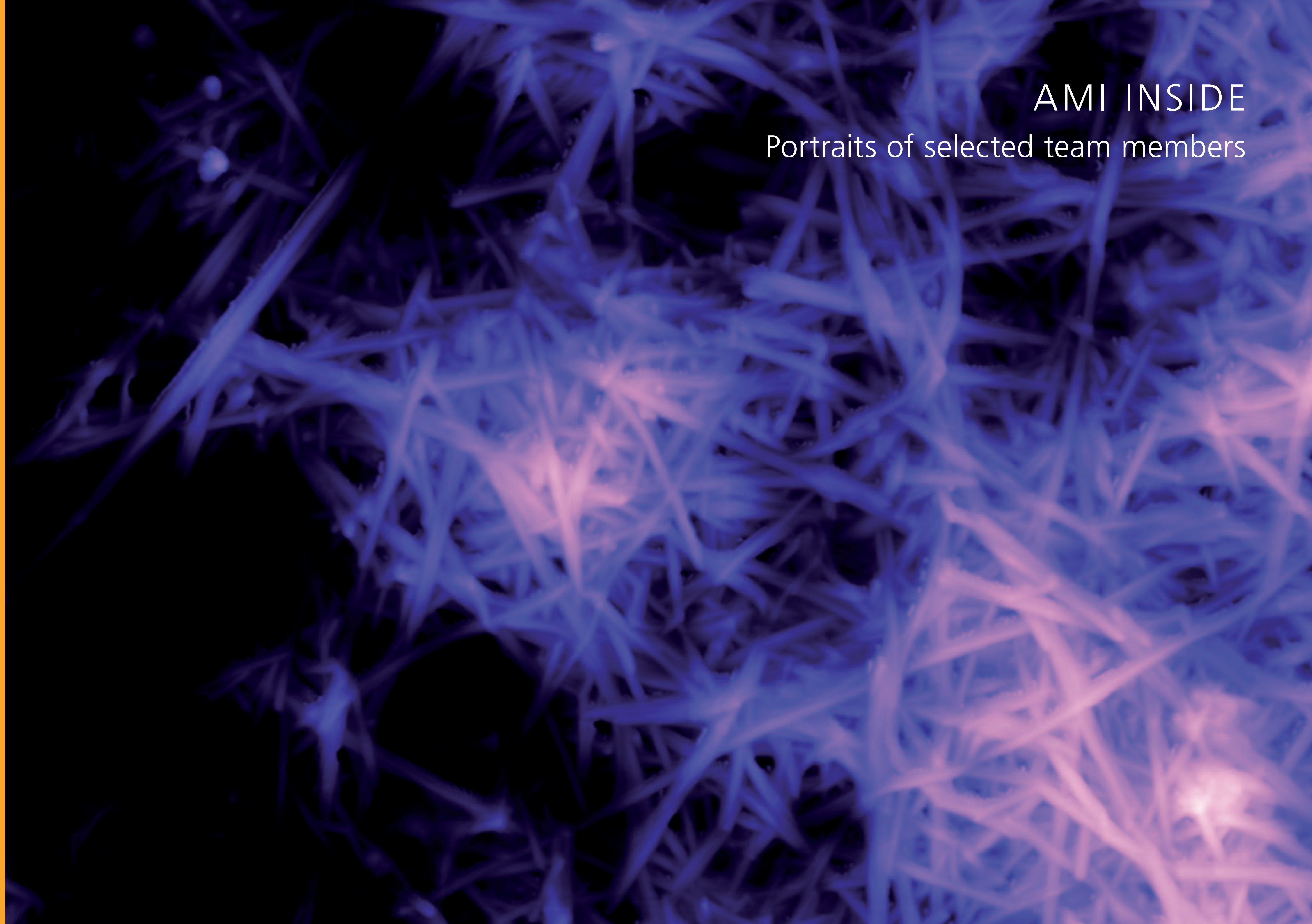
Swiss Aerosol Group (SAG) annual meeting

In November, more than 100 members of the SAG attended the annual meeting, which was hosted by Professor Barbara Rothen-Rutishauser from AMI and Professor Wendelin Stark from ETH Zurich in Bern. Participants from universities, industry, and public authority exchanged scientific concepts and discussed collaborations.

«Goûters Scientifiques» for future scientists

In November and December, AMI hosted two «Goûters Scientifiques» for elementary school students. The events were part of a series of «Science Afternoons» organized by the University of Fribourg and sought to stimulate the natural curiosity of children and to help them to discover the world of science. Over 200 children aged 7 – 12 received an introduction to nanoscience, followed by a series of exciting hands-on experiments.

Contact: M. Jaccard



AMI INSIDE

Portraits of selected team members

CALUM KINNEAR

Studying chemical physics can lead to rather surprising activities…This Scottish physicist studied liquid soaps for a full year during his internship in a large multinational company. He worked on the characterization and optimization of process parameters, assessing the quality of scale-up for liquid detergent. During this time, he worked with soft condensed matter and microtechnology in a plant. While he could have stayed in industry, Calum decided to go back to doing research in order to get his PhD and joined the bio-nanotechnology team at AMI. He enjoys doing research because of its exciting and experimental work frame.

Calum now works on the use of biomedical nanoparticles for photodynamic therapy, although it has many more potential applications in areas such as pollution control, photovoltaic cells, and waste treatment. Other projects relate to the optimization of nanoparticles, which is currently under investigation for cancer therapy using photothermal therapy.

The things that Calum enjoys the most about Switzerland are the smell of chocolate when he walks by the factory and the sound of cowbells when he opens his windows in the morning…Even if it does sound a little cliché! He also appreciates how easy it is to travel around Europe from Switzerland. In winter, you will find him on the snowy slopes of the Swiss Alps.

YOAN SIMON

An engineer at heart, Yoan considered going into aircraft or car manufacturing. However inspired by a passionate chemistry professor, he decided to pursue an academic career in nanoscience where he could combine his application-oriented mindset with his desire to solve more fundamental problems. This Montpellier (France) native therefore decided to carry on with his studies at the Ecole Nationale Supérieure de Chimie de Montpellier, specializing in materials chemistry. Attracted by foreign cultures and languages, Yoan travelled extensively during his scientific career, from Italy to Spain, and then to the US where he spent 5 years. At the University of Massachusetts in Amherst (one of the top polymer centers in North America), he obtained a PhD in the Department of Polymer Science and Engineering. After that, Yoan decided to return to Europe and was granted a postdoctoral fellowship to work at ETH Zürich. In 2009, he took a position as a group leader at AMI, where he now mentors a group of 8 students and postdocs of all backgrounds. His interests revolve around functional materials chemistry, hybrid organic-inorganic architectures, and mechano- and light-responsive materials. The projects developed in his group benefit from external partnerships with both academia and industry. Like most chemists, Yoan is a «frustrated chef» and very much enjoys cooking in his spare time.

SYLVANA MUELLER

Silvana Mueller, who lives in Bern, Switzerland's capital, had decided to get her PhD at AMI and started working there in May 2011. After having obtained a Master's Degree in Chemistry in the field of peptide dendrimers, Silvana wanted to further explore the various aspects of chemistry. Participating in material sciences research at AMI allows her to combine chemistry, physics, and biology. She enjoys the interdisciplinary work at AMI and is currently working on the formation of aerogels from cellulose nanowhiskers and the extraction of cellulose nanowhiskers from rice husks and banana plants.

«Making materials out of natural resources such as banana stems or paper is just fascinating, I can see many potential applications for the aerogels I am currently working on.»

Like a true Swiss, Silvana likes to spend her free time outdoors, swimming, biking, or organizing activities for her girl scout troops. Being able to survive outdoors even in awful weather (the way a scout can!) will surely be useful to Silvana, as she will keep on biking from the train station to the office in winter, even under tough weather conditions!

