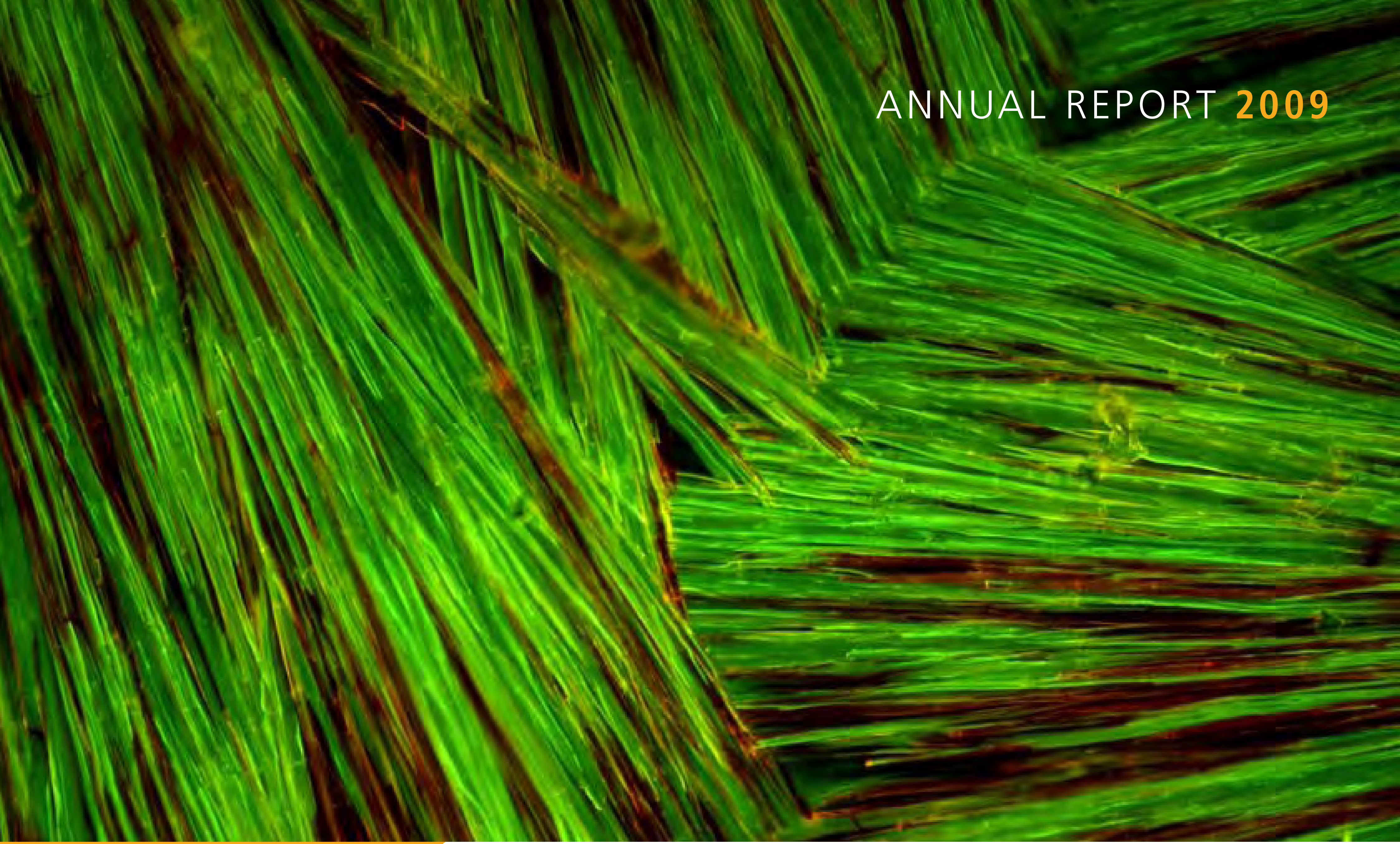


# ANNUAL REPORT 2009

adolphe merkle institute
excellence in pure and applied nanoscience

UNIVERSITAS FRIBURGENSIS

UNIVERSITÉ DE FRIBOURG / UNIVERSITÄT FREIBURG

# Summary

## Message of the directors

**Dynamic growth of a young institute**

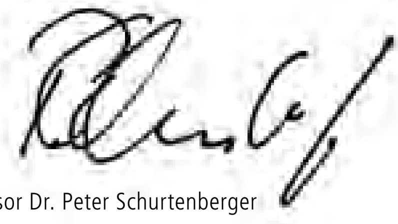
The year 2009 at AMI is probably best summarized by the word "transformation". The young institute, founded only in 2008, developed in such a remarkably rapid and valiant manner that it is hardly recognizable from its fledgling days two years ago. The last year brought the relocation to new laboratories in Marly, the installation of a second research group, the realization of an own technology transfer office, and the creation of organizational structures. The number of our researchers has more than doubled and their scientific output has been beyond any of our expectations. We initiated a new seminar series, a journal club, the café scientifique, and many other platforms that foster collaborative interactions. We networked at the local, regional, national and international level and built many partnerships with academic, industrial, and public institutions. We also developed a strategic plan, which has won unanimous support from our main stakeholders and serves as blueprint for the future development of the institute.

At times, AMI felt very much like a start-up company, where the opportunity of being able to shape something new and unique released lots of vibrant energy and excitement. This thriving environment allowed us to rapidly transform our founder Adolphe Merkle's vision – to establish an interdisciplinary research center devoted to fundamental and application-oriented nanoscience and technology – into a tangible institute, which in the landscape of Switzerland's research institutions is in many aspects unique. This includes its research focus and -approach, funding mechanism, and structure.

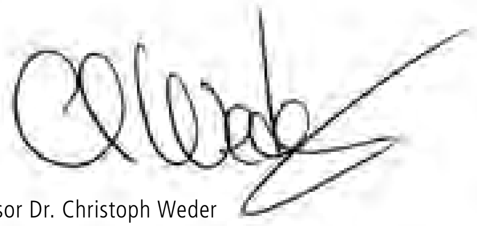
New ventures not only represent opportunities but also bear some risks. Creating the appropriate governance structure for a privately funded, independent institute associated with a public university proved indeed to be more difficult than anticipated. Divergent views on the definition of autonomy of AMI and the respective competences of its director, the university, and the foundation board have induced the founding director Peter Schurtenberger to resign from his positions at the institute. His departure is deeply regretted by all partners and constitutes a major loss for the institute.

But the venture AMI should not be stopped by this setback – the visionary ideas that define the institute are simply too powerful and the opportunities too great. In January 2010 Christoph Weder has taken the helm of the institute. The top priorities for the next year are to keep the institute on its course towards becoming a leading competence center for fundamental and applied interdisciplinary research on soft nanoscience and to work together with AMI's institutional partners towards a solution for the structural problems encountered during the past year.

AMI recognizes the value of partnerships and we are grateful for the interest, courtesy, and support that we encountered from our partners, stakeholders and peers during our first two years of operation. Our team will continue to work hard to be a valuable and reliable partner in the future and to make relevant contributions to science and society.



Professor Dr. Peter Schurtenberger
Director until January 2010



Professor Dr. Christoph Weder
Director ad interim as of January 2010

## Vision and mission

The Adolphe Merkle Institute (AMI) is a recently established independent center of competence associated with the University of Fribourg, which focuses on research in the area of soft nanoscience. In the landscape of Switzerland's research institutions, AMI is in many aspects unique. Its focus on soft nanomaterials is unmatched in Switzerland and beyond. AMI prides itself with an unusual blend of fundamental and application-oriented research within a multidisciplinary setting. Backed by an own technology transfer office, and through collaborations with industrial partners, AMI aims to stimulate innovation, foster industrial competitiveness and more generally, improve the quality of life.

**AMI strives to be a leader in fundamental and applied interdisciplinary research on soft nanoscience. Our research stimulates innovation, fosters industrial competitiveness, and improves the quality of life.**

Associated with the Faculty of Science of the University of Fribourg, AMI, once fully developed, will be comprised of four research groups with complementary expertise and interest in strategic areas of soft nanoscience: soft matter physics, polymer chemistry and materials, both of which are already in place, biomaterials and surface science, which are expected to be established by 2012. Interdisciplinary collaboration between the groups and a spirit of exchange are the basis for the successful and efficient execution of complex research projects in an important "new" field of science. This environment, together with world-class research facilities, also makes AMI a desirable destination for Master's and PhD Students, Postdocs and other researchers. Currently, over 40 researchers call AMI their home.

The creation of the institute has been made possible through the generous donation of Dr. Adolphe Merkle, a successful Fribourgeois entrepreneur, who established the Adolphe Merkle Foundation. This entity is devoted to strengthening research and teaching at the University of Fribourg, and especially the Faculty of Natural Sciences. Dr. Merkle's endowment of 100M Francs constitutes one of the most important private donations supporting academic research in Switzerland. AMI aims to operate in a sustainable manner, and a significant level of competitive external funding is therefore a must. The Adolphe Merkle Institute strives to establish itself as a leader in pure and applied nanoscience through cutting-edge research that aims to solve our societies most interesting scientific and technological problems.

**We conduct strategically oriented and programmatically focused scholarly research and develop new technologies. We study and apply nano-based and nano-structured materials. We focus on a soft nanotechnology approach that is based on bottom-up principles, self-assembly and fab-less nano strategies.**



## Highlights 2009

**A wide range of highly dynamic developments characterized the year of 2009 at AMI. A second research group joined the institute and the research staff doubled, the situation resembling that of a start-up company evolving from the pioneer phase into a new organization. AMI staff worked intensively on the development and implementation of a strategic plan and on the positioning of the Institute within the international scientific and industrial community.**

### Relocation to Marly

In January the researchers of AMI moved into 1700 $m^2$ of laboratory and office space at the new temporary location in Marly. Together with the acquisition of state-of-the-art equipment, a first class research environment for synthesis, characterization and fabrication of nanomaterials was created.

### Foundation of the Nanotechnology Cluster

The Nanotechnology Cluster was founded at the beginning of the year as part of the Fribourg Science and Technology Centre. AMI took the lead in developing this networking initiative whose aim is to facilitate industry access to profitable and responsible nanotechnology applications.

### Appointment of Prof. Christoph Weder

Prof. Weder, formerly a professor in the Department of Polymer Science of Case Western Reserve University in Cleveland (USA), was appointed as the second chair of AMI and started his activities in the spring. His new research group has quickly grown to a team of 10 and includes 3 researchers who have followed him to Fribourg from the United States.

### Visitors from industry and politics

A close collaboration with the Fribourg development agency initiated contacts with many companies interested in the expertise and competences present at AMI. In addition to many individual visits, the Assembly of the European Regions (AER), a delegation from the Russian Republic of Mordovia, as well as a Chinese delegation of 24 directors of universities of applied sciences of the Shanghai region visited AMI to learn more about its research and training programs.
In August, the Institute presented its activities to a delegation from the Federal Office for Professional Education and Technology (OPET). This provided an opportunity to discuss various models for technology transfer and stimulation of innovation.

### NanotechDay Fribourg 2009

AMI was one of the founding partners for the first NanotechDay Fribourg, which took place on October 1st. This conference brought together experts from different fields to talk about the challenges associated with novel nanotechnologies in practice. NanotechDay was organized in collaboration with the Nanotechnology Network and with the School of Business Administration and the College of Engineering and Architecture Fribourg. The event was arranged for the general public and was considered a great success, with 175 participants spanning a diverse range of backgrounds and interests.

Prof. P. Schurtenberger explains the importance of scattering methods to a group of visitors from the OPET.

Prof. C. Weder shows examples of functional polymers and their use.


Promotion of the Nanotechday

Impressions from the Nanotechday

**Organizational structure**

In addition to the scientific staff, which constitutes over 90% of the personnel, a small but effective administration was built to ensure the smooth and efficient operation of the Institute. The human resources section plays a major role in an Institute with scientists from 15 different nations and an average employment period of 1 to 3 years. In addition to technology transfer support for industrial co-operations, marketing, grant proposals writing assistance, finance and controlling are other essential services provided by the Institute as it aims to gather 60 – 70 % of its funding through external projects.

**Distinguished awards for one of our junior researchers**

Dr. Ilja Voets, a Dutch Marie Curie scholar working at AMI, received two awards for her outstanding scientific work in 2009: the Houwink Polymer Prize and the DSM Science & Technology Award.

**Scientific exchange**

Renowned scientists are invited on a regular basis to visit AMI and present their work in AMI seminar series. Especially the junior researchers of the Institute are motivated to propose speakers they are interested in and would like to meet. These external experts represent an important contribution to the vibrant and stimulating scientific atmosphere at AMI, providing a platform for in-depth discussions with excellent scientists, while at the same time strengthening old and generating new national and international collaborations.

**New Institute building project**

In order to relocate the Institute to the campus of the University of Fribourg an unused building of a former clinic was bought by the canton of Fribourg. The project competition for the architectural and engineering phase of the reconstruction of the building was successfully completed in 2009. A feasibility study is now underway to look into the practicalities of converting the building into a lab and office space to host up to 160 AMI staff in the near future. Work on the entire project is scheduled for completion by 2012.

Picture of the former Clinic Garcia that will be reconstructed into the new building for AMI

# Research Programs

## AN INTERDISCIPLINARY CENTER OF COMPETENCE IN SOFT NANO- AND MATERIALS SCIENCE

**Soft materials are everywhere – just look around! Examples include liquids, colloids, gels, polymers, foams, and granular matter. These materials share the common characteristic of being easily deformable. Soft materials are the basis for many technological applications where they appear as plastics, rubbers, paints and adhesives, textiles, personal care products, cosmetics, foods, and in many other forms.**

Soft materials are also the very essence of life. Most biological materials – from virtually all parts of plants to blood and animal tissue to milk and honey – are soft. Nature's materials are usually characterized by an intriguing design complexity and feature hierarchical architectures, whose smallest features are often at the nanoscale and impart the material with unique functionalities. All bio-nanostructures – from DNA to lipid bilayers to the extracellular matrix to complex hierarchical structures, such as tendon or gecko setae – have in common that they are formed by self-assembly processes. Molecular recognition effects between mutually complementary chemical motifs play a key role in these so-called bottom-up 'fabrication' schemes. Nature uses a range of different non-covalent interactions to control the interplay among biopolymers and small molecules in highly specific and very efficient ways. Over time, a plethora of supramolecular motifs have evolved, which can exert precise structural control over matter, ranging from the conformation of individual molecules to the formation of complex hierarchical objects.

### Nanomaterials through self-assembly: let Nature do the work

The idea of mimicking Nature's approach to create artificial nanomaterials through self-assembly of small molecules, macromolecules or nanoparticles sounds simple and almost naïve: mix the components, and let the forces of Nature assemble them into the desired architecture. However, this general framework has been proven to be viable for the fabrication of two- and three-dimensional artificial nanostructures. Examples range from the formation of molecular structures, such as micellar nanocarriers and monolayers, to higher-order architectures built from nanoparticles, nanotubes or nanofibers. The general approach has become an attractive pathway to a rapidly increasing number of meso- and macroscopic materials and devices ranging from artificial opals to self-assembled electronic circuits.

### From fundamental studies to advanced functional materials

At AMI, scientists are combining bio-inspired self-assembly schemes with standard chemical processes for the production of functional nanomaterials with well-defined properties. This approach represents an attractive and generally inexpensive route to nanostructured materials. Our research ranges from the synthesis and in-depth characterization of nanoparticles to fundamental studies that aim to develop a predictive understanding for the interplay between nano-objects and their environment to the fabrication of nanocomposites and nanostructured materials. Complex architectures are created by directed self-assembly that incorporates features of bottom-up and top-down fabrication approaches, for example template-assisted assembly processes or the use of external fields as a means to orient magnetic or charged nanoparticles. The knowledge generated in fundamental studies is applied to work on practical problems of high societal relevance. For example, AMI researchers study the origin of cataract formation, create self-healing polymers, and develop mechanically adaptive materials for biomedical applications.