ALKE FINK

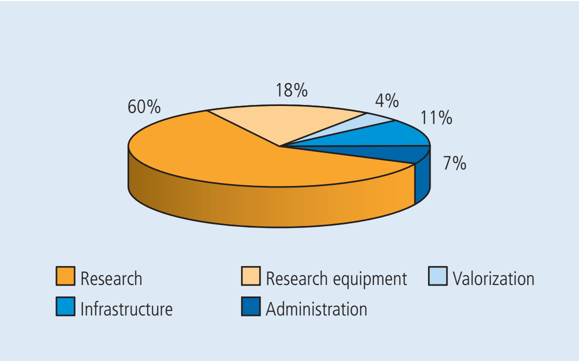
Alke Fink, a chemist by training, has a thirst for travelling and experiencing the many different cultures of the world, which has contributed to the person and scientist she is today. Alke received her PhD in inorganic chemistry in Germany, and subsequently travelled to Sydney, where she first got in contact with materials science. Next, her desire to travel led her to the United States (Florida), and last (but not least) to Switzerland… and not only for skiing! She worked with powder technology at the EPFL. During her many travels, Alke has learned to speak many languages, including both English and French. Although she thoroughly enjoys taking the time to see the world and to experience its offerings, Alke's true motivation comes from her work. «I have always liked fundamental and applied sciences: understanding what really happens in order to manage and predict properties. The interdisciplinary framework of AMI offers me a unique freedom in my research to generate innovative new projects». Alke now shares a position as a professor with Barbara Rothen-Rutishauser. She is currently working on several fundamental and applied projects. Since she only works at AMI part-time, she spends the other half of her working life as an SNF professor in the department of Chemistry at the University of Fribourg, where she also teaches on the bachelor and master level.

FACTS & FIGURES

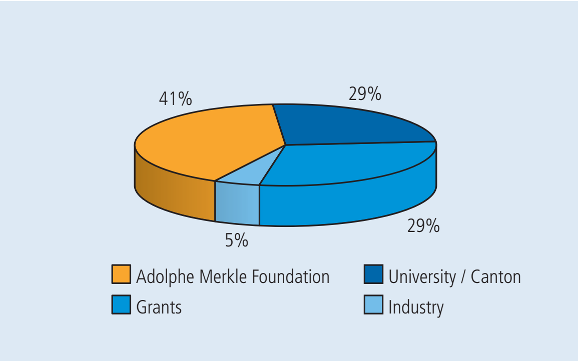
FINANCES

The institute's overall expenditures in 2011 amounted to CHF 6.3 Mio. About 60 % of the expenses were spent on research and 18 % on investments for research equipment. About 4 % of the budget supported valorization activities such as technology transfer and communication & marketing. About 18 % were used to support the general infrastructure and administration. The main sources of income were the Adolphe Merkle Foundation, the University and the canton of Fribourg, as well as research funds from funding agencies and industry.

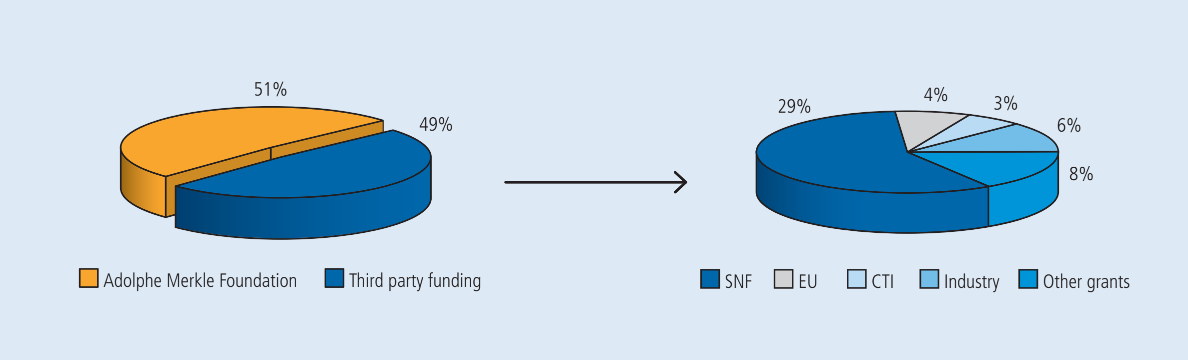
In absolute terms, the third party funding of research projects grew considerably from the last year, covering about half of all research expenditures and making up 34 % of the total budget. Here the most important sources were the Swiss National Science Foundation (SNF) and industrial partners.



Distribution of overall expenses 2011 by cost types (total cost of CHF 6.3 Mio.).



Sources of funding for overall expenses in 2011.

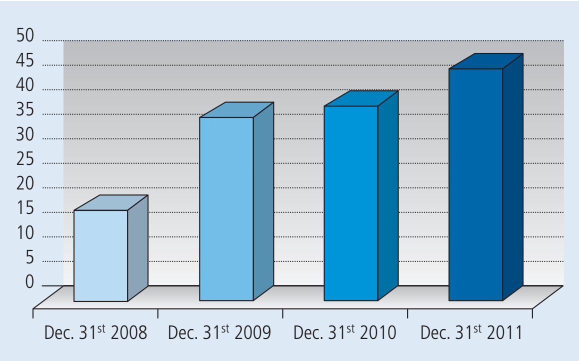


Sources of funding for research projects in 2011 (total research expenditures of CHF 3.7 Mio.).

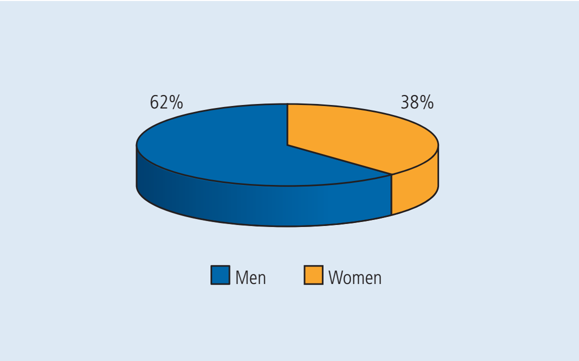
PERSONNEL

In 2011, 23 new collaborators joined AMI and 15 people left the institute due to natural fluctuation. Most of the new collaborators joined the Bio-Nanomaterials department that was created this year, further increasing the total number of collaborators. As of December 31, 2011, 52 people worked full- or part-time at AMI, which corresponds to about 47 full-time employees. 86 % of them were active in research, a percentage that has remained stable through the years.

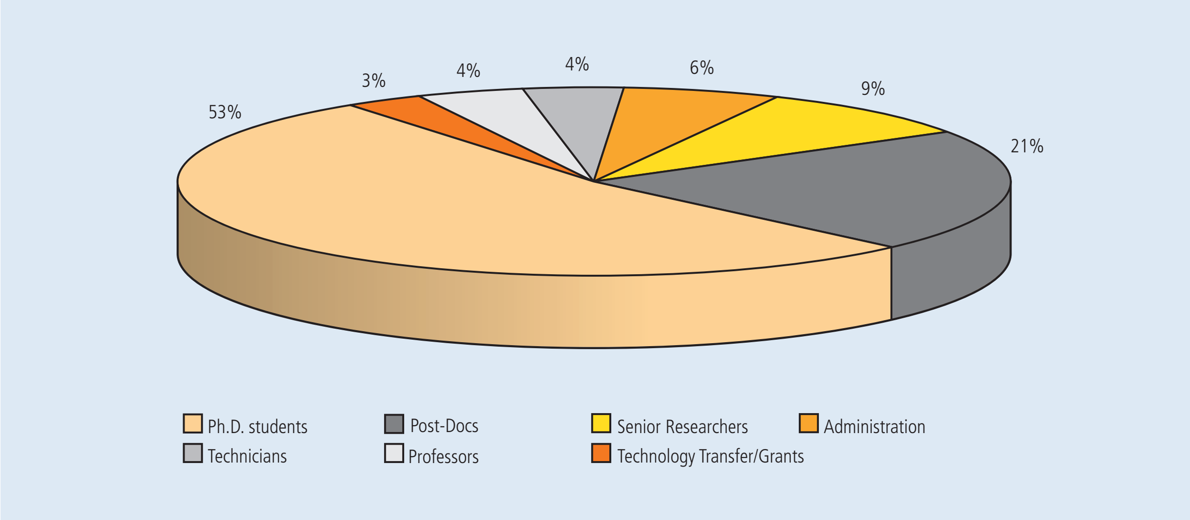
The AMI team is multinational with 16 different nationalities and very young with an average age of 33 years. The majority of AMI employees are Swiss. The next most prominent nationalities are French, German, and Indian. 38 % of employees are women. The ratio of PhD students to Post-Docs more than doubled in 2011, which is in line with AMI's educational mission.



Development of personnel over the last three years, in full time equivalents.



Gender distribution at AMI on December 31st, 2011.



Composition of personnel on December 31st, 2011.

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(Associate Director)

Prof. Alke Fink

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Chair Professor of Chemistry at the Hong Kong University of Science and Technology (HKUST), China

Prof. Dr. Hans Marcus Textor
Former Head of Biointerface Group at Department of Materials, ETH Zürich, Switzerland

Adolphe Merkle Foundation

Prof. Joseph Deiss
(President)
Former member of the Swiss Government, President of the General Assembly of the United Nations, Professor at the University of Fribourg

Dr. Adolphe Merkle
Founder of the Adolphe Merkle Foundation,
Former Director and Owner of Vibrometer SA

Isabelle Chassot
State Councilor, Minister of Public Education, Culture, and Sport of the Canton of Fribourg, President of the Swiss Conference of Cantonal Ministers of Education

Dr. Peter Pfluger
CEO of Tronics Microsystems SA, Former CEO of the Phonak Group and of the Swiss Center for Electronics and Microtechnology (CSEM SA)

Prof. Claude Regamey
Former Chairman of the Department of Internal Medicine, Hôpital Cantonal Fribourg, Former President of the Ethical Committee of the Swiss Academy of Sciences

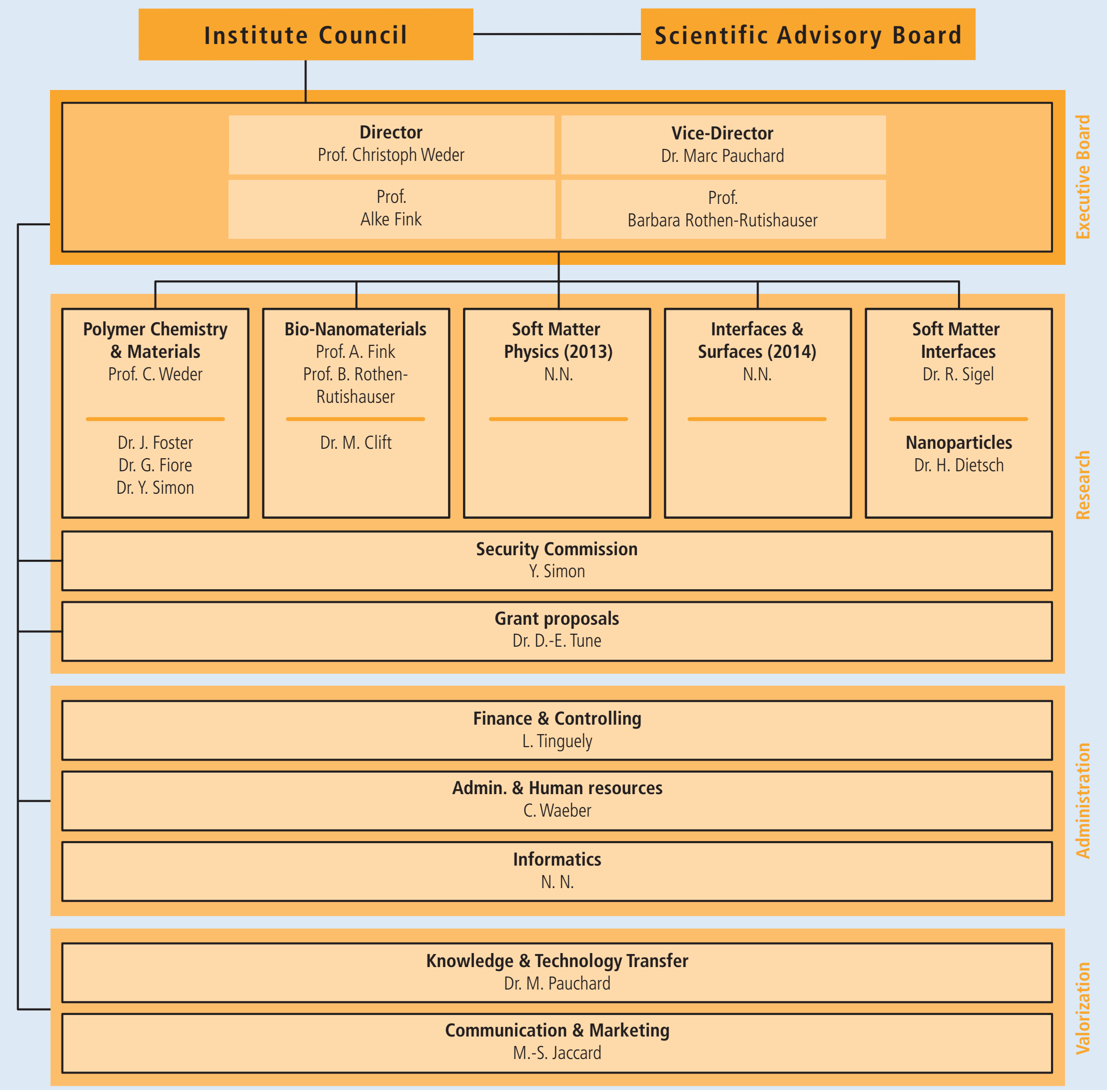
Dr. Hans Rudolf Zeller
Former Vice-President of Technology & Intellectual Property at ABB Semiconductors

ORGANIZATIONAL CHART

AMI has the formal status of an independent institute of the University of Fribourg, whose scientific, administrative, and strategic leadership rest with its directors. An Institute Council, composed of representatives of the University of Fribourg and the Adolphe Merkle Foundation, provides oversight and serves as a platform in which AMI's main stakeholders can dialogue. An independent external advisory board composed of scientists with outstanding international reputations advises the Institute Council and AMI directors in strategic and scientific questions.

AMI's research departments form the core of the institute. In 2011, AMI was comprised of two research departments (Polymer Chemistry & Materials, Bio-Nanomaterials) and two small research groups. The current development plan foresees a continuous growth with two new departments to be installed in the coming years. Average department sizes of about 30 researchers with 4 group leaders are envisioned. In addition to a small administrative team, several comprehensive services endorse the strategic activities of the institute:

- The security commission guarantees safe research operations.
- The professional support in EU project proposal writing guarantees an efficient participation of AMI in European research programs.
- A technology transfer service sets the basis for successful collaborations with industry.



Status December 2011

SCIENTIFIC OUTPUT

Researchers at AMI have published their recent findings in numerous high impact journals, such as Nature, Angewandte Chemie International Edition, Soft Matter, and Advanced Materials. Most notably two publications were selected as covers for the following journals: *Nature, Angewandte Chemie international Edition, Soft Matter, Advanced Materials*

The results were disseminated in almost 100 presentations, including 27 international conferences. AMI researchers represented the institute and presented their latest research results to the scientific community at conferences such as the American Chemical Society National Meeting in Anaheim, California (USA), the International Soft Matter Conference in Crete, Greece, and the Congress of International Society for Aerosols in Medicine in the Netherlands.

SCIENTIFIC OUTPUT

Publications in scientific journals:	
published	39
accepted	11
submitted	8
covers	2
Contributions at conferences and workshops:	
Invited talks	21
Talks	33
Posters	28
Keynote Lecture	2
External presentations:	
Invited seminars	14

Publications

1. Ahmad, S.; Raemy, D. O.; Loader, J. E.; Kailey, J. M.; Neeves, K. B.; White, C. W.; Ahmad, A.; Gehr, P.; Rothen-Rutishauser, B. «Interaction and localization of synthetic nanoparticles in healthy and cystic fibrosis airway epithelial cells: Effect of ozone exposure» *Journal of Aerosol Medicine and Pulmonary Drug Delivery* **2011,** In press.

2. Almasy, L.; Bende, A. «Ab initio structures of interacting methylene chloride molecules with comparison to the liquid phase» *Journal of Molecular Liquids* **2011,** *158,* 205 – 207.

3. Bobowska, I.; Hengsberger, S.; Hirt, A.; Grobéty, B.; Vanoli, E.; Chappuis, T.; Dietsch, H. «Tuning the magnetic response of iron oxide spindle-type nanoparticles with a fixed morphology» **2011,** Submitted.

4. Burnworth, M.; Rowan, S. J.; Weder, C. «Structure-Property Relations in Metallosupramolecular Poly(p-xylylene)s» *Macromolecules* **2011,** ASAP.

5. Burnworth, M.; Tang, L. M.; Kumpfer, J. R.; Duncan, A. J.; Beyer, F. L.; Fiore, G. L.; Rowan, S. J.; Weder, C. «Optically healable supramolecular polymers» *Nature* **2011,** *472,* 334 – 337.

6. Capadona, J. R.; Tyler, D. T.; Zorman, C. A.; Rowan, S. J.; Weder, C. «Mechanically Adaptive Nanocomposites for Neural Interfacing» Submitted.

7. Cardinaux, F.; Zaccarelli, E.; Stradner, A.; Bucciarelli, S.; Farago, B.; Egelhaaf, S. U.; Sciortino, F.; Schurtenberger, P. «Cluster-Driven Dynamical Arrest in Concentrated Lysozyme Solutions» *Journal of Physical Chemistry B* **2011,** *115,* 7227 – 7237.