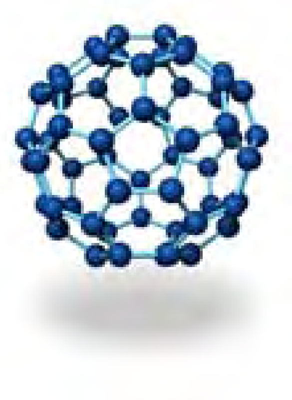
### Interdisciplinarity is key

During the past decade, nanoscience has established itself as a new field that transcends the interface of the traditional disciplines of physical and materials chemistry, physics, biology, and medicine. To conduct cutting-edge research, interdisciplinary collaboration is not a luxury, but a must. Thus, AMI's researchers have come together from a broad range of science and engineering disciplines to learn to speak a common language. They already share the same goal: to make AMI leader in the area of fundamental and applied soft nanoscience and materials science.

**Nanoscale** Between approximately 1 and 100 nanometers

The size ratio between a 1 nm big particle and a tennisball is the same as the ratio between an tennisball and the earth

**1 nm =** $10^{-9}$ m — X 100 Mio. → $10^{-1}$ m — X 100 Mio. → $10^{7}$ m



**Nanoscience** The understanding and control of matter at dimensions at the nanoscale, where unique phenomena enable novel applications

**Nanotechnology** The application of scientific and engineering principles to make and utilize nano-scale things

## SOFT-NANOSCIENCE GROUP

**The focus of the research being pursued by Prof. Peter Schurtenberger's Group is on the interaction of nanoparticles and their ability to form either highly ordered or amorphous structures, topics that are of fundamental importance for novel applications in fields such as photonics or composite materials. The Group's soft nanotechnology approach involving the creation of nanostructured materials through self-assembly processes is strongly inspired by Nature**

Soft condensed matter represents a rapidly expanding field of research in which the primary focus is on three different but complementary fields: colloids, polymers and surfactants (Figure 1). Soft condensed matter science is not only an attractive field in modern basic research but is also of considerable technological importance to materials science and nanotechnology. AMI thus focuses on fundamental and applied soft matter research with the aim of understanding the formation processes, structure, and functional properties of the nanostructured systems that play an important role in various sectors, such as materials and food science.

### Performing fundamental condensed matter physics research with nanoparticles

In addition to their relevance in many other fields, such as that of materials science, colloidal suspensions are also used as tunable model systems for atomic and molecular systems. They provide new insights into phase behavior and transitions because they facilitate experimental observations at quasi-atomic length and time scales (Figure 2). They also allow for a variation of the form, strength and range of the interaction potential almost at will, in contrast to the situation encountered when working with atomic or molecular systems.

### Exploring analogies to food science and biology

Food science and technology has started to profit from parallel developments made in soft condensed matter science, materials science and nanotechnology. However, most food research is still carried on in traditionally oriented research institutes and the enormous progress made in these other areas of science has not been utilized sufficiently. We have thus started a research program at AMI where we combine our competencies in soft matter physics and chemistry, materials science and using our advanced suite of instruments. These techniques are applied to key areas in food science, such as developing new routes to gelation, investigating and optimizing emulsion stability, and studying the properties of food colloids (Figure 3). We also develop analogies between nanoparticle suspensions and complex protein solutions; these are relevant to the understanding of protein condensation diseases, such as cataracts, a leading cause of blindness worldwide.

### Making and exploring novel materials

In combination with polymers, hybrid nanocomposites have been developed to combine the advantages of both classes of materials and widen their application range. The key to success in many areas of bottom-up based nanotechnology is the growing variety of functional nanoparticles with well-defined properties that chemists are able to produce (Figures 4 and 5). At AMI we design functionalized nanoparticles that can be used to create adaptive polymer-colloid nanomaterials with tailored optical, magnetic and mechanical properties.

Contact: Prof. Peter Schurtenberger

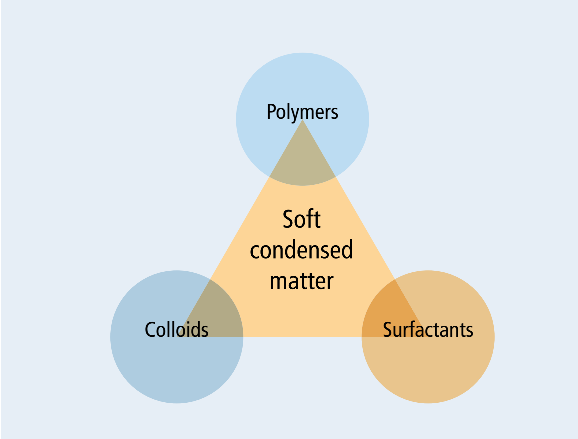



Figure 1: The magic triangle of soft matter research

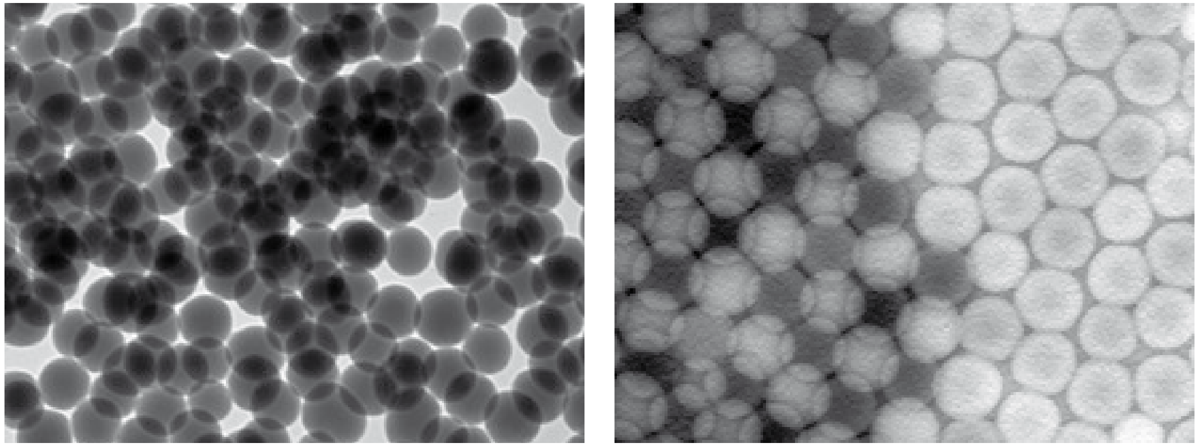


Figure 2: Electronic micrograph pictures of spherical nanoparticles in different states. left: non-equilibrium solid state, right: equilibrium crystal state.

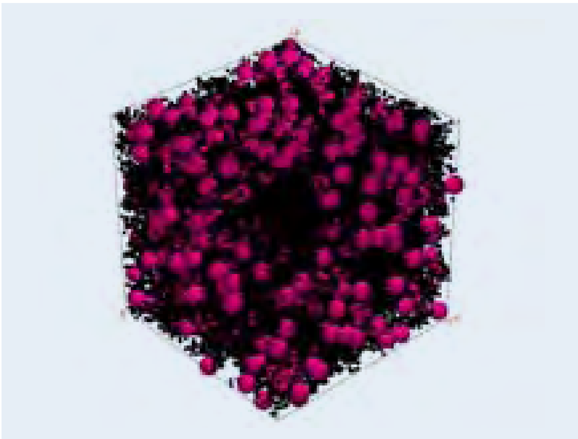


Figure 3: Snapshot of a computer simulation of a mixture of eye lens proteins used to investigate possible models for cataract formation

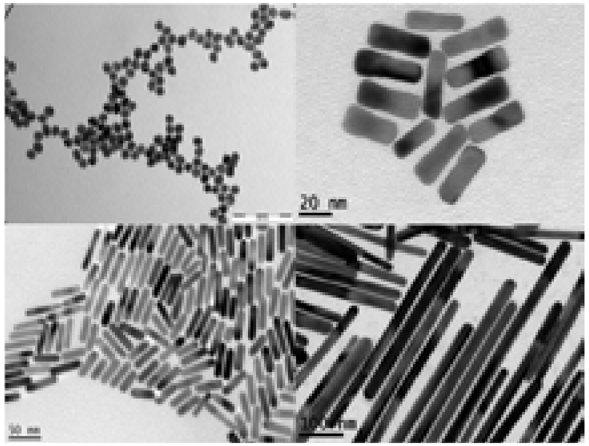



Figure 4: Electron micrograph pictures of gold nanoparticles with different shapes produced in the synthesis facility of AMI.

Figure 5: Aqueous dispersions of gold nanoparticles with different shape, colour is dependent on the shape.

## Understanding cataract formation and other protein condensation diseases

### Cataracts – a leading cause of blindness worldwide

A quantitative understanding of a cellular system starts with collecting information about molecular interactions. In the current project we are trying to implement this procedure for the eye lens. The eye lens is normally a transparent structure consisting of elongated eye lens fiber cells containing highly concentrated aqueous mixtures of crystallins, the characteristic lens proteins. Cataracts – the loss of lens transparency due to increased light scattering – are a leading cause of blindness worldwide. Cataracts are caused by various processes, the most important of which being phase separation and condensation of lens proteins into aggregates. Currently a cataracteous lens has to be surgically replaced with an artificial lens. While cataract extraction is extremely successful in restoring a clear image from a given distance, the implanted artificial lens does not have the flexible refractive power of the natural lens. Significant advances should result from gaining an understanding of the protein condensation mechanism in the lens, a prerequisite for developing an approach to prevent cataract formation. The so-called ‹cold cataract› is a possible scenario for the formation of cataract: cooling the eye lens solution below body temperature leads to an arrangement of the different crystallins in groups which give rise to an opacification of the eye lens. In the course of life the critical temperature where this happens can increase and result in a turbid, cataracteous lens already at body temperature (see Figure 1)

### The colloid approach to protein mixtures

At AMI we use a combination of experimental methods, such as scattering, rheology and phase behavior studies, and computer modelling of molecular interactions to investigate complex lens protein mixtures. We apply concepts from soft matter physics that provide new insight into the stability of eye lens protein mixtures. Exploring a colloid-protein analogy we have already been able to demonstrate that weak attractions between dissimilar proteins help to maintain lens transparency in an extremely sensitive and nonmonotonic manner. These results not only represent an important step toward a better understanding of protein condensation diseases but also provide general guidelines for tuning the stability of colloid mixtures, a topic relevant for academic soft matter physics and industrial applications.

### Targeting protein condensation diseases

In the long term we hope to be able to generalize the link between phase separation, aggregation and cataract formation. This will further our understanding of a broad class of protein condensation diseases, such as cataracts, sickle-cell disease, and Alzheimer’s as well as numerous other neurodegenerative diseases in which protein phase separation and condensation play a central role.

In collaboration with Prof. G. Foffi, EPFL, Switzerland, and Prof. G. Thurston, Rochester Institute of Technology, USA

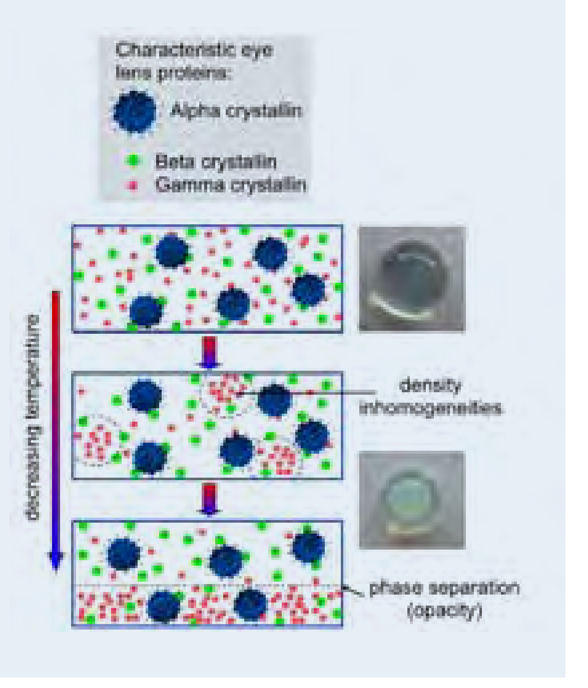



Figure 1: Healthy and cataracteous eye lens and a schematic representation of processes on the nanoscale that lead to the turbidity in the so-called “cold cataract”.

Contact: PD Dr. Anna Stradner

## Soft nanotechnology approach to food

### New routes to food gels

Finding new ways to make food gels with a minimum of extreme energy-consuming processes is one of the main challenges for AMI's food physicists. Although we have been able to make products such as cheese and yoghurt for centuries, our understanding of the microscopic structure of such products only dates from the last decades. Where earlier milk inspired colloid scientists to develop synthetic model systems, it is now the model systems that open up new ways to create innovative products. The AMI research group is interested in improving its fundamental understanding via synthetic model mixtures and wants to apply those new insights to real, simplified products.

### The soft matter physics approach to food

Food is a complex mixture of soluble and insoluble, large and small, interacting and noninteracting ingredients. If you take away the small solutes, like salt and sugar, what are left are macromolecules of 1 to 100s nm, such as proteins and polysaccharides, and dispersed structures like micelles and emulsion droplets. Even without any specific repulsions or attractions between emulsion droplets or proteins – which are like hard spheres –, and polysaccharides – the food polymers –, mixtures of these can lead to unwanted instability (see examples in Figure 1). The polymers induce an attraction between the spheres that can cause aggregation and subsequent macroscopic phase separation. Interestingly, the same underlying principle also offers a way to create solid, chewable products with low amounts of protein, fat, and sugar.

### Learning from fundamental research

The simplest form in which to study this phenomenon is in a mixture of spheres and polymers. In an SNF funded project attention is being focused on the small solutes as they influence additional repulsions between the spheres due to their surface charges. AMI's Particle and Material Synthesis Facility is playing a vital role in developing well-defined ingredients, which can be described theoretically.

Figure 2: AMI researcher investigating food gels at the confocal microscope.

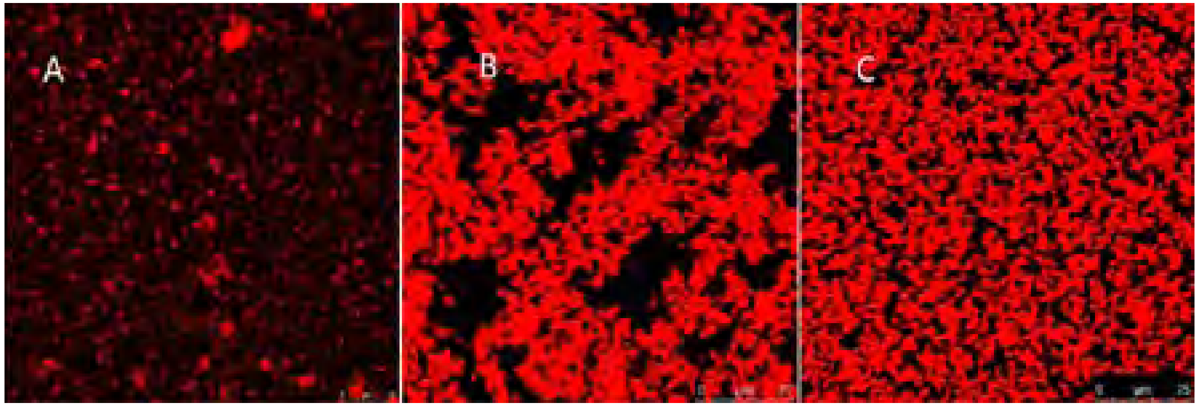



Figure 1: Examples of different phenomena seen with food colloid-polymer mixtures visualized with a confocal laser scanning microscope. Left: Stable fluid with colloid clusters; Middle: suspension undergoing phase separation; Right: arrested colloidal gel.

Contact: Kitty van Gruijthuijsen

## Hybrid nanoparticles and nanocomposites

### Hybrid materials – combining the best of two worlds

Nanostructured organic-inorganic hybrid systems represent an exciting class of materials. The combination of nanoscale inorganic moieties with organic polymers allows us to combine the properties of nanoparticles and polymers and to create materials with enhanced or even completely new properties. At AMI we thus design and synthesize functionalized nanoparticles that can be used to make adaptive polymer-colloid nanomaterials with tailored optical, magnetic and mechanical properties.