8. Changsarn, S.; Mendez, J. D.; Shanmuganathan, K.; Foster, E. J.; Weder, C.; Supaphol, P. «Biologically Inspired Hierarchical Design of Nanocomposites Based on Poly(ethylene oxide) and Cellulose Nanofibers» *Macromolecular Rapid Communications* **2011,** *32,* 1367 – 1372.

9. Changsarn, S.; Mendez, J. D.; Weder, C.; Srikhirin, T.; Supaphol, P. «Electrospinning of Light-Emitting Fibers from a Tertiary Blend Solution of an Inert Polymer and Two Conjugated Polymers» *Chiang Mai Journal of Science* **2011,** *38,* 193 – 209.

10. Chappuis, T.; Bobowska, I.; Hengsberger, S.; Vanoli, E.; Dietsch, H. «Influence of the Hydrogen Reduction Time and Temperature on the Morphology Evolution and Hematite/Magnetite Conversion of Spindle-Type Hematite Nanoparticles» *Chimia* **2011,** *65,* 12.

11. Clift, M. J. D.; Foster, E. J.; Vanhecke, D.; Studer, D.; Wick, P.; Gehr, P.; Rothen-Rutishauser, B.; Weder, C. «Investigating the Interaction of Cellulose Nanofibers Derived from Cotton with a Sophhisticated 3D Human Lung Cell Coculture» *Biomacromolecules* **2011,** *12,* 3666 – 3673.

12. Clift, M. J. D.; Rothen-Rutishauser, B. «Study the oxidative stress paradigm in vitro: A theoretical and practical perspective»; Armstrong, D., Bharali, D., Eds. 2011, Submitted.

13. Crassous, J. J.; Dietsch, H.; Pfeiderer, P.; Malik, V.; Diaz, A.; Ackermann-Hirschi, L.; Drechsler, M.; Schurtenberger, P. «Preparation and Characterization of Ellipsoidal-shaped Thermosensitive Microgel Colloids with Tailored Aspect Ratios», Submitted.

14. Crassous, J. J.; Millard, P. E.; Mihut, A. M.; Polzer, F.; Ballauff, M.; Schurtenberger, P. «Asymmetric Self-Assembly of Oppositely Charged Composite Microgels and Gold Nanoparticles» *Soft Matter* **2011,** In press.

15. Crassous, J. J.; Millard, P. E.; Mihut, A. M.; Drechler, M.; Ballauff, M.; Schurtenberger, P. «Biomimetic self-assembly of oppositely charged polyelectrolytes brushes and gold particles into giant hollow fibers» Submitted

16. Dagallier, C.; Cardinaux, F.; Dietsch, H.; Scheffold, F. «Magnetic orientation of soft particles in a jammed solid» *Soft Matter* **2011,** 2174 – 2177.

17. Dorsaz, N.; Thurston, G. M.; Stradner, A.; Schurtenberger, P.; Foffi, G. «Phase separation in binary eye lens protein mixtures» *Soft Matter* **2011,** 1763 – 1776.

18. Escher, W.; Brunschwiler, T.; Shalkevich, N.; Shalkevich, A.; Burgi, T.; Michel, B.; Poulikakos, D. «On the Cooling of Electronics With Nanofluids» *Journal of Heat Transfer* **2011,** *133,* 051401 – 051411.

19. Fiore, G. L.; Rowan, S. J.; Weder, C. «Light-Activated Healing of Metallosupramolecular Polymers» *Chimia* **2011,** *65,* 745.

20. Gibaud, T.; Cardinaux, F.; Bergenholtz, J.; Stradner, A.; Schurtenberger, P. «Phase separation and dynamical arrest for particles interacting with mixed potentials-the case of globular proteins revisited» *Soft Matter* **2011,** 857 – 860.

21. Harris, J.; Capadona, J. R.; Miller, R. H.; Healy, B. C.; Shanmuganathan, K.; Rowan, S.; Weder, C.; Tyler, D. «Mechanically Adaptive Intracortical Implants Improve the Proximity of Neuronal Cell Bodies» *Journal of Neural Engineering* **2011,** *8,* 066011.

22. Harris, J.; Hess, A.; Rowan, S.; Weder, C.; Zorman, C. A.; Tyler, D. J.; Capadona, J. R. «In vivo deployment of mechanically adaptive nanocomposites for intracortical microelectrodes» *Journal of Neural Engineering* **2011,** *8,* 046010.

23. Hess, A.; Capadona, J. R.; Shanmuganathan, K.; Rowan, S. J.; Weder, C.; Tyler, D. J.; Zorman, C. A. «Development of a stimuli-responsive polymer nanocomposite toward biologically-optimized, MEMS-based neural probes» *Journal of Micromechanics and Microengineering* **2011,** *21,* 054009.

24. Hsu, L.; Weder, C.; Rowan, S. J. «Stimuli-responsive, mechanically-adaptive polymer nanocomposites» *Journal of Materials Chemistry* **2011,** *21,* 2812 – 2822.

25. Justino, L. L. G.; Ramos, M. L.; Knaapila, M.; Marques, A. T.; Kudla, C. J.; Scherf, U.; Almasy, L.; Schweins, R.; Burrows, H. D.; Monkman, A. P. «Gel Formation and Interpolymer Alkyl Chain Interactions with Poly (9,9-dioctylfluorene-2,7-diyl) (PFO) in Toluene Solution: Results from NMR, SANS, DFT, and Semiempirical Calculations and Their Implications for PFO beta-Phase Formation» *Macromolecules* **2011,** *44,* 334 – 343.

26. Lemmers, M.; Voets, I. K.; Stuart, M. A. C.; van der Gucht, J. «Transient network topology of interconnected polyelectrolyte complex micelles» *Soft Matter* **2011,** 1378 – 1389.

27. Lott, J.; Ryan, C.; Valle, B.; Johnson, J.; Schiraldi, D. A.; Shan, J.; Singer, K. D.; Weder, C. «High-density optical data storage in two-photon absorbing polymer-dye blends» *Advanced Materials* **2011,** *23,* 2425 – 2429.

28. Lott, J.; Ryan, C.; Valle, B.; Johnson, J. R.; Schiraldi, D. A.; Shan, J.; Singer, K. D.; Weder, C. «Two-Photon 3D Optical Data Storage via Aggregate Switching of Excimer-Forming Dyes» *Advanced Materials* **2011,** *23,* 2425 – 2429.

29. Mahmoudi, M.; Hofmann, H.; Rothen-Rutishauser, B.; Petri-Fink, A. «A sessing the In Vitro and In Vivo Toxicity of Superparam agnetic Iron Oxide Nanoparticles» *Chemical Reviews* **2011,** In press.

30. Mahmoudi, N.; Axelos, M. A. V.; Riaublanc, A. «Interfacial properties of fractal and spherical whey protein aggregates» *Soft Matter* **2011,** *7,* 7643 – 7654.

31. Makowski, B. T.; Valle, B.; Singer, K. D.; Weder, C. «A Melt-Processable Squaraine-Based Organic Glass for Nonlinear Optics» *Journal of Materials Chemistry* **2011,** In press.

32. Makowski, B. T.; Lott, J.; Valle, B.; Singer, K. D.; Weder, C. «Functionalized Cyano-OPVs as Melt-Processable Two-Photon Absorbers» *Journal of Materials Chemistry* **2011,** In press.

33. Martchenko, I.; Dietsch, H.; Moitzi, C.; Schurtenberger, P. «Hydrodynamic properties of magnetic nanoparticles with tunable shape anisotropy: prediction and experimental verification» *J. Journal of Physical Chemistry B* **2011,** In press.

34. McCain, M. L.; Desplantez, T.; Geisse, N. A.; Rothen-Rutishauser, B.; Oberer, H.; Parker, K. K.; Kleber, A. G. «Cell-to-cell coupling in engineered pairs of rat ventricular cardiomyocytes: relation between Cx43 immunofluorescence and intercellular electrical conductance» *American Journal of Physiology – Heart and Circulatory Physiology* **2011,** In press.

35. Mendez, J.; Annamalai, P. K.; Eichhorn, S. J.; Rusli, R.; Rowan, S. J.; Foster, E. J.; Weder, C. «Bio-inspired Mechanically Adaptive Polymer Nanocomposites with Water-Activated Shape Memory Effect» *Macromolecules* **2011,** *44,* 6827 – 6835.