### Controlling and optimizing the dispersion of nanoparticles

Polymers reinforced with nanoparticles have the potential to show vastly improved properties. However, experimental evidence suggests that simple extrapolation of the design paradigms of conventional macro-scale composites cannot be used to predict the behavior of nanocomposites. One major hurdle arises from the difficulty in controlling the mixing between the two dissimilar phases, further compounded by the lack of data on structure-property relationships at a nanoscale level. We have thus started a systematic study in which we combine synthetic activities with an application of state-of-the-art characterization methods in order to understand and improve the formation mechanism of polymer-colloid nanocomposites. Part of this research activity is conducted within the European "Nanomodel" collaborative research project, where AMI scientists coordinate a significant part of the experimental program. This collaboration has allowed researchers at AMI to successfully functionalize and integrate not only spherical silica nanoparticles but also anisotropic magnetic particles in classical polymeric matrices such as PMMA (also known as Plexiglas®) (Figure 1).

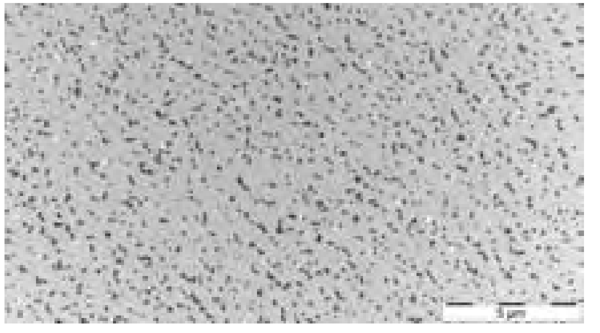


Figure 1: Transmission electron micrograph from an 80nm thick nanocomposite slice of 2 dimensionally oriented spindle hematite particles (7wt%) within a PMMA matrix obtained via in-situ polymerization.

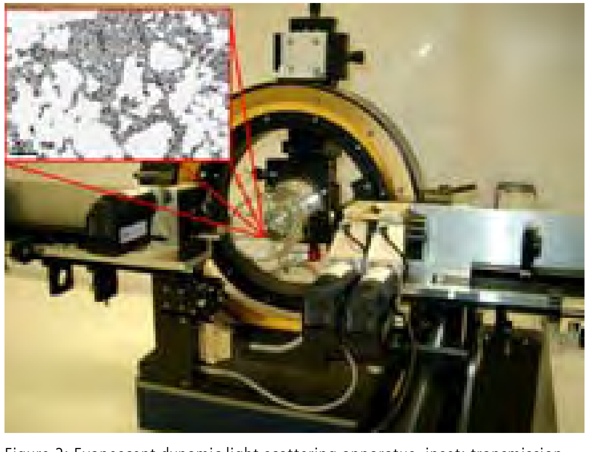


Figure 2: Evanescent dynamic light scattering apparatus, inset: transmission electron microscope image of gold nanorods.

### Hybrid nanoparticles probe interfacial properties

Although particles at interfaces have attracted considerable attention, there is still a lack of detailed Knowledge about the behavior of nanoparticles in close proximity to the interfaces. AMI researchers have thus synthesized hybrid gold nanorods with a stabilizing polymer surface layer (see inset Figure 2). Using unique experimental infrastructure, the dynamics of particles in the vicinity of a liquid-liquid interface using evanescent dynamic light scattering can be probed (Figure 2). Currently, the diffusion of these nanorods at the water-oil interface are investigated.

Collaboration within FP7 collaborative project "Nanomodel" and Network of Excellence "SoftComp" (gold nanorods).

Contact: Dr. Hervé Dietsch and Dr. Reinhard Sigel

## Understanding crystallization and glass formation

Structure formation in colloidal suspensions is of enormous importance in modern materials science. Areas such as dynamical arrest or jamming in suspensions of repulsive or attractive colloids and the formation of ordered versus amorphous photonic materials attract considerable attention. At AMI, researchers focus on the use of responsive colloids to trigger crystallization or glass formation. They investigate both fundamental properties of these phase transitions as well as their use to create materials with tunable optical and mechanical properties.

### Temperature-responsive particles as ideal model systems

Microgels are cross-linked polymer particles with diameters typically in the range 0.1 to several µm immersed in a solvent. As the solvency of the polymer depends on external parameters such as temperature or salt concentration, varying these external parameters can reversibly change the size of microgels. Due to this responsiveness, microgels are interesting model systems for studying the phase behavior of hard and soft particles and to elucidate the nature of phase transitions. At AMI we use for example poly-(N-isopropylacrylamide) (PNIPAM) microgel particles that shrink when the temperature is increased above a critical value close to 32°C. This size change can be used to change the effective volume fraction of the suspension and to reversibly induce a transition from the fluid to a crystal or to the glassy state (Figure 1).


Figure 1: (A) Cross-linked microgel colloids undergo a reversible volume change in response to temperature, pH, or salt concentration. (B) Different thermodynamic states such as liquid, crystal, and glass can be obtained at a fixed number density by changing the particle by varying e.g. the temperature.

### Monitoring nucleation and crystallization

AMI researchers use for example microgel suspensions to follow crystal nucleation with diffraction and imaging experiments. Using time-resolved light-scattering the crystal structure and the kinetics of crystal formation and growth can be determined. The growth of crystal precursors that are too small to give a detectable signal in scattering experiments can be followed by time-resolved real space imaging using a confocal laser scanning microscope. As shown in Fig. 2, individual particles tagged with a fluorescent dye can be detected and followed during the course of the phase transition.

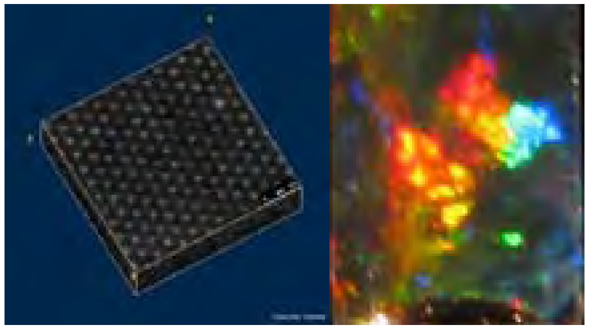


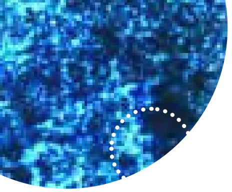
Figure 2: Left: 3D confocal microscopy image of a self-assembled colloidal crystal. Right: Colors (Bragg reflections) that can be seen by naked eye, when a poly-crystalline suspension of such crystals is illuminated with white light.

### A closer look at the glass transition

A glass transition from the fluid to a jammed, disordered solid state is observed in many molecular and soft matter systems. However, the exact nature of the glass transition is still not well understood. With thermo-sensitive microgel particles the glass transition can be reached from a truly disordered fluid state simply by reducing temperature. Confocal microscopy allows AMI researchers to track individual particles in 3D (Fig. 3) and to directly follow local rearrangements involving clusters of particles that are known to occur close to the transition and in the glassy state.

Figure 3: Confocal microscopy image of fluorescently labeled PS-PNIPAM particles at high concentration.

Contact: Dr. Urs Gasser and Mathias Reufer



## FUNCTIONAL POLYMER NANOMATERIALS

**Motivated by the desire to create novel materials, which exhibit currently unavailable properties and enable new applications, the primary research focus of Prof. Christoph Weder's research team is the design, synthesis, and investigation of structure-property relationships of novel functional polymers.**

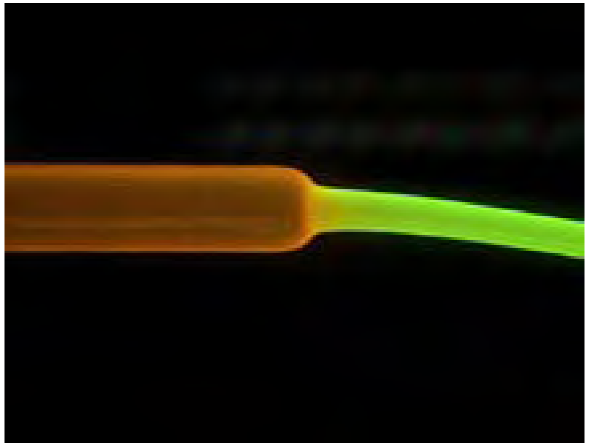
Examples of such materials include self-healing polymers, materials with adaptive mechanical properties, and plastics with built-in structural health monitors

Functional polymers, as a broad class, are attracting significant interest in academia and industry because these materials combine the advantages of polymers – low cost, ease of processing, good mechanical characteristics – with the variety of readily-tailored functions that can be generated by carefully-designed organic molecules. In particular, the ability to design the chemical structure of polymer molecules virtually at will, and also the possibility to exert control over their supramolecular architecture allows one to manipulate the properties of this broad class of materials over a wide range

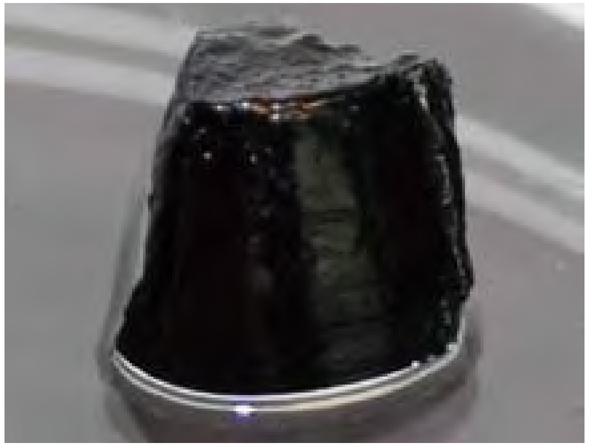
**AMI researchers develop design principles for advanced nanomaterials with unusual but desirable optical, electronic, and mechanical properties.**

### From fundamental studies to advanced functional materials

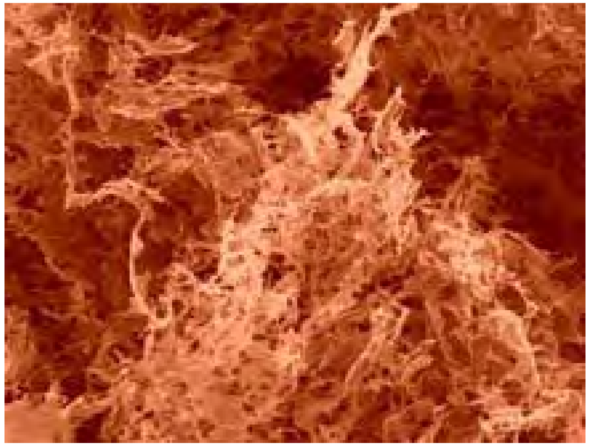
For the efficient development of new polymers, it is of fundamental importance to develop a predictive understanding for the relation between molecular structure, supramolecular architecture, and the macroscopic property of interest. AMI's interests and activities in this area are therefore highly interdisciplinary and range from the synthesis of new monomers and polymers to advanced polymer processing, to the in-depth investigation and (in some cases) technological exploitation of materials with unusual, but desirable optical, electronic, and/or mechanical properties.



Picture of a stimuli-responsive polymer, which changes its fluorescence color upon deformation.



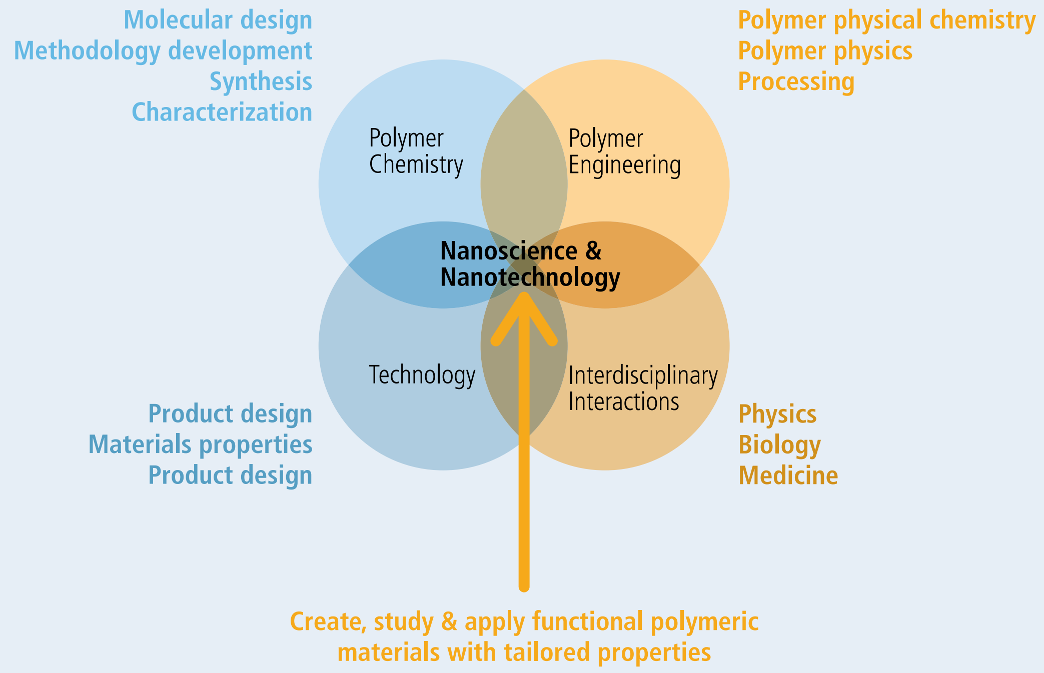
Picture of an electrically conductive polymer gel.



Electron microscopy image of a cellulose nanowisker based aerogel.

**At the interface between Chemistry, Polymer Engineering, and other Disciplines**

Architectural control at the nanometer length scale is an important design tool for many projects in this area. The use of non-covalent interactions has emerged as another important aspect. AMI researchers employ supramolecular assembly processes as polymerization tools and also exploit specific intermolecular interactions for the formation of targeted supramolecular architectures. AMI's research activities on functional polymer nanomaterials are at the interface between polymer chemistry and polymer engineering and often rely on collaborations with local, national, and international partners whose expertise ranges from solid-state physics to biomedical engineering and medicine.




Contact: Prof. Christoph Weder

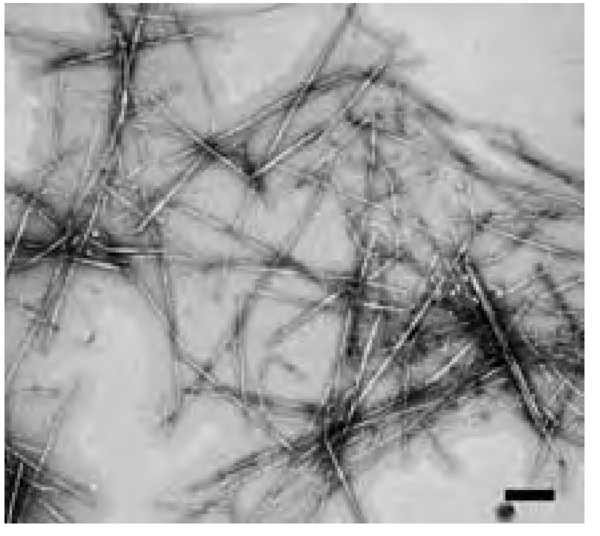
## Bionanocomposites – Attractive materials from renewable sources

Another illustrative experimental research program in AMI's polymer department targets the design, synthesis, processing, investigation and application of a new family of bio-inspired polymer nanocomposites with stimulus-responsive mechanical properties. AMI researchers recently introduced the first examples of such adaptive materials, in which a chemical stimulus causes a significant and reversible stiffness change.

**Cellulose nanofibers are used as a cost-effective, green alternative to carbon nanotubes for the mechanical reinforcement of polymers: optical, electronic, and mechanical properties.**

### Abundant in nature, but difficult to mix with polymers

Highly crystalline cellulose nanofibers – commonly referred to as «whiskers»- can be isolated from a variety of renewable sources including wood, cotton, straw, bacteria, and many other sources. AMI researchers have already investigated a diverse list of nanocomposites comprising cellulose whiskers from a range of different sources as well as a range of polymeric matrices and demonstrated that these nanomaterials have desirable properties. In particular, it was shown that the stiffness of many commonly used polymers – from epoxy resins to butyl rubber to polyacrylates – can be increased by orders of magnitude by introducing as little as a few percent of the cellulose nanofiller. But creating polymer-whisker mixtures, in which the cellulose nanofibers are well dispersed, was originally not easy. The polar nanofibers have very 'sticky' surfaces and tend to aggregate, rather than disperse well, if mixed with a polymer. However, AMI researchers have developed a powerful toolbox, which allows – at least at the laboratory scale – the fabrication of percolating cellulose nanofiber/polymer composites of virtually any composition.



Transmission electron micrograph of cellulose nanofibers isolated from tunicates. Scalebar = 500 nm.

### Towards commercial exploitation

Having laid the scientific foundation for the fabrication of new bionanocomposites, and developed already a good predictive understanding for the structure-property relatitionship of these materials, AMI is uniquely positioned to move the platform technology towards commercial applications. Several research projects have been launched, which seek to develop and/or refine processes for the isolation of cellulose nanofibers from agricultural waste and the development of polymer nanocomposites comprising these nanofillers that target specific applications.

Cotton is a natural source for cellulose nano-whiskers

Contact: Prof. Christoph Weder

## Biomimetic, mechanically adaptive nanocomposites

**AMI researchers are developing "intelligent" polymers that change their mechanical properties "on demand". These materials morph upon exposure to a pre-defined stimulus in a highly selective and reversible manner and are attractive for many technologically relevant applications.**

Recently, AMI researchers introduced the first examples of a new family of bio-inspired polymer nanocomposites with stimulus-responsive mechanical properties. The material's design mimics the structural concepts at play in the dermis of sea cucumbers. Like other echinoderms, these creatures have the fascinating ability to rapidly and reversibly alter the stiffness of their skin when threatened. This dynamic mechanical behaviour is achieved through a nano-composite architecture, in which rigid, high-aspect-ratio collagen fibrils reinforce a visco-elastic matrix. The stiffness of the tissue is regulated by controlling the molecular interactions, and therewith the stress transfer, among adjacent collagen fibrils by locally secreted proteins. AMI researchers prepared and studied the first chemo-responsive materials that mimic this architecture and whose morphing mechanical characteristics are very similar to those of the biological model. It was demonstrated that nanocomposites based on selected host polymers and a percolating network of rigid cellulose nanofibers can exhibit a reversible, 40-fold modulus reduction upon exposure to a chemical regulator that switches off the hydrogen bonds among the nanofibers. Larger contrasts are possible by amplifying this effect with a chemically triggered phase transition.

One specific target that AMI researchers have pursued for several years is the use of chemically responsive materials in biomedical applications, specifically as mechanically adaptive substrates for intracortical microelectrodes. For this interdisciplinary project, AMI researchers collaborate with partners at Case Western Reserve University and the Veteran's Affairs Hospital, both in Cleveland USA. The targeted devices are electrodes that record brain unit activity or provide electrical stimulation. These implants offer promising solutions to medical conditions, such as Parkinson's disease, stroke, and spinal-chord injuries. One problem of current experimental microelectrodes is that their signal quality usually degrades within months, presumably because micro-motion of the rigid electrodes within the soft cortical tissue chronically inflicts trauma on the neurons. Initial studies in the rat cortex afforded encouraging data regarding the biocompatibility of the new materials and the validity of the hypothesis that mechanically adaptive materials are uniquely suited to solve the compatibility problem.

Pictures of a sea cucumber in soft and stiff state.

With funding from the Swiss National Science Foundation under the NFP 62 program and industrial support, AMI researchers have begun to broadly exploit the new design approach to mechanically adaptive materials. They are in the process of creating a range of "smart" materials that respond to different stimuli in pre-programmed ways and promise to enable a plethora of technologically relevant applications. Electroactive molecules, which can be reversibly oxidized or reduced by electrochemical means, represent another example of targeted switches. Nanofibers decorated with these moieties may become the basis for a radically new class of electro-responsive nanocomposites, which are useful in artificial muscle systems, active vibration dampening systems, adaptive protective clothing, and many other electromechanical applications.

Pictures of a mechanic dynamical implant in the soft and stiff state

Contact: Dr. Johan Foster

## Optical up-conversion in polymeric systems

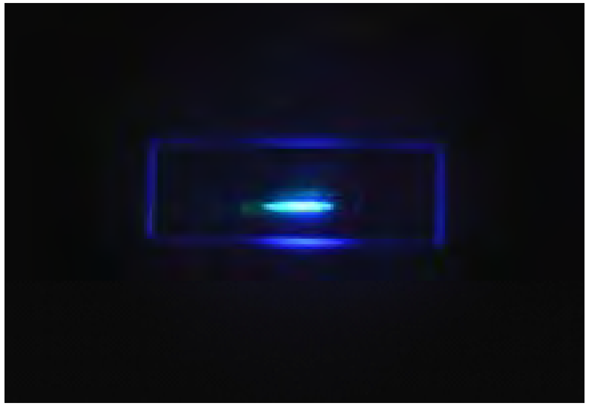
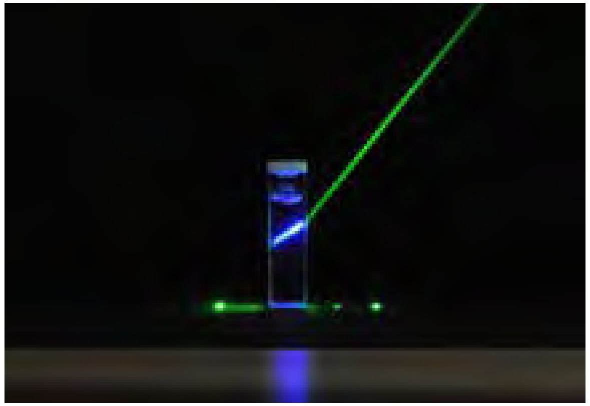
**The possibility to create materials capable of harnessing and manipulating light has major implications for a variety of technology domains ranging from solar energy harvesting to optical data storage to biomedical applications. AMI researchers are specifically interested in the development of innovative polymeric materials which up-convert optical waves, or in other words, decrease the wavelength and increase the energy of incident light. Of course, these materials cannot produce energy out of nothing. Rather, they combine several photons of lower energy to generate new light quanta, which are indeed higher in energy, but fewer in numerical terms.**

### Realizing a well-known effect in polymers

The new materials rely on a complex cascade of photophysical events between two carefully matched chromophores. The effect, commonly referred to as sensitized triplet-triplet annihilation (TTA), was introduced by physical chemists over 40 years ago and offers a variety of advantages over other up-converting methods, in particular that it is efficient even at low powers and allows for the use of non-coherent light irradiation. Despite drawing significant attention in recent years, TTA-based upconversion has until recently been limited to solutions of upconverting dye mixtures. Most recently AMI researchers, in collaboration with scientists at Bowling Green State University (USA), reported low power photon upconversion in solid polymer matrices.

### Synergies trough interdisciplinary collaboration

Unlike the previously known dye solutions, the new polymeric upconverters can be processed into mechanically coherent objects which have technologically useful shapes and in which the dye molecules are contained. Coatings and micro/nano particles are two relevant examples. The breakthrough was enabled by the collaboration of two research teams with complementary expertise. While the specific dye cocktail was developed by the Bowling Green group, the AMI researchers contributed their expertise on integrating functional molecules into polymer host systems. Initial proof-of-concept experiments progressed into systematic investigations on the mechanistic aspects of the upconversion process and how the optical properties of the new materials depend on specific materials and environment parameters. The knowledge generated and experience gained in these studies puts the AMI researchers in an outstanding position to design and explore the next generation of upconverting materials tailored for specific applications, including photovoltaics, bioimaging and drug release. The integrative approach will continue to combine aspects of both fundamental research and technological exploration.

Optical up-conversion material absorbing green light and emitting blue. Left: functional polymer film, Right: solution.

Contact: Dr. Yoan Simon

## Dynamic photonic crystals

**The combination of nanostructured materials with nonlinear optical chromophores results in novel devices that are extremely useful to manipulate the propagation of light.**

The control over the propagation of light in optical media is of great technological interest, especially for telecommunication devices and in integrated optics. Since the late 1980s, so-called photonic crystals (PCs) with this specific ability have attracted significant interest. PCs are periodically ordered, nanostructured optical materials with lattice dimensions that are of similar magnitude as the wavelength of light. Such architectures have enabled the fabrication of materials that display complete photonic band gaps, i.e., frequency regimes in which light cannot propagate. These materials are useful for many optical elements, including waveguides, interconnects, switches, filters, lasers and others.

### Modulating the properties of photonic crystals

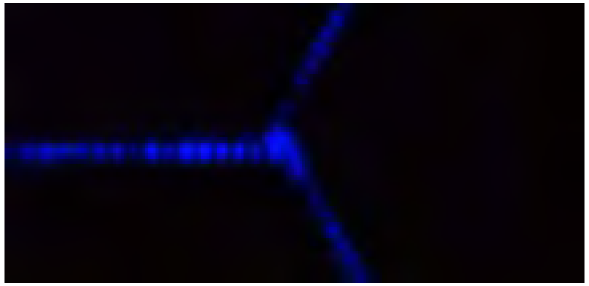
A plethora of fabrication methods has been developed to create suitable PC nanostructures, including the lithographic fabrication of porous silicon, extrusion of multilayer polymer films, and self-assembly of colloidal crystals. However, once fabricated, the optical properties of a PC are fixed because the geometry and the optical properties of the materials can no longer be changed. AMI researchers, together with scientists from the Max Planck Institute of Microstructure Physics (Halle, Germany), the University of Halle (Germany), the Karlsruhe Institute of Technology (Germany), and Case Western Reserve University (Cleveland, USA) attempt to overcome this limitation by the incorporation of nonlinear optical (NLO) organic chromophores into PCs. The team uses macroporous silicon PCs, which are a specialty of the German collaborators. The dyes synthesized by the AMI team exhibit a dramatic change of their index of refraction upon illumination by laser light. This then changes the bandgap of the PC in which they are comprised. The dynamic PCs thus created may pave the way to a new generation of ultra-fast optical switches and wave guides based on the local infiltration of structures with organic materials of fine-tuned optical properties.

### Square meters of nanostructures

In a related collaboration with the Center for Layered Polymeric Systems at Case Western Reserve University, AMI researchers have used multilayer polymer coextrusion to fabricate large-area polymeric PC films with another intriguing functionality. Laser dyes were incorporated into these materials to create the first optically-pumped all-polymer lasers that were produced by a large-scale roll-to-roll process. Each laser film consists of hundreds of alternating, nanometer-thin layers of two transparent polymers with different refractive indices, of which one contains a laser dye. The resulting lasers show efficiencies as high as 8 % and the emission color can be tailored via the choice of the dye and the thickness of the individual polymer layers.

### Writing tuneable NLO matrix materials

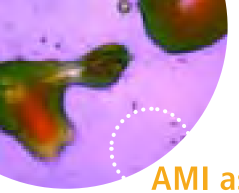
Expanding on these developments, the AMI team has entered into a collaboration with researchers from the University of Fribourg to fabricate PCs from reactive polymer resins by way of laser direct writing lithography. This novel technique allows the fabrication of complex architectures with well-defined structure and promises to be useful for the next generation of active photonic crystals.



Optical waveguide comprised of 2D macroporous silicon infiltrated with an NLO dye.

Roll-to-roll manufactering of a multilayer Laser film.

Contact: Markus Geuss



# AMI as partner

## STIMULATE INNOVATION – FACILITATE ACCESS TO NANOTECHNOLOGY

**The valorisation of research results is one of the key missions of our institute. Besides the presentation of our findings to the scientific community, the AMI develops different other means to create value by reaching out to the industry and the general public.**

AMI ensures that its innovative developments and ideas are quickly passed on to industrial firms for practical implementation through an efficient knowledge and technology transfer process. Since the beginning of 2009, an internal Technology Transfer Office has been providing all necessary support to researchers on all aspects of intellectual property rights, analysis and drafting of contractual agreements and exploitation of scientific and technical research results.

### Industry partnerships

The most common method of transferring knowledge and technology is through cooperation with partners on specific research topics. In 2009, various research projects, ranging from classical CTI projects through industry financed feasibility studies to long-term strategic alliances, were conducted at AMI. Strategic long-term collaborations with companies are taking place bilaterally or in research consortia, e.g. EU programs. Here, AMI helps to build the foundation for next generation products based on nanotechnology. AMI also gives significant support to small and medium enterprises (SMEs) with the aim of facilitating industry access to the profitable and responsible use of nanotechnology.

Personal networking at conferences is another important method of establishing contacts. In many cases this led to discussions about possible joint research projects; in 3 cases cooperation agreements could be signed with new industry partners in the past year. Further, four new research agreements were signed with established industry partners, local SMEs and major multinational companies.

Another longer term approach to knowledge and technology transfer is the training and education of people who can then use their skills when working for a company. Researchers can either work on a sponsored PhD thesis at AMI or AMI supervises candidates who write their PhD theses while working in industry.

### Collaboration models 2009

- **Research projects: Industry financed research in fields that are of mutual interest**
- **Joint research teams: Mixed team of researchers from AMI and Industry, which work in a common field**
- **Projects for economic promotion: Publically funded research projects with the aim to help an industry partner to enhance existing or create new products (CTI, PST-FR)**
- **PhD Thesis: Supervision of industry researchers making their PhD inside their company**
- **«Walk-in-Lab»: Parented use of AMI infrastructure by collaborators from industry partners**
- **Service and application lab: Small mandates from industry, where specific competences of the AMI are needed**

**Collaboration models that are adapted to the needs of our partners**

AMI has started to implement a more integrated approach with greater flexibility in terms of collaboration models, an approach that suits the needs of SMEs. In the Application Lab, AMI helps partners to find answers to very specific questions. In this manner, industry partners can determine whether AMI's expertise is of value in solving their specific problems, thus opening up some interesting perspectives for future developments.

If a company would like to use specific infrastructure more frequently, e.g. for more thorough examination of an internal feasibility study, AMI offers to train the company's staff and provide access to its facilities through our Walk-in-Lab program.

The collaboration with Frewitt S.A. illustrates this approach. Frewitt is an SME located in Fribourg, involved in the development of powder-handling equipment and processes for the pharmaceutical industry. AMI placed its competences at the disposal of Frewitt for an internal project developing milling equipment to produce nanoparticles. The first analyses of new milling products were carried out by AMI staff in the Application Lab, followed by subsequent measurements being made by the staff of Frewitt in the Walk in Lab. Flexibility in collaboration permits companies to advance research along with their ability to invest in new technologies leaving them time to test concepts internally.

**Technology Transfer Office Fribourg**

AMI is playing a leading role in establishing a joint Technology Transfer Office in Fribourg, unifying the efforts of the Technical College of Fribourg (EIA-FR), the University of Fribourg and AMI in this direction. The Technology Transfer Office will be operational in mid 2010 and will then act as the unique point of contact for researchers and industry, covering all the technological fields present in Fribourg including life sciences, materials science, nanoscience and engineering.

Measurements in the Application Lab at the AMI.

Demonstration of the milling prototype at Frewitt.

## NETWORKING AND PUBLIC RELATIONS

**Useful links:**

- **Adolphe Merkle Institute:** www.am-institute.ch
- **Faculty of sciences of the University of Fribourg:** www.unifr.ch/science
- **Fribourg Center for Nanomaterials (FriMat):** www.frimat.ch
- **University of Applied Sciences Fribourg:** www.eia-fr.ch
- **Fribourg Development Agency:** www.promfr.ch
- **Nanotechnology Cluster:** www.nano-net.ch
- **Science and Technology Centre Fribourg:** www.pst-fr.ch
- **SoftComp:** www.eu-softcomp.net
- **NanoImpact Net:** www.nanoimpactnet.eu
- **NanotechDay Fribourg 2009:** www.nano-net.ch/presse/nanotechday2009

### Bridging the gap between science and application

AMI is devoted to basic and applied nanoscience and is positioned at the beginning of the value chain. Although AMI is very interested in transferring knowledge into products, the Institute does not focus on technological developments. To bridge the gap between research and applications, AMI relies on partnerships with R&D sections of companies or on the competences of universities of applied sciences (UAS). The Fribourg College of Engineering and Architecture already specializes in industrial chemistry and injection moulding, two subjects with high relevance to the research being pursued at AMI. AMI took the lead in the creation and development of a nanotechnology cluster of the Science and Technology Centre Fribourg, an initiative generated by the UAS and financed by the Canton of Fribourg and the SECO (State Secretarial for Economic Affairs). The cluster's main objective is to facilitate industry access to profitable, responsible nanotechnology applications. The main interest of the 8 members of the cluster lies in networking and exchange of experience. At the moment the center of technical competence is centered around AMI and Fribourg College of Engineering and Architecture.