36. Mihut, A. M.; Crassous, J. J.; Schmalz, H.; Drechsler, M.; Ballauff, M. «Self-Assembly of Crystalline-Coil Diblock Copolymers in Solution: Experimental Phase Map», Submitted.

37. Mihut, A. M.; Sànchez-Ferrer, A.; Mezzenga, R.; Crassous, J. J.; Ackermann-Hirschi, L.; Dietsch, H. «Influence of the particle filler content on the mechanical properties of model elastomeric nanocomposites» Submitted

38. Moitzi, C.; Donato, L.; Schmitt, C.; Bovetto, L.; Gillies, G.; Stradner, A. «Structure of beta-lactoglobulin microgels formed during heating as revealed by small-angle X-ray scattering and light scattering» *Food Hydrocolloids* **2011,** *25,* 1766 – 1774.

39. Moitzi, C.; Menzel, A.; Schurtenberger, P.; Stradner, A. «The pH Induced Sol-Gel Transition in Skim Milk Revisited. A Detailed Study Using Time-Resolved Light and X-ray Scattering Experiments» *Langmuir* **2011,** *27,* 2195 – 2203.

40. Mühlfeld, C.; Poland, C. A.; Duffin, R.; Brandenberger, C.; Murphy, F. A.; Rothen-Rutishauser, B.; Gehr, P.; Donaldson, K. «Differential effects of long and short carbon nanotubes on the gas-exchange region of the mouse lung» *Nanotoxicology* **2011,** In press.

41. Müller, L.; Comte, P.; Czerwinski, J.; Kasper, M.; Mayer, A. C. R.; Schmid, A.; Rosinus, L.; Clift, M. J. D.; Steiner, S.; Gehr, P.; Rothen-Rutishauser, B. «Investigating the potential for different scooter and car exhaust emissions to cause cytotoxic and (pro-)inflammatory responses to a 3D in vitro model of the human epithelial airway» *Toxicological and Environmental Chemistry* **2011,** In press.

42. Padalkar, S.; Capadona, J. R.; Rowan, S. J.; Weder, C.; Moon, R. J.; Stanciu, L. A. «Self-assembly and alignment of semiconductor nanoparticles on cellulose nanocrystals» *Journal of Materials Science* **2011,** *46,* 5672 – 5679.

43. Poland, C. A.; Clift, M. J. D. «Nanoparticle-lung interactions and their potential consequences to human health» In *Bio-Nanotechnology: A revolution in Food, Biomedical and Health Sciences;* Bagchi, D., Bagchi, M., Mariyama, H., Shahidi, F., Eds. 2011, In press.

44. Reufer, M.; Dietsch, H.; Gasser, U.; Grobety, B.; Hirt, A. M.; Malik, V. K.; Schurtenberger, P. «Magnetic properties of silica coated spindle-type hematite particles» *Journal of Physics-Condensed Matter* **2011,** *23,* 065102.

45. Rufier, C.; Reufer, M.; Dietsch, H.; Schurtenberger, P. «Single Step Hybrid Coating Process to Enhance the Electrosteric Stabilization of Inorganic Particles» *Langmuir* **2011,** *27,* 6622 – 6627.

46. Rusli, R.; K, S.; Rowan, S. J.; Weder, C.; Eichhorn, S. J. «Transfer in Cellulose Nanowhisker Composites – Influence of Whisker Aspect Ratio and Surface Charge» *Biomacromolecules* **2011,** *12,* 1363 – 1369.

47. Ryan, C.; Christenson, C. W.; Valle, B.; Saini, A.; Lott, J.; Johnson, J.; Schiraldi, D.; Weder, C.; Baer, E.; Singer, K. D.; Shan, J. «High Density Optical Data Storage in Co-extruded Multilayer Polymer Films», Submitted.

48. Sanchez-Ferrer, A.; Mezzenga, R.; Dietsch, H. «Orientational Behavior of Ellipsoidal Silica-Coated Hematite Nanoparticles Integrated within an Elastomeric Matrix and its Mechanical Reinforcement» *Macromolecular Chemistry and Physics* **2011,** *212,* 627 – 634.

49. Simon, Y. C.; Bai, S.; Sing, M. K.; Dietsch, H.; Achermann, M.; Weder, C. «Low-Power Upconversion in Dye-Doped Polymer Nanoparticles» *Macromolecular Rapid Communications* **2011,** In press.

50. Staedele, V.; Gasser, U.; Dietsch, H. «Ellipsoidal hybrid magnetic microgel particles with thermally tunable aspect ratios», Submitted.

51. Steiner, S.; Muller, L.; Raemy, D. O.; Czerwinski, J.; Comte, P.; Mayer, A.; Gehr, P.; Rothen-Rutishauser, B.; Clift, M. J. D. «Investigating the effects of cerium dioxide nanoparticles and diesel exhaust co-exposure upon the epithelial airway barrier: A pilot study», Submitted.

52. Stocco, A.; Mokhtari, T.; Haseloff, G.; Erbe, A.; Sigel, R. «Evanescent-wave dynamic light scattering at an oil-water interface: Diffusion of interface-adsorbed colloids» *Physical Review E* **2011,** *83,* 011601.

53. Stocco, A.; Tauer, K.; Pispas, S.; Sigel, R. «Dynamics of amphiphilic diblock copolymers at the air-water interface» *Journal of Colloid and Interface Science* **2011,** 172 – 178.

54. Suter, M.; Ergeneman, O.; Zurcher, J.; Moitzi, C.; Pane, S.; Rudin, T.; Pratsinis, S. E.; Nelson, B. J.; Hierold, C. «A photopatternable superparamagnetic nanocomposite: Material characterization and fabrication of microstructures» *Sensors and Actuators B-Chemical* **2011,** *156,* 433 – 443.

55. Vincent, R. R. R.; Gillies, G.; Stradner, A. «Simple transmission measurements discriminate instability processes in multiple emulsions» *Soft Matter* **2011,** *7,* 2697 – 2704.

56. Vincent, R. R. R.; Schurtenberger, P. «Work hardening of soft glassy materials, or a metallurgist's view of peanut butter» *Soft Matter* **2011,** 1635 – 1637.

57. Weder, C. «Mechanoresponsive Materials» *Journal of Materials Chemistry* **2011,** *21,* 8235 – 8236.

58. Worakitsiri, P.; Pornsunthorntawee, O.; Thanpitcha, T.; Chavadej, S.; Weder, C.; Rujiravanit, R. «Synthesis of polyaniline nanofibers and nanotubes via rhamnolipid biosurfactant templating» *Synthetic Metals* **2011,** *161,* 298 – 306.

59. Zaccone, A.; Crassous, J. J.; Beri, B. «Quantifying the Reversible Association of Thermosensitive Nanoparticles» *Physical Review Letters* **2011,** *107,* 168303.

60. Zhang, B. Z.; Wepf, R.; Fischer, K.; Schmidt, M.; Besse, S.; Lindner, P.; King, B. T.; Sigel, R.; Schurtenberger, P.; Talmon, Y.; Ding, Y.; Kroger, M.; Halperin, A.; Schluter, A. D. «The Largest Synthetic Structure with Molecular Precision: Towards a Molecular Object» *Angewandte Chemie-International Edition* **2011,** 737 – 740.

Conferences and Seminars

1. Abteilungsseminar, Max Planck Institute for Polymer Research, Mainz, Germany, 16 December 2011
Invited seminar, «Absorption and diffusion dynamics at interfaces», R. Sigel

2. Abteilungsseminar, Max Planck Institute for Polymer Research, Mainz, Germany, 9 March 2011
Invited seminar, «A soft matter approach to microscopic and macroscopic interfaces», R. Sigel

3. American Chemical Society National Meeting, Anaheim, California, USA
Talk, «Mechanically adaptive nanocomposites based on cellulose nanowhiskers», E. J. Foster, J. Mendez, C. Weder
Talk, «Reinforcement of self-healing polymer films with cellulose nanowhiskers», G. L. Fiore, M. Burnworth, L. Tang, S. J. Rowan, C. Weder
Talk, «Bio-inspired mechanically-adaptive polymer/cellulose nanofiber nanocomposites», C. Weder, E. J. Foster, L. Hsu, J. R. Capadona, K. Shanmuganathan, S. J. Rowan
Talk, «Low-Power Light Upconversion in Solid Materials», Y. C. Simon, J. Lott, J. Blumhoff, F. N. Castellano, C. Weder
Talk, «Oriented crystal growth of nonlinear optical dyes in macroporous silicon 2D photonic crystals», M. Geuss, B. Makowski, P. Nolte, M. Steinhart, R. Wehrspohn, C. Weder