### Establishing contacts

The foundation of AMI involved a major expression of political will in that support was given to the project and preferential conditions were established for the prosperity of the Institute. The Parliament of the Canton of Fribourg adopted a decision to co-finance the acquisition and refurbishment of a building to serve as the future home of the institute. Additionally, during 2009, a close link was forged with the Fribourg Development Agency with mutual benefits for both parties. The Agency helped AMI to increase its visibility among local and regional companies and to establish ties to important partners outside the scientific community. AMI also worked closely with the Agency on projects to enhance the attractiveness of the Canton of Fribourg for high-tech companies, e.g. through the establishment of the Technology Transfer Office Fribourg or hosting political delegations from the Association of European Regions (AER). During the last year AMI could also present its activities on a national level e.g. by hosting a delegation from the Federal Office for Professional Education and Technology (OPET) during the Office's annual excursion. As part of the Federal Department of Economic Affairs and as the supervisory body of the Commission for Innovation and Technology (CTI), the OPET plays an important role in the technology transfer politics of Switzerland and is an important partner for AMI.

### Positioning AMI in the scientific community

The explicit aim of AMI is to gain international recognition as a leading player in the nanotechnology field. To project the reputation of the professors to the Institute, AMI established and strengthened its ties to the international research community through partnerships with other universities and memberships in important networks. AMI plays a major role in SoftComp, a European Network of Excellence (NoE) aiming to establish a knowledge base for the intelligent design of functional and nanoscale soft-matter composites. AMI is also a member of Swiss Food Research (SFR), an association for the promotion of research and innovation in the food and food-related sectors – SFR is a network of Swiss academic institutions established to enhance the competitiveness of the Swiss food industry and its suppliers. As an expert stakeholder in NanoImpactNet, a network of European researchers studying the health and environmental impacts of nanomaterials, AMI also stays informed on significant findings regarding the potential risks of nanotechnology, an aspect which is also important to industry partners.

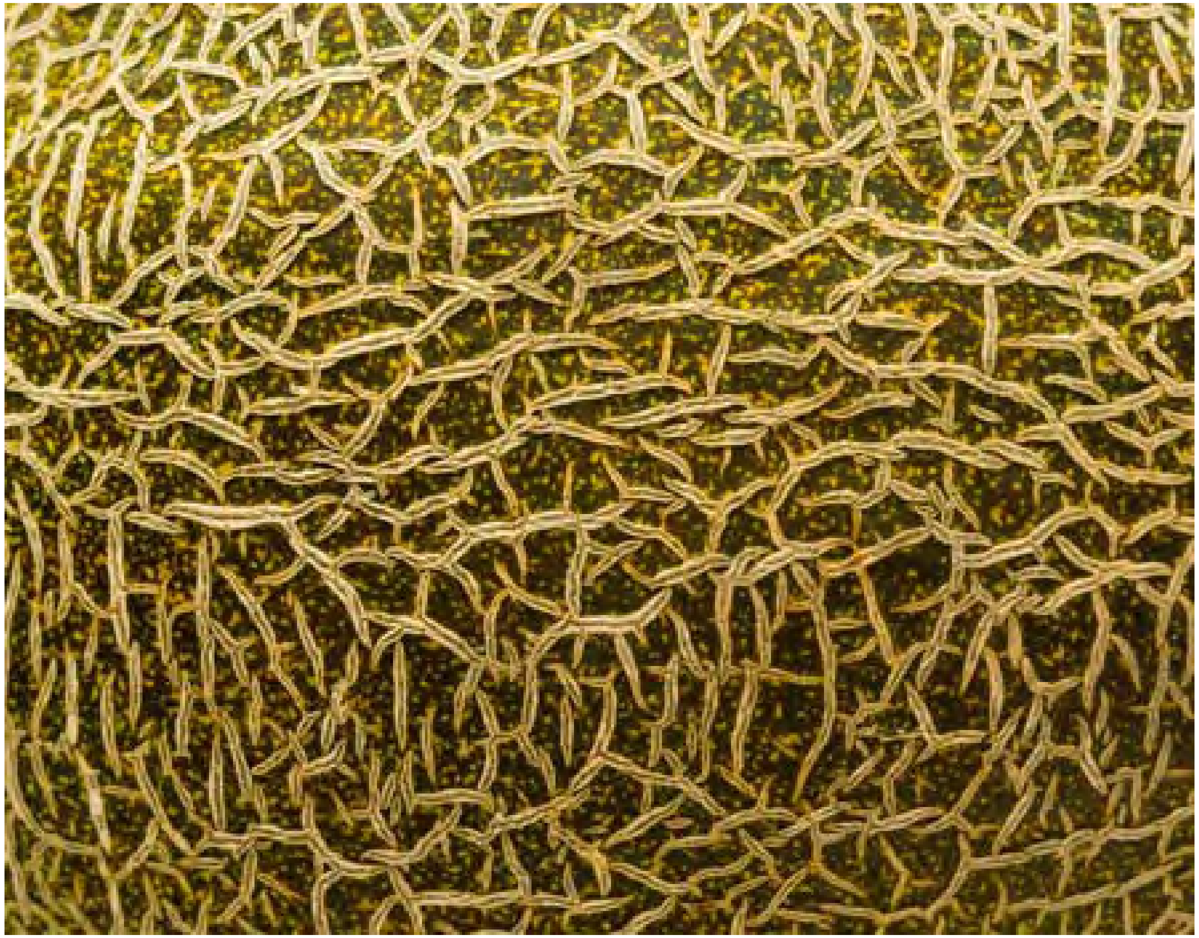
**How small is "nano" and what's it all about, anyway?**

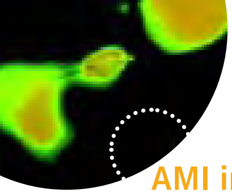
The general public is an important stakeholder when it comes to transforming pure research results into benefits for society. As consumers, people with an interest in technology or environmental activists, the public, has an interest in entering into a dialogue with the scientists to better understand the potential benefits and risks of this new science, nanotechnology, that, it is said, will revolutionize our daily life in the near future. One of AMI's missions is to actively participate and contribute to this dialogue and for this reason it opened its doors to several journalists during the past year. In interviews, reports and discussions AMI's staff explained what they were doing and what potential nanotechnology has for the future. Several invitations to make presentations were accepted opening up the opportunity to explain the benefits of nanoscience and nanotechnology to a broader public.

**Links to the Faculty of Science**

Building on the background in materials science, AMI was evolving from the Faculty of Science of the University of Fribourg in 2008. The synergies with the faculty are still cultivated via the Fribourg Centre for Nanomaterials (FriMat). This center reunites independent research groups from the departments of physics, chemistry, geosciences and AMI, which are active in the field of nano and materials science.

In mid-2009, Prof. Weders research group, with a background in polymer chemistry and materials science, joined AMI complementing Prof. Schurtenberger's established Soft-matter Physics group. A third chair in Biomaterials will soon be advertised. The Faculty of Science also strengthened its position through the appointment of new professors in the departments of chemistry and physics. Subsequently, FriMat experienced considerable growth and now has nine members throughout the Faculty and AMI and continues to play an important role in establishing a center of excellence for nanomaterials in Fribourg.







## A STRONG COMMITMENT TO EDUCATION AND TRAINING

**As part of the Faculty of Natural Sciences of the University of Fribourg, AMI has a strong commitment to education in the field of nanoscience and technology. AMIs program emphasizes the interdisciplinary nature of materials science and focuses on training masters and PhD students and on postdoc mentoring.**

Within Ami, education and research go hand in hand. The educational components, which are largely integrated with the research mission, were defined after careful consideration by the Institute. The interdisciplinary environment and collaborative spirit prevailing at the Institute create an ideal environment to prepare the next generation of scientists to face the challenges associated with nanomaterials research, while allowing them to interface with the academic and industrial worlds. This dual approach with access to both worlds represents a unique opportunity for scientists to gain a well-rounded education, thus equipping them to understand the ins and outs of tomorrow's materials research.

**As part of the Faculty of Natural Sciences of the University of Fribourg, AMI is strongly committed to excellence in education and training. Our students enjoy an interdisciplinary environment and a cooperative spirit.**

In a very short time, our research groups have established a prime setting for the pursuit of high calibre doctoral studies in the field of soft nanomaterials. Targeting a PhD student population in excess of 50 % of the entire research staff, the Institute has already recruited some 10 outstanding PhD students from around the world, who have come to Fribourg from Germany, the USA, the Netherlands, Russia, India and many other countries to benefit from the outstanding training offered at the Institute (yes, some of them even come from Switzerland). As members of highly qualified research teams working at the forefront of fundamental and applied research, they enjoy daily interaction with scientists from their own discipline and from other fields of science. Highly specialized classes at the Faculty of Natural Sciences provide formal training that is complemented by the Institute's seminar series, to which internationally recognized experts are regularly invited. The research facilities are state-of-the-art, and PhD students are given the opportunity to acquire hands-on experience in a broad range of sophisticated techniques.

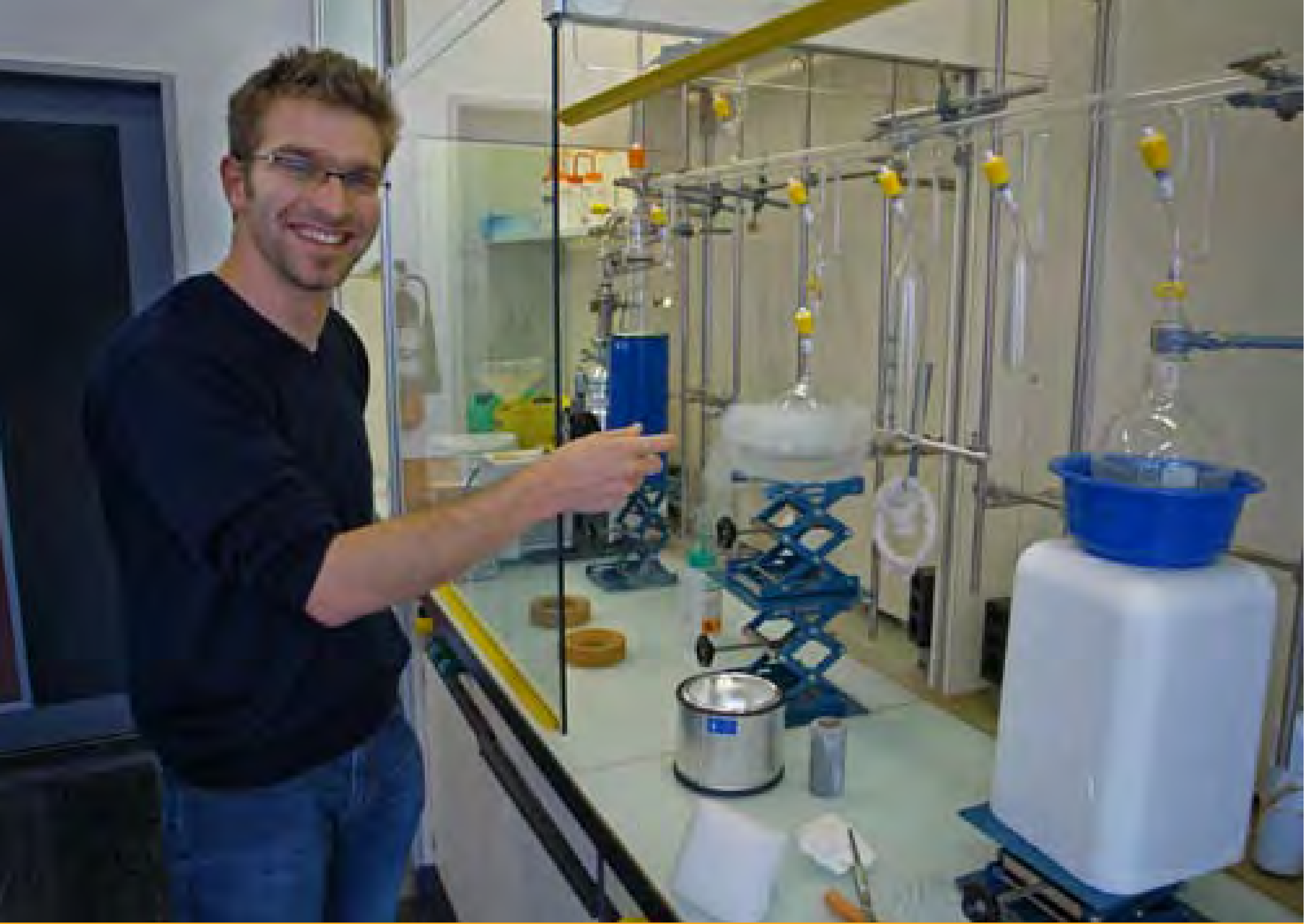
To further expand education at the Institute, AMI professors and other members of the Faculty of Natural Sciences are in the process of planning a new, specialized Master's program in Nano Material Science, which will be offered as early as 2011. This program, which will be taught in English, aims to attract outstanding students from a broad range of disciplines, including chemistry, physics, materials science and biology. Cross-disciplinarity will be particularly emphasized in a core curriculum that addresses the synthesis, processing, characterization, properties and application of nanomaterials. Further in-depth studies in specialty areas are planned.

**Coming soon: a specialized Master's program in Nano Materials Science**

## WORKING AT AMI

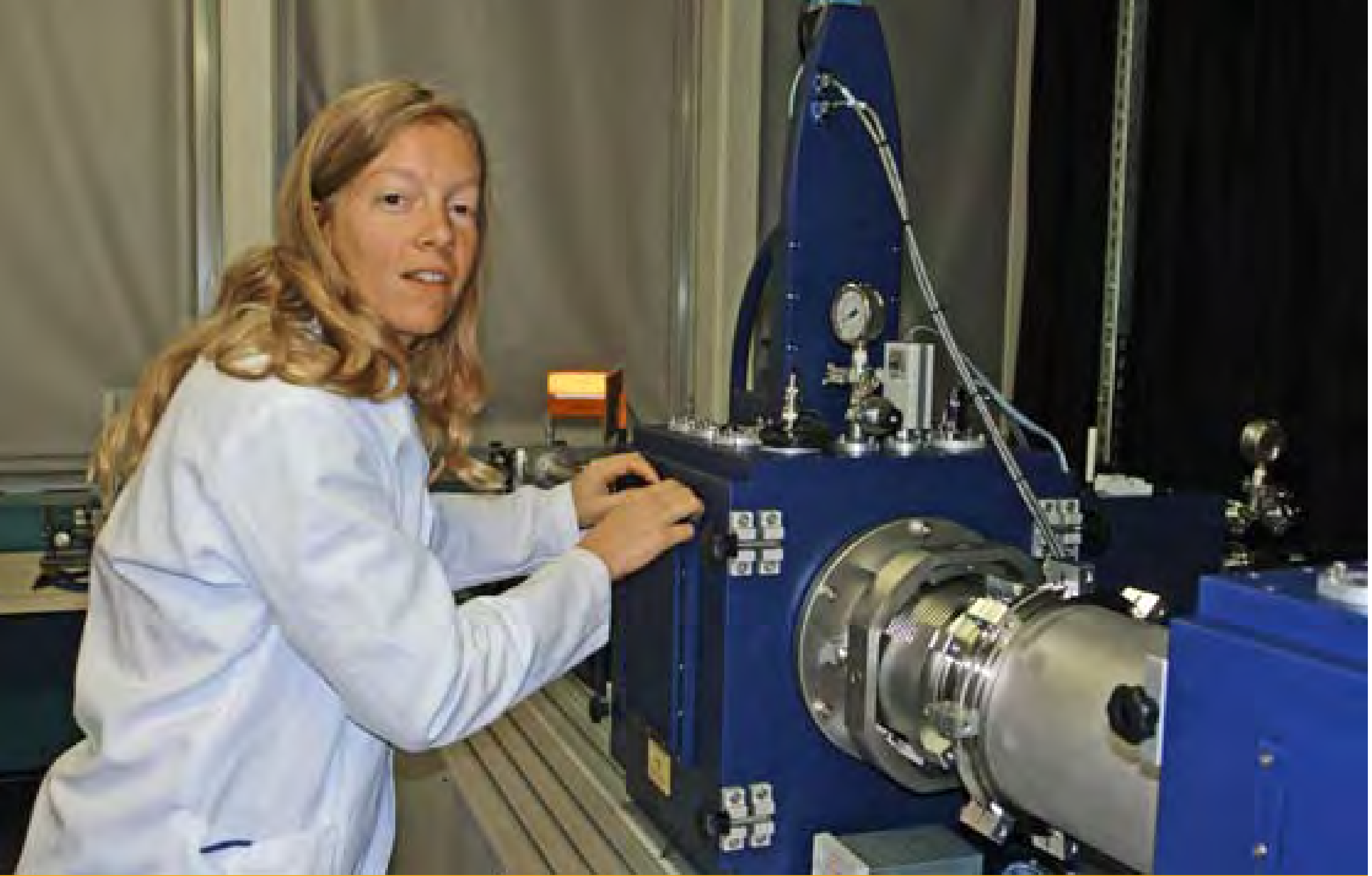
Ideally located at the center of Europe, AMI gathers outstanding scientists from around the world and is a mosaic of cultures, a meeting place for scientists who are driven by the same enthusiasm and have the same goal: namely pushing back the existing boundaries of knowledge. Researchers from 15 different countries work "hand-in-glove" with each other in our laboratories. During "Cafés Scientifiques", you can hear them debate not only in English, German and French, but also in Dutch, Indian, Russian and Arabic. Openness and sharing are central to the ideals of the Institute. Passionate discussions take place not only at organized events such as Journal club or during group meetings and workshops, but also on a daily basis in the hallways and offices. Students and faculty intermingle in a stimulating environment where open discussions and the exchange of scientific ideas are strongly advocated. Additionally, all researchers are encouraged to participate in international conferences at least once a year, to present scientific findings and to establish contacts with fellow scientists. We also regularly welcome scientists working at other research institutions or companies who collaborate actively with AMI laboratories. Currently, AMI comprises around 49 people, with the ultimate goal of hosting between 120 and 160 people (95 % scientists).

At AMI you can become part of a vibrant, diverse group, whose members are fascinated with getting to the bottom of Nature's secrets and acquiring the knowledge needed to solve science's most interesting problems in the realm of soft nanomaterials



## Portrait: Dr. Hervé Dietsch

"Nanoparticles are fascinating, as we can tune their size, shape, surface functionality and bulk properties and use them for studies and materials application", states Hervé Dietsch. "For instance they add new properties to polymers, either reinforcing them – with an even distribution of equal non-clumping particles or adding new magnetic or optical features." That was his topic when writing his thesis at the Empa. There he got to know Peter Schurtenberger who was his PhD director and invited him to move to the AMI and build up the Particle and Materials Synthesis Facility which he is heading now. "It's great to see what amazing developments we can make by creating innovative responsive new systems", states the physico-chemist. Although the focus of his investigation is on basic research, he has a sharp ear for industrial needs. "At present we have a Nanotech project running with BASF, Bosch and FIAT within the 7th EU Framework Programme about the influence of the dispersion and distribution of nanoparticles within polymer matrixes, and a Feasibility Study with a construction chemistry company." Hervé pleads for balancing basic and applied research. "Private economy circles will invest in basic research when they conceive its utility." The Frenchman likes the exchange of ideas with scientists who are as enthusiastic as he is. "The human aspect is very important in science; every get-together with inventive minds can open up new horizons." With such a commitment, is there any free time left for the father of a little girl? "I organize my leisure time properly by going on walks each week-end with my family."



## Portrait: Dr. Ilja Voets

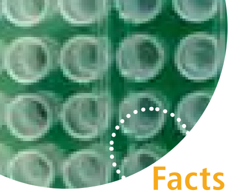
Complex polymer assemblies were a core theme of Ilja Voets when she was at the University of Wageningen with Professor Martien Cohen Stuart, her PhD supervisor. And she had a clear vision about her future activity: "I wanted to stay in science, to broaden my horizon and to investigate both synthetic and biological matter", she explains. In 2008 she moved to the Adolphe Merkle Institute. "I'm especially interested in the structure and interactions in concentrated protein solutions. I try to understand for example how a solution of lysozyme, an enzyme capable of destroying the cell walls of certain bacteria, evolves from a liquid phase into a gel phase." In her PhD thesis she demonstrated that a clever combination of different polymers yields an entirely new class of nanoparticles that form spontaneously in a simple one-step-mixing procedure. As their structure, stability, properties and interactions are well understood, they can be tailor-made to meet specific requirements. This allows the development of new functional, responsive, biocompatible materials in nanotechnology and medicine. For her finding she received the KNCV Polymer Prize 2009 and the DSM Science & Technology Award (NORTH) 2009. Living in Switzerland as a Dutchwoman is not a problem for Ilja, as she sees similarities in lifestyle and speaks German. In her rare leisure time she enjoys discovering Switzerland, particularly the mountainous regions. She is still involved in the organisation of a yearly street theatre festival in the Netherlands.

## Portrait: James Mendez

Many multifunctional polymers with optical, electronic, mechanical and other properties are exciting to be looked at as they combine the advantaged of polymers' low cost and the ease of processing with tailorable properties of functional organic molecules. This was the fascinating domain of the Indianapolis-born James Mendez when he was working at the Case Western Reserve University of Cleveland/Ohio. So when his boss – Christoph Weder – wanted to go back to Switzerland to join the AMI crew, the decision to leave the States was easy for the physicist – provided his wife could go along! That's why today PhD Student James and Postdoctoral fellow Julie Mendez are both involved in Polymers and Materials research at the AMI. The first job was a rather tricky one as the newcomers first had to equip their laboratories before they could get down to work. But in the meanwhile they have got into top gear. "For me it's important not only to acquire knowledge and produce research results, but to bring out something that makes sense, leads to a useful application, like for instance photovoltaic cells", explains James. On weekends, when he doesn't bury his nose in his funny-coloured laboratory bottles, he and Julie go on scouting expeditions throughout Europe. "In the States you always travel by car; but here it's comfortable to take the train." Are there things he misses in Switzerland? "Well, the big supermarkets where you can shop around the clock and", he smiles to himself and adds with a wink, "the delicious American junk food!"

## Portrait: Ilya Martchenko

Born in Leningrad, Soviet Union, he studied physics at the local State University and got his master in 2009 working with Prof. Nikolai Tsvetkov on dendritic cylinders. "AMI and Prof. Peter Schurtenberger's group attracted my attention as a place to pursue PhD re-search. I had the strong impression that the research opportunities, motivation and infrastructure must be outstanding", he says. He sees physics not only as a profession, but also as a passion and somewhat a lifestyle. Since 1999 he is closely affiliated with the Young Physicists› Tournaments, research-oriented competitions for students from upper secondary schools. The combination of team work and longterm research fascinates him about this activity in «everyday life physics» (with many topics from soft matter, such as surface tension, colloids, and even rheology of complex fluids, like starch thixotropy or the Kaye effect.) Formerly a participant, he now acts on the jury and as a coach. Another passion is languages. He smiles and refuses to say how many languages he speaks or understands, "this is a statistical distribution; I am more skilled in certain languages, but many others are closely related, and as a physicist I enjoy employing these similarities". He has co-authored papers with professional linguists since 2006, focusing on language acquisition for professional communication. "I adore the multilingual environment here at AMI. A lot of people feel perfectly okay discussing physics in three languages at once. For me, working here is a combination of comfortable atmosphere with devotion to research". During his leisure time, he enjoys traveling across and outside Switzerland. "The winter temperatures here in Switzerland do not frighten me, as I am a Russian".

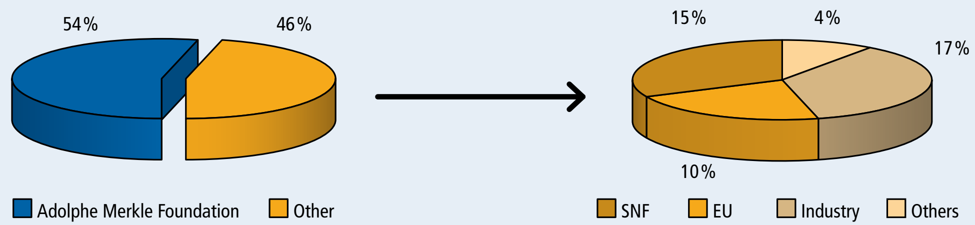




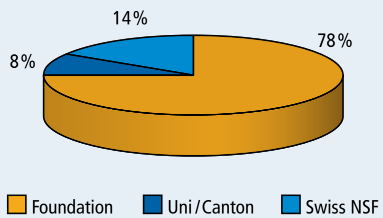
## FINANCES

AMI was successful in implementing its strategy of working on fundamental and applied nanoscience as is reflected in the composition of the external funding sources. The foundation also provided supplementary funding for projects reinforcing strategically important fields of research.

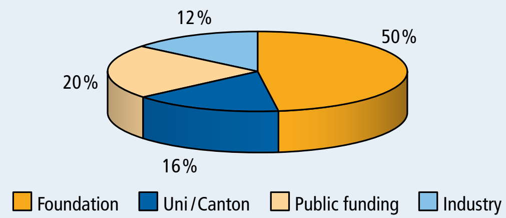
Considerable funds had to be used for investments in laboratory infrastructure and equipment because the Institute is still in the early stages of its build up.
The Institute's overall running costs were financed by the Foundation, the University and the Canton of Fribourg, Swiss and European public funds and contributions from industry projects.




Sources of Project Financing 2009 (total expenditive CHF 2'990'000)




Financing of investments

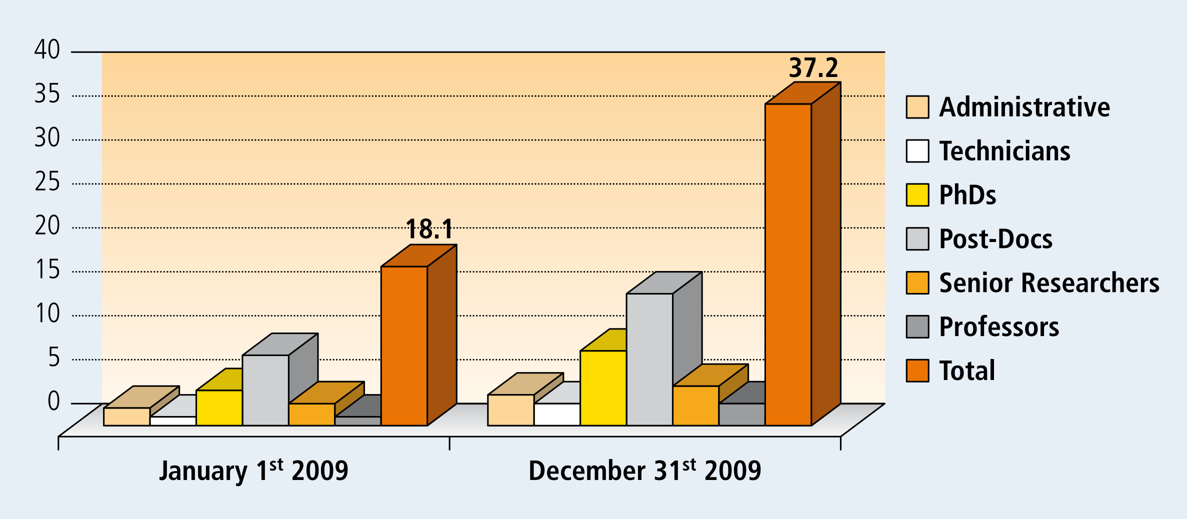



Financing of Running Costs

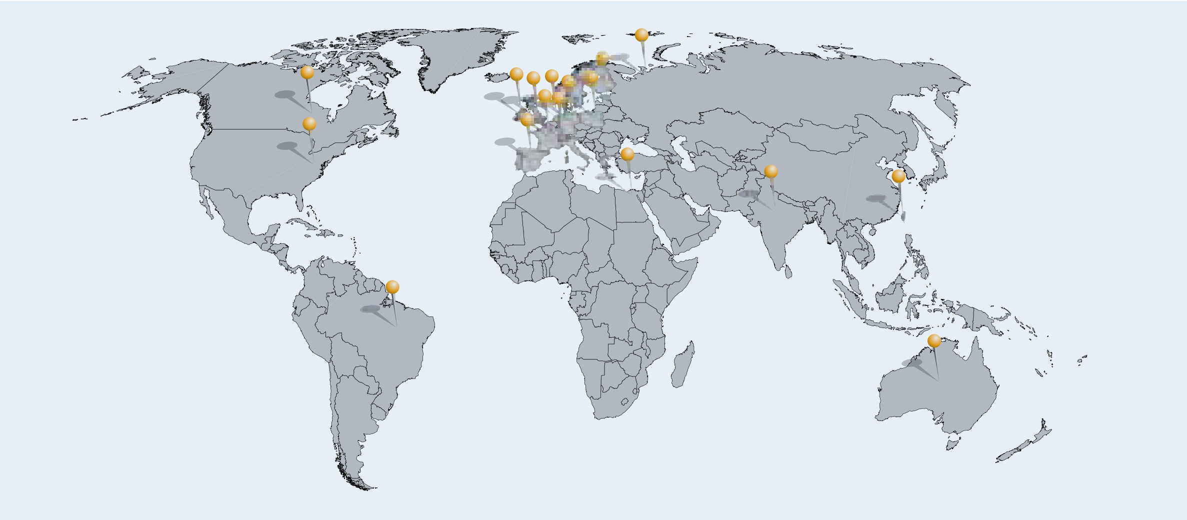
## PERSONNEL

The evolution of the institute was very dynamic with a growth rate of 100% in 2009. 49 people work fully or part time at the AMI (corresponding to 37.2 full time equivalents), and 90% of them are active in research. The staff is multinational and very young (15 different nationalities and a mean age of 27 years). The most prominent nationality is Swiss, followed by French, German and American. 37% percent of the employees are women.

In order to support the two professors in the government of the research projects and the acquisition of third party funding, the number of senior researchers was considerably increased. The administrative staff almost reached its steady state, being able to provide the most important services for the functioning of the institute.




Development of Personnel in 2009, in full time equivalents.