4. American Chemical Society National Meeting, Denver, Colorado, USA, 28 August – 1 September 2011
Invited Talk, «Polymer Nanocomposites with Cellulose Nanocrystals», C. Weder
Invited Talk, «Optically Responsive Metal-Containing Polymers», C. Weder

5. BASF SE, Ludwigshafen, German, 21 January 2011
Invited Talk, «Smart nanomaterials: From particles to properties». H. Dietsch

6. Colloids and Materials 2011, Amsterdam, The Netherlands 8 – 11 May 2011
Poster, «Rheological investigations of the effect of the addition of a free non adsorbing polymer on creaming of sterically stabilized emulsions», A. Simon, C. Holtze, T. Tadros P. Schurtenberger

7. 4th International Workshop on Smart Materials and Structures, Agadir, Marocco, 14 – 16 September 2011
Invited Talk, «Hybrid colloids as building blocks for novel materials», H. Dietsch

8. Physics Days 2011, University of Fribourg, 13 May 2011
Talk, «Nanoparticles», H. Dietsch

9. SoftComp Annual Meeting, Crete, Greece, 16 – 18 May 2011
Talk, «Nanoengineering-Composite Microgels», J. J. Crassous, H. Dietsch, P. Schurtenberger
Talk, «Synthesis and potential of particles-based nanocomposite materials», H. Dietsch, P. Schurtenberger
Talk, «Optically Self-Healing Metallosupramolecular Materials» G. Fiore
Talk, «PNIPAM microgel : Structure and Dynamics beyond the glass transition», D. Paloli, J. Crassous, P. S. Mahanty, E. Zaccarelli, P. Schurtenberger

10. NanoModel Meeting, Technical University of Darmstadt, Darmstadt, Germany, 31 March – 1 April 2011
Talk, «M8: Nanocomposites available – Proof of concept of in-situ polymerization in order to create homogeneous nanocomposites with different polymers» O. Pravaz, P. Schurtenberger, H. Dietsch

11. Nanocomposites Workshop 2011, SoftComp, University of Montpellier 2, Montpellier, France, 16 – 17 June 2011
Talk, «In-situ polymerization as a route towards properties tuned polymer-colloid nanocomposites», O. Pravaz, P. Schurtenberger, H. Dietsch

12. NanoModel meeting, BASF SE, Speyer, Germany, 6 – 7 October 2011
Talk, «Activities & Review – D10.2: Comparison of structures obtained via the different integration strategies», O. Pravaz, P. Schurtenberger, H. Dietsch

13. Particles 2011 Meeting, Stimuli Responsive Particles and Particle Assemblies, Berlin, Germany, 9 – 12 July 2011
Talk, «Ellipsoidal Hybrid Magnetic Microgel Particles with Thermally Tunable Aspect Ratios», H. Dietsch
Poster, «Nanoengineering-Composite Microgels», J.J. Crassous, H. Dietsch, V. Malik, L. Ackerman-Hirshi, P. Schurtenberger

14. Interdisciplinary Training for Young Scientists in Material Sciences Meeting, Lugano, Switzerland, 25 – 28 May 2011
Workshop, «Summer School», A. Mihut, H. Dietsch

15. SNF «Smart Materials» Annual Meeting 2011, Fribourg, Switzerland 15 – 16 September 2011
Talk, «Ellipsoidal-Shaped Iron Oxide Particles: Building Blocks for LC Elastomers Hybrid Materials», A. Mihut, H. Dietsch

16. Hybrid Materials 2011, March 2011
Poster, «In-situ polymerization as a route towards polymer-colloid nanocomposites», O. Pravaz, P. Schurtenberger, H. Dietsch

17. 4[th] Swiss Soft Days, Lausanne, Switzerland, 3 February 2011
Poster, «Understanding casein/xanthan-mixtures beyond phase separation», K. van Gruijthuijsen, V. Herle, R. Tuinier, P. Schurtenberger, A. Stradner
Talk, «Dendronized polymers investigated by neutron scattering», R. Sigel, S. Lages, Y.-C. Li, P. Schurtenberger, A. Zhang, B. Zhang, D. Schlüter

18. 5[th] Swiss Soft Days, Basel, Switzerland
Poster, «Synthesis and characterization of hybrid α-Fe_2O_3/Fe_3O_4 anistropic nanoparticles», I. Bobowska, S. Hengsberger, E. Vanoli, T. Chappuis, B. Grobéty, H. Dietsch
Talk, «Towards a better understanding of eye lens transparency and cataract formation», C. Jud, N. Mahmoudi, Y. Umehara, A. Stradner, P. Schurtenberger

19. FriMat Day 2, Fribourg, Switzerland
Poster, «Engineering the magnetic response of iron oxide particles at a fixed morphology», I. Bobowska, S. Hengsberger, E. Vanoli, T. Chappuis, B. Grobéty, A.M. Hirt, H. Dietsch
Poster, «Nanoparticles surface modification», A. Barbiero
Poster, «Influence of surface charge on protein adsorption on polymer coated iron oxide nanoparticles», V. Hirsch

20. Reactor Institute Delft, Delft, the Netherlands, 21 April 2011
Invited Talk, «Depletion interactions in charged, aqueous colloid/polymer-mixtures», K. van Gruijthuijsen, P. Schurtenberger, A. Stradner

21. Gordon-Kenan Research Seminar on Soft Condensed Matter Physics, New London, USA, 13 – 14 August 2011
Talk, «Depletion-induced gels of charged colloids: Towards or away from equilibrium?», K. van Gruijthuijsen, W. Bouwman, P. Schurtenberger, A. Stradner

22. Gordon Research Conference on Soft Condensed Matter Physics, New London, USA, 14 – 19 August 2011
Poster, «Depletion-induced gels of charged colloids: Towards or away from equilibrium?», K. van Gruijthuijsen, W. Bouwman, P. Schurtenberger, A. Stradner

23. Physical and Colloid Chemistry, University of Utrecht, Utrecht, the Netherlands, 25 October 2011
Invited Talk, «Good old depletion and the effect on charges», K. van Gruijthuijsen, P. Schurtenberger, A. Stradner

24. 7[th] Zsigmondy Colloquium, Münster, Germany 21 – 23 February 2011
Talk, «Rheological investigations of the effect of the addition of a free non adsorbing polymer on creaming of sterically stabilized emulsions», A. Simon, C. Holtze, T. Tadros P. Schurtenberger

25. 13[th] European Student Conference on Colloid and Interface Science, Falkenberg, Sweden, 14 – 17 June 2011
Poster, «Prevention of emulsion creaming through the addition of a thickener», A. Simon, C. Holtze, T. Tadros, P. Schurtenberger

26. Department Seminar, German University in Cairo, Egypt, 16 June 2011
Invited seminar, «A soft matter approach to microscopic and macroscopic interfaces», R. Sigel

27. Workshop: Nano structures on surfaces and light scattering, Institut für Werkstofftechnik, Uni Bremen, Germany 25 March 2011
Talk, «Treatment of Smearing in Ellipsometry», R. Sigel, A. Erbe

28. Department Seminar, University Ulm, Germany, 22 June 2011
Invited seminar, «A soft matter approach to microscopic and macroscopic interfaces», R. Sigel

29. 8[th] Liquid Matter Conference, Wien, Austria, 7 – 9 September 2011
Talk, «Dendronized polymers investigated by neutron scattering», R. Sigel, B. Zhang, S. Lages, Y.-C. Li, A. Zhang, D. Schlüter, P. Schurtenberger
Talk, «Structural and dynamic properties of concentrated suspensions of ellipsoids», I. Martchenko, C. Rufier, M. Reufer, J. J. Crassous, H. Dietsch, P. Schurtenberger
Poster, «Light scattering on gold nanorods at an oil/water interface», R. Sigel, T. Mokhtari, H. Dietsch, P. Schurtenberger
Poster, «Scattering of light by non-concentric core-shell particles», D. Ross, R. Sigel
Poster, «Escaping the squeeze: Soft particles at high effective volume fractions», P. Mohanty, J. Crassous, D. Paloli, K. van Gruijthuijsen, M. Obiols-Rabasa, A. Stradner, U. Gasser, J.J. Lietor-Santos, A. Fernandez-Nieves, E. S. Herman, L.A. Lyon, E. Zaccarelli, P. Schurtenberger