Nationalities of collaborators working at the AMI in 2009

## ORGANS OF AMI

### Adolphe Merkle Foundation Board:

**Prof. Joseph Deiss** (president)
Former member of the Swiss Government,
Professor at the University of Fribourg

**Dr., Dr. hc. Adolphe Merkle**
Founder of the Adolphe Merkle Foundation,
Former director and owner of Vibrometer SA

**Isabelle Chassot**
State Councillor, 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 Tronic›s 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 Medical Sciences

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

### Scientific Advisory Board:

**Prof. Louis Schlapbach** (Chairman)
Former Director of EMPA, Switzerland

**Prof. Andreas Engel**
M.E. Müller Institute for Structural Biology, Biozentrum,
University of Basel, CH-4056 Basel, Switzerland

**Prof. Jochen Feldmann**
Lehrstuhl für Photonik und Optoelektronik, Department für Physik und CeNS, Ludwig-Maximilians-Universtität München,
D-80799 München, Germany

**Prof. Jean-Marie Lehn**
Laboratoire de Chimie Supramoléculaire,
F-67083 Strasbourg Cedex, France

**Prof. Helmuth Möhwald**
Max Planck Institute of Colloids & Interfaces,
Wissenschaftspark Golm, D-14476 Potsdam-Golm, Germany

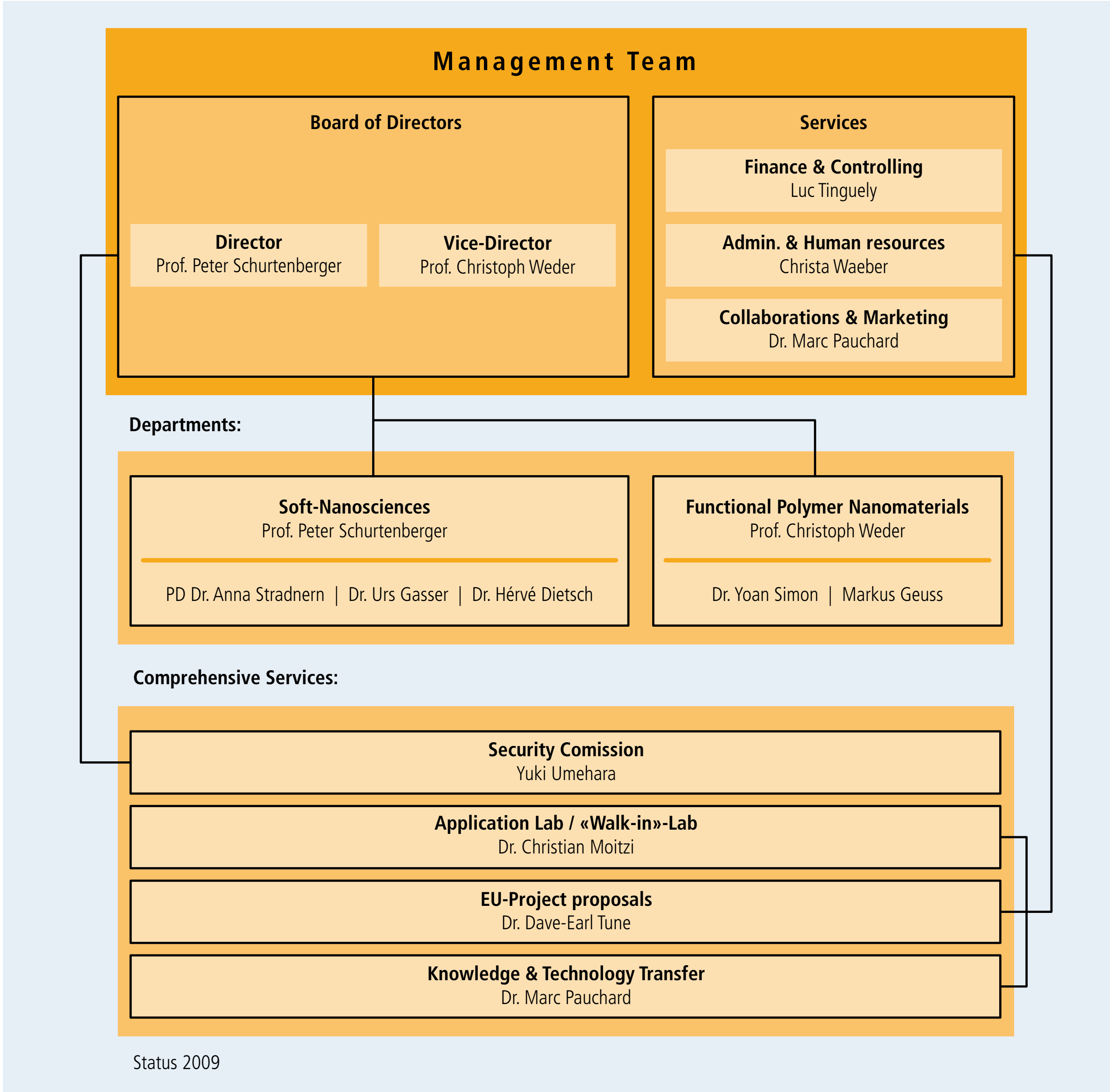
**Prof. Anthony J. Ryan**
OBE, ICI Professor of Physical Chemistry, Department of Chemistry, University of Sheffield, Sheffield S3 7HF, England

**Prof. Christian Schönenberger**
Department of Physics and NCCR on Nanoscale Science and Technology, Swiss Nanoscience Institute (SNI), CH-4056 Basel, Switzerland

**Prof. Ulrich W. Suter**
ETH Hönggerberg, Institut für Polymere,
CH-8093 Zürich, Switzerland

## ORGANIZATIONAL CHART

The research departments and cross-disciplinary research teams are the most important structural entities. For a smooth functioning of the institute and for the attainment of its multiple goals a service department is complementing the research departments. Together, the heads of the departments are defining the management team, which is in charge of the governing of the institute under the lead of its director. The cross-disciplinary research teams and the comprehensive services are melting together the institute and provide an ideal basis for the creation of synergies and excess value.



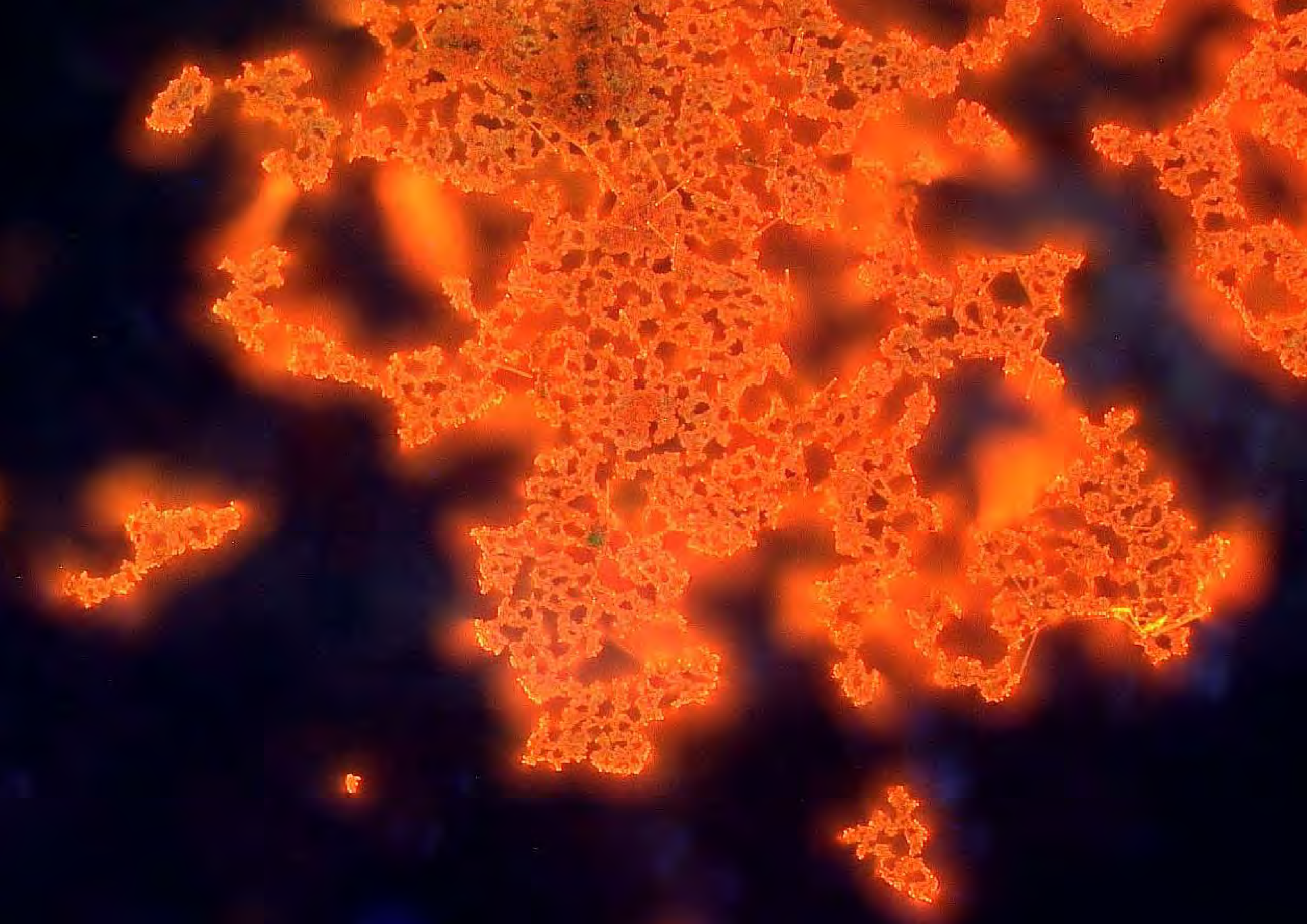
## SCIENTIFIC OUTPUT

AMI researchers have published their findings in numerous scientific journals: The two publications with the most impact were an article in Nature by Prof. Weder and a fast-track communication in the Journal of Physics by Prof. Schurtenberger. AMI researchers represented the Institute, presented their results and enlarged their networks by attending and participating in 35 international conferences, the main ones being the 23rd Conference of the European Colloid and Interface Society (Antalya, Turkey), the Joint User Meeting at PSI (Villigen, Switzerland) and the SoftComp Annual Meeting 2009 (Venice, Italy).

Recent research results were presented to other research groups at 25 external seminars.

### SCIENTIFIC OUTPUT

| | |
|---|---|
| **Publications in scientific journals:** | |
| published | 34 |
| accepted | 6 |
| submitted | 13 |
| **Contributions at international conferences and workshops:** | |
| Key note lectures | 7 |
| Invited talks | 21 |
| Talks | 18 |
| Posters | 16 |
| Contributions to external seminars | 25 |



# Appendix

## Publications


1. Capadona, J.R, Shanmuganathan, K., Trittschuh, S., Seidel, S., Rowan, S.J., and Weder, C., (2009) Polymer Nanocomposites with Microcrystalline Cellulose. *Biomacromolecules 10,* 712 – 716.

2. Dorsaz, N., Thurston, G.M., Stradner, A., Schurtenberger, P., and Foffi, G., (2009) Colloidal Characterization and Thermodynamic Stability of Binary Eye Lens Protein Mixtures. *J. Phys. Chem. B 113(6),* 1693 – 1709.

3. Dorsaz, N., Thurston, G.M., Stradner, A., Schurtenberger, P., and Foffi, G., (2009) Spinodal surface of a free energy model for eye lens protein mixtures: Relevance for cataracts. *Modeling and Simulation of New Materials, AIP Conference Proceedings 1091,* 246–248.

4. Erbe, A., Tauer, K., and Sigel, R., (2009) Separation of coherent and incoherent scattering contributions in ellipsometric light scattering experiments on latex mixtures. *Langmuir 25(5),* 2703 – 2710.

5. Gasser, U., (2009) Crystallization in three- and two-dimensional colloidal suspensions. *J. Phys. Condens. Matter 21(20),* 203101 – 203102.

6. Gasser, U., Sierra-Martin, B., and Fernandez-Nieves, A., (2009) Crystal structure of highly concentrated, ionic microgel suspensions studied by neutron scattering. *Phys. Rev. E 79(5),* 51403 – 51410.

7. Gawryla, M.D., van den Berg, O., Weder, C., and Schiraldi, D.A., (2009) Clay Aerogel / Cellulose Whisker Nanocomposites: A Nanoscale Wattle and Daub. *J. Mater. Chem. 19.* 2118 – 2124.

8. Gibaud, T., and Schurtenberger, P., (2009) A closer look at arrested spinodal decomposition in protein solutions. *J. Phys. Cond. Mat. 21(32)*, 322201 – 322209.

9. Kunzelman, J., Gupta, M., Crenshaw, B.R., Schiraldi, D.A., and Weder, C., (2009) Pressure-Sensitive Chromogenic Polyesters. *Macromol. Mater. Eng. 294,* 244 – 249.

10. Lietor-Santos, J.-J., Sierra-Martin, B., Vavrin, R., Hu, Z., Gasser, U., and Fernandez-Nieves, A., (2009) Deswelling Microgel Particles Using Hydrostatic Pressure. *Macromolecules 42(16),* 6225 – 6230.

11. Liu, L.-H., Dietsch, H., Schurtenberger, P., and Yan, M., (2009) Photoinitiated Coupling of Unmodified Monosaccharides to Iron Oxide Nanoparticles for Sensing Proteins and Bacteria. *Bioconjugate Chem. 20(7),* 1349 – 1355.

12. Mohanty, P.S., Dietsch, H., Rubatat, L., Stradner, A., Matsumoto, K., Matsuoka, H., and Schurtenberger, P., (2009) Synthesis and characterization of novel functional electrosterically stabilized colloidal particles prepared by emulsion polymerization using a strongly ionized amphiphilic diblock copolymer. *Langmuir 25(4),* 1940 – 1948.

13. Moitzi, C., Vavrin, R., Bhat, S. K., Stradner, A., and Schurtenberger, P. (2009) A new instrument for time resolved static and dynamic light scattering experiments in turbid media. *J. Colloid Interface Sci. 336(2),* 565 – 574.

14. Reufer, M., Diaz-Leyva, P., Lynch, I., and Scheffold, F., (2009) Temperature-sensitive poly (N-Isopropyl-ocrylamide) microgel particles: a light scattering study. *European Physical Journal E 28,* 165 – 171.

15. Rufier, C., Collet, A., Viguier, .M, Oberdisse, J., and Mora, S., (2009) SDS interactions with hydrophobically end-capped poly (ethylen oxide) studied by $^{13}$C NMR and SANS. *Macromolecules 14(14),* 5226 – 5235.

16. Savii, C., Almásy, L., Ionescu, C., Székely, N. K., Enache, C., Popovici, M., Sora, I., Nicoara, D., Savii, G. G., Resiga, D. S., Subrt, J., and Stengl, V., (2009) Mesoporous silica matrices derived from sol-gel process assisted by low power ultrasonic activation. *Processing and Application of Ceramics 3(1 – 2),* 59 – 64.

17. Schlaad, H., You, L., Sigel, R., Smarsly, B., Heydenreich, M., Mantion, A., and Masic, A., (2009) Glycopolymer vesicles with an asymmetric membrane. *Chem. Commun.(12),* 1478 – 1480.

18. Sigel, R., (2009) Light Scattering Near and From Interfaces using Evanescent Wave and Ellipsometric Light Scattering. *Curr. Opinion Coll. Interf. Sci. 14(6),* 426 – 437.

**19.** Sigel, R., Krasia-Christoforou, T., Below, I., and Schlaad, H., Micellization behavior of poly(n-butyl methacrylate)-block-poly (2-(acetoacetoxy)ethyl methacrylate). *Macromolecules 42(12),* 4257 – 4261.

**20.** Sing, C.E., Kunzelman, J., and Weder, C., (2009) Time-temperature Indicators for High Temperature Applications. *J. Mater. Chem. 19,* 104 – 110.

**21.** Singh-Rachford, T.N., Lott, J., Weder, C., and Castellano, F.N., (2009) Influence of Temperature on Low-Power Upconversion in Rubbery Polymer Blends. *J. Am. Chem. Soc. 131,* 12007 – 12014.

**22.** Song, H., Singer, K., Lott, J., Wu, Y., Zhou, J., Andrews, J.H., Baer, E., Hiltner, A., and Weder, C., (2009) Continuous Melt Processing of All-Polymer Distributed Feedback Laser. *J. Mater. Chem 19,* 7520 – 7524.

**23.** Stocco, A., Tauer, K., Pispas, S., and Sigel, R., (2009) Dynamics at the air-water interface revealed by Evanescent Light Scattering. *European Physical Journal E 29(1),* 95 – 105.

**24.** Tang, L., Whalen, J., Schutte, G., and Weder, C., (2009) Stimuli-Responsive Epoxy Coatings. *ACS Appl. Mat. Interf. 1,* 688 – 696.

**25.** Tauer, K., Weber, N., Nozari, S., Padtberg, K., Sigel, R., Stark, A., and Völkel, A., (2009) Heterophase Polymerization as Synthetic Tool in polymer chemistry for making nanocomposites. *Macromol. Symp. 281,* 1 – 13.