30. 5[th] Swiss Soft Days, University of Basel, Basel, Switzerland, 8 June 2011
Talk, «Towards a better understanding of eye lens transparency and cataract formation», C. Jud, N. Mahmoudi, S. Bucciarelli, Y. Umehara, A. Stradner, P. Schurtenberger

31. 6[th] Swiss Soft Days, ETH Zurich, Switzerland, 28 October 2011
Talk, «'Optical rheology' of soft core/shell particles», D. Ross, R. Sigel
Poster, «Dynamics and ordering of ellipsoidal nanoparticles: from low to high volume fractions», I. Martchenko, J. Crassous, C. Rufier, M. Reufer, H. Dietsch, P. Schurtenberger

32. NanoEvent, Kick-off IC NanoPolymers & Surfaces Conference, i-net Basel, Marly, Switzerland, 22 November 2011
Invited Talk, «Cellulose based Bio-Nanocomposites», E. J. Foster, P. Annamalai, M. Jorfi, M. Biyani, C. Weder

33. «Polymere besser verstehen» at the FHNW Fachhochschule Nordwestschweiz, Windisch, Switzerland, 8 September 2011
Invited Talk, «Bio-inspired Mechanically-Adaptive Polymer – Cellulose Based Nanocomposites – Thermal Properties», E. J. Foster, P. Annamalai, M. Jorfi, M. Biyani, C. Weder

34. RMS Foundation, Bettlach, Switzerland, 29 August 2011
Invited Talk, «Bio-inspired Mechanically-Adaptive Polymer – Cellulose Nanofiber Nanocomposites for Bone Reinforcement», E. J. Foster, M. J. D. Clift, B. Rothen-Rutishauser, C. Weder

35. 2011 TAPPI International Conference on Nanotechnology for Renewable Resources, Washington, D.C., USA, 6 – 8 June 2011
Talk, «Toxicology of Cellulose Nanowhisker Based Nanocomposites», E. J. Foster, M. J. D. Clift, B. Rothen-Rutishauser, C. Weder
Talk, «Bio-inspired Mechanically-adaptive Polymer / Cellulose Nanofiber Nanocomposites», E. J. Foster, M. J. D. Clift, C. Weder

36. Seminar at the Departments of Chemistry and Materials Science, University of New Hampshire, Durham, New Hampshire, USA, 31 May 2011
Invited Seminar, «Bio-Inspired Mechanically Responsive Polymer Nanocomposites and Toxicology», E. J. Foster, M. J. D. Clift, B. Rothen-Rutishauser, C. Weder

37. UK Nanomedicine Mission to Switzerland, Lausanne, Switzerland 24 May 2011
Talk, «Bio-Inspired Mechanically Responsive Polymer Nanocomposites for Medicine», E. J. Foster, C. Weder

38. Swiss NanoConvention, Baden, Switzerland, 18 – 19 May 2011
Poster, «Stimuli Responsive Cellulose Nanowhiskers», M. Biyani, E. J. Foster, C. Weder

39. PST-FR, Reseau nanotechnologies, Nanotechnologie Netzwerk, Murten, Switzerland, 17 May 2011
Talk, «Learning From Nature: How Cellulose Nanofibers Can Be Used to Reinforce Plastic», E. J. Foster, L. Lalande, J.-M. Boéchat, C. Weder

40. NRP 64 Kickoff Meeting, Nottwil, Switzerland, 3 – 4 March 2011
Talk, «Cellulose-based nanocomposite building materials: solutions and toxicity», E. J. Foster, M. J. D. Clift, C. Weder

41. Smart Coatings 2011 Symposium, Orlando, Florida, USA, 23 – 25 February 2011
Invited Talk, «Stimuli Responsive Cellulose Nanowhiskers», E. J. Foster, J. Mendez, C. Weder

42. 18th Congress of International Society for Aerosols in Medicine, Rotterdam, the Netherlands, 18 – 22 June 2011
Invited Talk, «Air-liquid exposures of particles onto lung culture surfaces: A new standard to study particle-cell interactions», B. Rothen-Rutishauser

43. FP-7-Nanommune Closing Workshop: Nano-immuno-interactions, Stockholm, Sweden, 17 June 2011
Invited Talk,, «Co-cultures of immune and lung cells for in vitro assessment of nanoparticle toxicity», B. Rothen-Rutishauser

44. Kollegium Spiritus Sanctus, Organised by the Fachschaft Chemie – Biologie, Brig, Switzerland, 30 August 2011
Invited Talk, «Nanotechnologie – Nutzen und Risiken», B. Rothen-Rutishauser

45. Jahrestagung Silag, Zürcherische Arbeitsgemeinschaft zur Erforschung und Bekämpfung der Staublungen in der Schweiz, Adolphe Merkle Institute, Marly, Switzerland, 4 October 2011
Invited Talk, «Nanopartikel-Lungenzell-Interaktionen: Risiken und Chancen», B. Rothen-Rutishauser

46. Seminars in Molecular Toxicology, Molecular and Systems Toxicology, Department of Pharmaceutical Sciences, University of Basel, Basel, Switzerland. 21 November 2011
Invited Seminar, «Risk assessment of nanomaterials – Do we need to worry?», B. Rothen-Rutishauser

47. 15th ETH-Conference on Combustion Generated Nanoparticles, ETH Zentrum, Zurich, Switzerland, 26 – 29 June 2011
Poster, «Investigating nanoparticle mutagenicity: Can nanoparticle-bacterial interactions provide an insight into the unknown?», B. Rothen-Rutishauser

48. Gouters Scientifique, Fribourg, Switzerland
Talk, «Entdecke die Nanowelt», A. Fink

49. University of Florida, Gainesville, Florida, USA
Invited Seminar, «The challenge of particle control», A. Fink

50. SCNAT, Bern, Switzerland
Invited Talk, «From innovative nanomaterials to life science – an interdisciplinary approach», A. Fink

51. Workshop on Magnetic Nanoparticles, Salzburg, Austria
Talk, «SPIONs for in vitro applications», A. Redjem

52. NRP62 Project Meeting, Fribourg, Switzerland
Talk, «Towards better control of superparamagnetic iron oxide nanoparticles», A. Barbiero
Talk, «Pathways to design magnetoliposomes», C. Bonnaud
Talk, «Smart vesicle for drug delivery: Cryo-EM study to elucidate particle/membrane interaction», C. Bonnaud
Poster, «Towards better control of superparamagnetic iron oxide nanoparticles», A. Barbiero
Poster, «Pathways to design magnetoliposomes», C. Bonnaud
Poster, «Smart vesicle for drug delivery: Cryo-EM study to elucidate particle/ membrane interaction», C. Bonnaud

53. 6th Swiss Aerosol Group Meeting, Bern, Switzerland
Talk, «Comparing the interaction of silver and gold nanoparticles using a 3D in vitro model of the epithelial airway barrier», F. Herzog
Talk, «Comparing the interaction of cellulose nanofiber derived from cotton, multi-walled carbon nanotubes and asbestos fibers with a sophisticated 3D human lung cell co-culture», M. J. D. Clift
Talk, «Toxicity of diesel exhaust in lung cells in vitro», S. Steiner

54. In Vitro Toxicological Society (IVTS) of the United Kingdom Annual Meeting; Liverpool, United Kingdom
Talk, «Investigating the nanoparticle-cell interaction in vitro: an advantageous 'alternative' approach?», M. J. D. Clift

55. DFG SPP1313 Workshop entitled 'Biological Responses to Nanoscale Particles', Mainz, Germany
Talk, «Investigating the influence of surface charge on the protein adsorption pattern and cellular interaction of polymer coated SPIONs in vitro», V. Hirsch
Poster, «Evaluating the potential for a variety of nanofibres to develop genotoxicity in the lung using a 3D in vitro model of the human epithelial airway-barrier», M. J. D. Clift

56. Swiss Chemical Society Annual Meeting, Lausanne, Switzerland
Poster, «Smart vesicle for drug delivery», C. Bonnaud
Poster, «Protein adsorption and its impact on particle-cell interaction», V. Hirsch
Poster, «New polymeric materials for light upconversion via triplet-triplet annihilation», S.-H. Lee, Y. C. Simon, C. Weder

57. SSAHE/SGAHE Annual Meeting, Geneva, Switzerland
Poster, «Comparing the interaction of silver and gold nanoparticles using a 3D in vitro model of the epithelial airway barrier», F. Herzog
Poster, «Effect of CeO2 Nanoparticles on Diesel Exhaust Toxicity», S. Steiner

58. European Respiratory Society Annual Conference, Amsterdam, The Netherlands
Poster, «An evaluation of the potential for inhaled xenobiotics to develop cancer in the lung use a 3D in vitro model of the human epithelial airway wall», M. J. D. Clift

59. Technical University of Eindhoven, Eindhoven, The Netherlands, 23 November 2011
Invited Seminar, «Noncovalent interactions as a design Tool for Smart Polymers», C. Weder

60. International Symposium on Stimuli-Responsive Materials, Hattiesburg, Mississippi, USA, 24 – 26 October 2011
Invited Talk, «Bio-Inspired, Mechanically Adaptive Nanocomposites», C. Weder

61. Kick-off Meeting for all Teachers, Lycée St. Croix, Fribourg, Switzerland, 5 September 2011
Keynote Lecture, «Interdisziplinarität in Forschung und Lehre», C. Weder

62. Gordon Research Conference Polymers, South Hadley, Massachusetts, USA, 12 June 2011
Invited Talk, «Noncovalent Interactions as a Design Tool for Functional Polymers», C. Weder

63. 60th SPSJ Meeting, Osaka, Japan, 26 May 2011
Keynote Lecture, «Noncovalent Interactions as a Design Tool for Functional Polymers», C. Weder

64. University of Tokyo, Department of Chemistry, Tokyo, Japan, 24 May 2011
Invited Seminar, «Stimuli-Responsive Nanomaterials through Integration of Functional Organic Dyes into Nanostructured Environments», C. Weder

65. Chulalongkorn University, Bangkok, Thailand, 16 May 2011
Invited Seminar, «Supramolecular Interactions as a Design Tool for Functional Polymers», C. Weder

66. Jahrestagung Ehemaliger Chemie- und Biochemiestudenten, Fribourg, Switzerland, 7 May 2011
Invited Seminar, «Exploiting Supramolecular Interactions for the Design of Smart Polymers», C. Weder

67. PolyColl 2011, Geneva, Switzerland, 29 April 2011
Invited Talk, «Exploiting Noncovalent Interactions for the Design of Functional Polymers», C. Weder

68. Swiss Engineering, Fachgruppe Kunststofftechnik, Seminar Funktionalisierte Kunststoffe, Fribourg, Switzerland, 22 March 2011
Invited Talk, «Funktionelle Polymere und Nanocomposite», C. Weder

69. Makromolekulares Kolloquium Freiburg, Freiburg, Germany, 24–26 February 2011
Invited Talk, «Bio-inspired, mechanically adaptive polymer nanocomposites», C. Weder

70. 15th Swedish Neutron Scattering Society Meeting (SNSS-15), Göteborg, Sweden, 25 August 2011
Invited Talk, «Escaping the squeeze: Soft particles at high effective volume fractions», P. Mohanty

71. Department of Physics and Phys. Oceanography Memorial University of Newfoundland, St. John's, Canada, 4 March 2011
Invited Seminar, «Structural ordering and phase behavior in responsive microgels», P. Mohanty

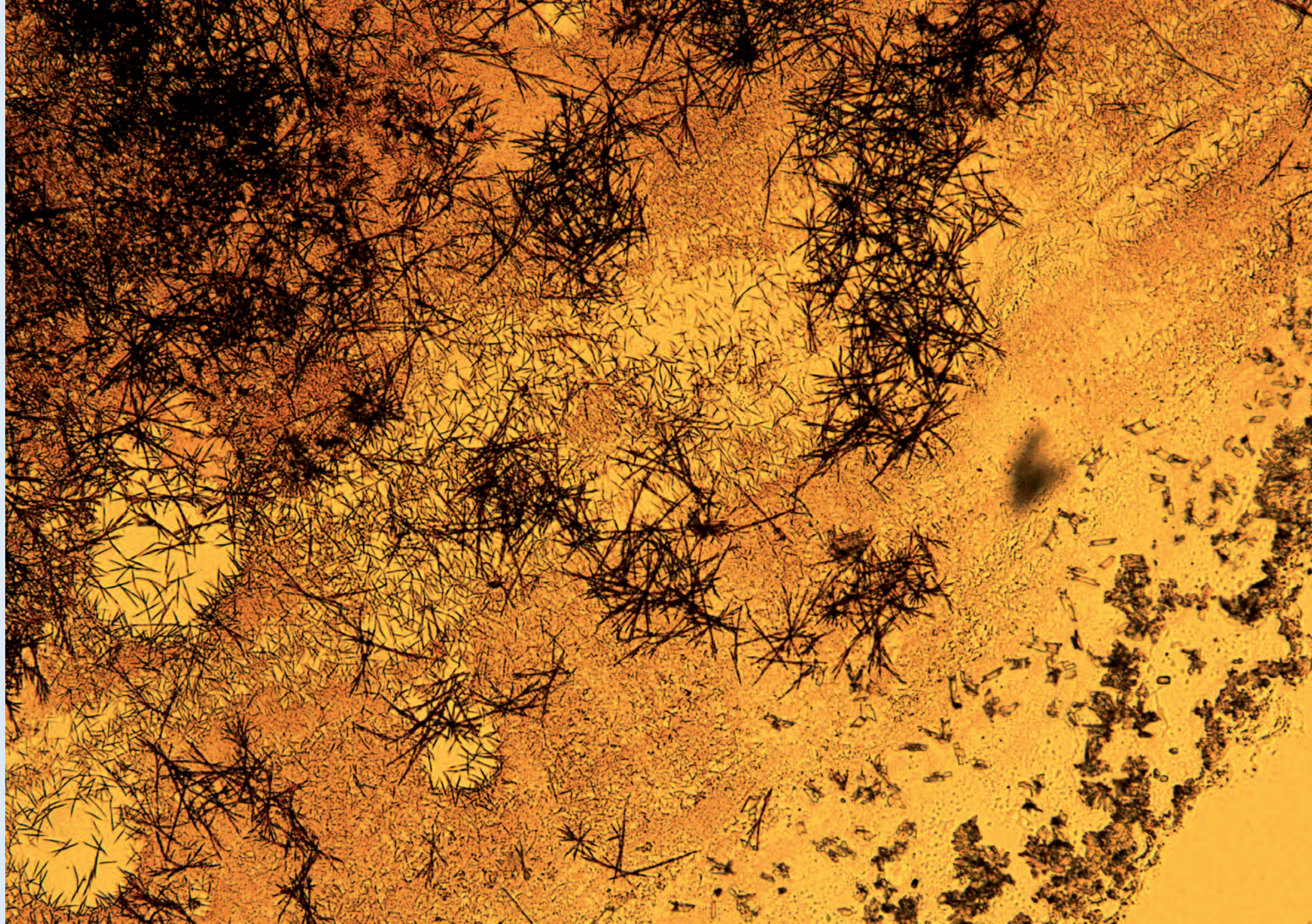
72. Condensed matter division, Institute of Physics, Bhubaneswar, India, 8 July 2011
Invited Seminar, «Interacting soft-microgel colloids», P. Mohanty

73. Department of Physics, University of Vienna, Vienna, Austria, 12 September 2011
Invited Seminar, «Escaping the squeeze: Soft particles at high effective volume fractions», P. Mohanty

74. Soft and Hard materials symposium on surface & material chemistry, Lund, Sweden, 25–27 October 2011
Poster, «Escaping the squeeze: Soft particles at high effective volume fractions», P. Mohanty, J. Crassous, D. Paloli, K. van Gruijthuijsen, M. Obiols-Rabasa, A. Stradner, U. Gasser, J.J. Lietor-Santos, A. Fernandez-Nieves, E. S. Herman, L.A. Lyon, E. Zaccarelli, P. Schurtenberger

75. Euromat, Montpellier, France, 12–15 September 2011
Talk, «Low Power Sensitized Upconverting Nanoparticles», Y. C. Simon

76. 6th International Conference on Microtechnologies in Medicine and Biology, Lucerne, Switzerland, 4–6 May 2011
Poster, «Optical Fiber Biosensors for Wound Monitoring», B. Schyrr, S. Pasche, R. Ischer, E. Scolan, Y. C. Simon, C. Weder, G. Voirin



Pictures

Title page:

Martin Clift & Dimitri Vanhecke. A 3D reconstructed image from an electron tomogram showing a cellulose nanofiber derived from cotton (orange) inside a vesicular body (yellow) within a human monocyte derived macrophage. For more details see the NRP64 project «Cellulose-based nanocomposite building materials: solutions and toxicity» by C. Weder, J. Foster, and M. Clift as well as Clift et al. *Biomacromolecules* 2011. The Dr. Alfred Bretscher Fund from the University of Bern is acknowledged for the possibility to use the Tecnai F20 TEM.

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