**26.** Weder, C., (2009) Polymers React to Stress; News and Views Article. *Nature 459,* 45.

**27.** Weder, C., (2009) Functional Polymer Nanocomposites and Blends. *Chimia 63,* 758 – 763.

**28.** Weder, C., (2009) Book Review: Molecular Recognition and Polymers – Control of Polymer Structure and Self-Assembly; By Vincent Rotello and Sankaran "Thai" Thayumanavan. Macromol. *Chem. Phys. 210,* 1349.

**29.** Weder, C., (2009) Functional Blends and Nanocomposites. *Chimia 63,* 758 – 763.

## Online-Publications:

**1.** Dahbi, L., Alexander, M., Trappe, V., Dhont, J.K.G., and Schurtenberger, P., (2009) Rheology and Structural Arrest of Casein Suspensions. *J. Colloid Interface Sci.,* on-line October 31.

**2.** Dietsch, H., and Schurtenberger, P., (2009) Functionalizing the surface of nanoparticles: the approaches used at the Adolphe Merkle Institute. *Azonano.com*

**3.** Eichhorn, S.J., Dufresne, A., Aranguren, M., Capadona, J. R., Rowan, S.J., Weder, C., Thielemans, W., Roman, M., Renneckar, S., Gindl, W., Weigel, S., Yano, H., Abe, K., Nogi, M., Mangalam, A., Simonsen, J., Benight, A.D., Bismarck, A., and Berglund, L.A., (2009) Review: Current International Research into Cellulose Nanofibres and Nanocomposites. J. *Mater. Sci.* published online 24/10/09.

**4.** Lott, J., and Weder, C., (2009) Luminescent Mechanochromic Sensors Based on Poly(Vinylidene fluoride) and Excimer-Forming p-Phenylene Vinylene Dyes. Macromol. *Chem. Phys.,* published online 12/8/09.

**5.** Shanmuganathan K., Capadona, J.R., Rowan, S.J., and Weder, C., (2009) Biomimetic Mechanically Adaptive Nanocomposites. *Progr. Polym. Sci.,* published online 12/7/09.

## Conference Contributions

1. 13th IACIS International Conference on Surface and Colloid Science and the 83rd ACS Colloid & Surface Science Symposium, New York (USA):
   **Key note lecture,** "Equilibrium Cluster Formation in Concentrated Protein Solutions", A. Stradner
   **Talk,** "Surface-Functionalized Inorganic-Organic Multilayer Particles-Thermosensitive particles with anisotropic magnetic core", H. Dietsch
   **Talk,** "Charged temperaturesensitive microgel particles as a model system to study equilibrium and non-equilibrium phase behaviour of soft colloids", M. Reufer

2. 23rd Conference of the European Colloid and Interface Society and 3rd COST D43 Action Workshop - Antalya, Turkey:
   **Invited talk,** "Cataract formation from a colloid physicist's viewpoint", A. Stradner
   **Talk,** "Synthesis and optical Characterization of optically anisoptropic thermosensi tive particles - Thermosensitice particles with anisotropic magnetic core", H. Dietsch
   **Talk,** "Depletion interactions in charged, aqueous colloid-polymer mixtures", K. Van Gruijthuijsen
   **Talk,** "Phase-separation and gelation of protein-poly(ethylene oxide) mixtures", N. Mahmoudi
   **Poster,** "Multiple Emulsion Breakdown Probed by DWS", G. Gillies, R. Vincent, A. Stradner
   **Poster,** "Colloidal Stability of Poly(Methyl Methacrylate/Butylate/Butyl Acrylate) Latexes Synthesized Using an Inulin (Polyfructose) Derivative Surfactant", M. Obiols-Rabasa, C. Moitzi, G. Gillies, P. Schurtenberger, C. Solans, B. Levecke, K. Booten, T.F. Tadros, J. Esquena

3. 6th Nordic Workshop on Scattering from Soft Matter – Arhus, Denmark:
   **Invited talk,** "A small-angle scattering investigation of protein interactions and solution structure", P. Schurtenberger

4. ACS 2008 Spring Meeting – Salt Lake City, UT, USA:
   **Invited talk,** "Mechanically-Dynamic (Adaptive, Mechanomutable, Stimuli-Responsive) Polymer Nanocomposites", C. Weder
   **Invited talk,** "Cellulose-Polymer Nanocomposites: Processing Self-Assembled Templates", C. Weder

5. APS Physics – Pittsburgh, USA:
   **Talk,** "Structure-Properties Relationship in Proton Conductive Sulfonated Polystyrene-Polymethyl Methacrylate Block Copolymers", H.Dietsch

6. BASF Summer course – Ludwigshafen, Germany:
   **Poster,** "Synthesis and Characterization of Surface-Functionalized Inorganic-Organic Multilayer Particles", C. Dagallier, H. Dietsch, F. Scheffold

7. Biological and soft matter – University of Warwick, UK:
   **Poster,** "Employing succinylated lysozyme to investigate the protein – colloid analogy", I. K. Voets, P. Schurtenberger

8. CECAM Workshop on "New Trends in Simulating Colloids: from Models to Applications" – Lausanne, Switzerland:
   **Invited talk,** "Analyzing self-assembled protein clusters, gels and glasses – the need for multiscale characterization", P. Schurtenberger

9. Dispersionen und Emulsionen – Rheologie und Partikelmesstechnik 2009 – Karlsruhe, Germany:
   **Invited talk,** "An introduction to dynamic light scattering", P. Schurtenberger
   **Invited talk,** "Light Scattering with turbid suspensions", P. Schurtenberger

10. ESC 2009 – Almeria, Spain:
    **Talk,** "Controlling the size, shape, magnetic properties and crystal morphology of magnetic nanoparticles", V. Malik

11. European Biophysics Congress 2009 – Genoa, Italy:
    **Invited talk,** "Protein condensation diseases – a protein physicists viewpoint", P. Schurtenberger
    **Poster,** «Sol-gel transition in DMSO/lysozyme/water mixtures», I.K. Voets, W. A. Cruz, P. Schurtenberger, E.P.G. Arêas

12. Frontiers of Soft Condensed Matter – Les Houches, France:
    **Invited Talk,** "Non-Central Forces in Crystals of Charged Colloids", U. Gasser

**13.** International Polymer Colloids Group Conference – Il Ciocco, Italy:
**Invited talk,** "Microgels as Versatile Model Systems to Investigate Phase Transitions: Crystals, Glasses and Squeezed States", P. Schurtenberger

**14.** International Symposium on Food Rheology and Structure 2009 – Zurich, Switzerland:
**Talk,** "Towards full control of the interactions between like-charged (food) colloids and polymers", K. Van Gruijthuijsen

**15.** International Symposium on Stimuli-Responsive Materials – Hattiesburg, MS, USA:
**Key note lecture,** "Polymer Chameleons", C. Weder

**16.** Jullich Soft Matter Days 2009 – Bonn, Germany:
**Poster,** «In-Plane Diffusion of Colloids adsorbed to an Oil-Water Interfacece», T. Mokhtari, A. Stocco, K. Tauer, R. Sigel
**Poster,** "DWS investigations on double emulsions », R. Vincent

**17.** JUM@P, Joint user meeting at PSI – Villigen, Switzerland:
**Invited talk,** "The colloid analogy of casein micelles – stability and internal structure", C. Moitzi
**Talk,** "Static and dynamic properties of anisotropic magnetic particles in an external magnetic field", M. Reufer
**Poster,** "Structural Characterization of Radiation-Grafted Block Copolymer Films, Using SANS Technique", K. Mortensen, U. Gasser, S. Balog, S. Alkan Gürsel, G.G. Scherer
**Poster,** "Correlation between Morphology, Water Uptake, and Proton Conductivity in Radiation Grafted Proton Exchange Membranes», S. Balog, U. Gasser, K. Mortensen, L. Gubler, H. Ben youcef, and G.G. Scherer
**Poster,** "Crystal structure of highly concentrated, ionic microgel suspensions studied by (U)SANS and SAXS", U. Gasser, B. Sierra-Martin, and A. Fernandez-Nieves

**18.** MRS Fall Meeting – Boston, USA:
**Invited talk,** "Microgels as Versatile Building Blocks to Explore Self-Assembly and Phase Transitions: Crystals, Glasses and Squeezed States", P. Schurtenberger

**19.** NanoEurope 2009 – Rapperswil, Switzerland:
**Invited talk,** "From soft matter physics to functional nanostructured materials", P. Schurtenberger
**Poster,** "In-situ polymerization: different routes towards better nanocomposites", O. Pravaz, B. Droz, H. Dietsch, P. Schurtenberger
**Poster,** «Tuning size, morphology and magnetic properties of iron oxide nanoparticles», V. Malik, H. Dietsch, P. Schurtenberger

**20.** Nanotechday 2009 – University of Applied Science Fribourg, Fribourg, Switzerland:
**Invited talk,** "From Nanoscience to Nanotechnology", P. Schurtenberger

**21.** Neutrons in Biology 2009 – Lund, Sweden:
**Invited talk,** "Shedding light on eye lens transparency and cataract formation with neutrons", A. Stradner
**Poster,** "Phase behavior and criticality of core-shell colloids", M. Zackrisson, A. Stradner, P. Schurtenberger, J. Bergenholtz

**22.** SKIN 2009, Studying kinetics with neutrons – Grenoble, France:
**Talk,** "A colloid chemist´s view on the reassemblies and the stability of casein micelles during yoghurt making. The casein micelle – colloid analogy", C. Moitzi

**23.** Smart Coatings 2009 – Orlando, FL, USA:
**Key note lecture,** "Mechanically-Dynamic Polymer Nanocomposites", C. Weder

**24.** SoftComp annual meeting 2009 – Venice, Italy:
**Talk,** "Shape transition in strongly segregated block copolymer micelles", R. Sigel
**Talk,** "Understanding the sol-gel transition in DSMO/lysozyme/water mixtures", I.K. Voets
**Talk,**"Scattering from a depletion induced food colloid-polymer composite", K. Van Gruijthuijsen
**Talk,** "Strain hardening of peanut butter", V. Romaric
**Talk,** "A colloid chemist´s view on the reassemblies and the stability of casein micelles during yoghurt making. The casein micelle - colloid analogy.", C. Moitzi

**25.** Swiss Academy of Technical Science/Swiss Food Research Transferkolleg on "Food Processing" – Liebefeld, Switzerland:
**Invited talk,** "Emerging Food Technologies – Nanotechnology in Food?", P. Schurtenberger

**26.** Swiss Chemical Society: Fall Meeting 2009 - EPFL, Lausanne, Switzerland:
**Talk,** "Nanocomposites: Tuning morphology, concentration and orientation of particles integrated within a Polymethylmethacrylate matrix", O. Pravaz
**Poster,** "Origin of arrested phase separation in protein/polysaccharide-mixtures", K. Van Gruijthuijsen, V. Trappe, F. Scheffold, P. Schurtenberger, A. Stradner
**Poster,** "Opposites attract?! Hierachical co-assemblies of block copolymers in ageous solution", I.K. Voets

**27.** TAPPI Place Symposium on Nanomaterials for Flexible Packaging – Columbus OH, USA:
**Key note lecture,** "Temperature and Deformation Sensors for Polymer Films", C. Weder

**28.** Final Workshop COST 539 ELENA - University of Aveiro, Aveiro, Portugal:
**Talk,** «Structural characterisation of small magnetic nanoparticles», L. Almásy

**29.** The Flow of Soft Matter : Midwinter meeting of the British Society of Rheology:
**Poster,** "Structure and collapse of depletion-induced protein-polymer gels", N. Mahmoudi, P. Schurtenberger and A. Stradner

**30.** Trends and Perspectives in Neutron Scattering on Soft Matter, Julich Center for Neutron Scattering Workshop – Tutzing, Germany:
**Invited talk,** "Analyzing self-assembled protein clusters, gels and glasses" P. Schurtenberger

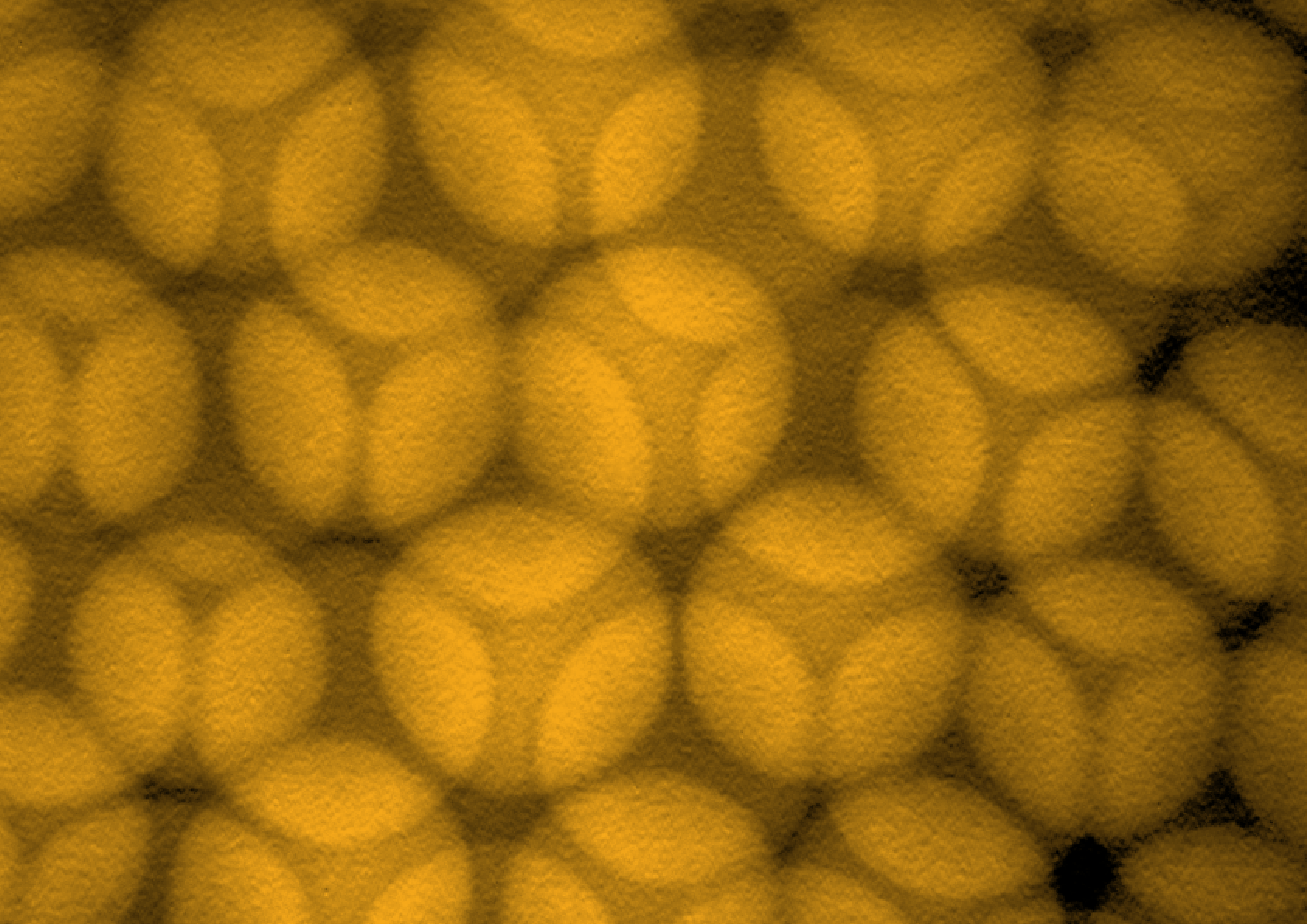
**31.** Trends in Nanotechnology TNT 2009 – Barcelona, Spain:
**Key note lecture,** "Mechanically Adaptive Polymer Nanocomposites", C. Weder
**Key note lecture,** "Synthesis And Characterization Of Functionalized Nanoparticles And Their Use In Nanocomposites With Tailored Properties", H. Dietsch
**Poster,** «Comparison of magnetic and non-magnetic stirring in the process of ferrophase preparation for stable magnetic fluids», C. Nadejde, D. E. Creanga, L. Almásy, E. Pomyakushina, M. Ursache-Oprisan, N. Apetroaie, V. Badescu

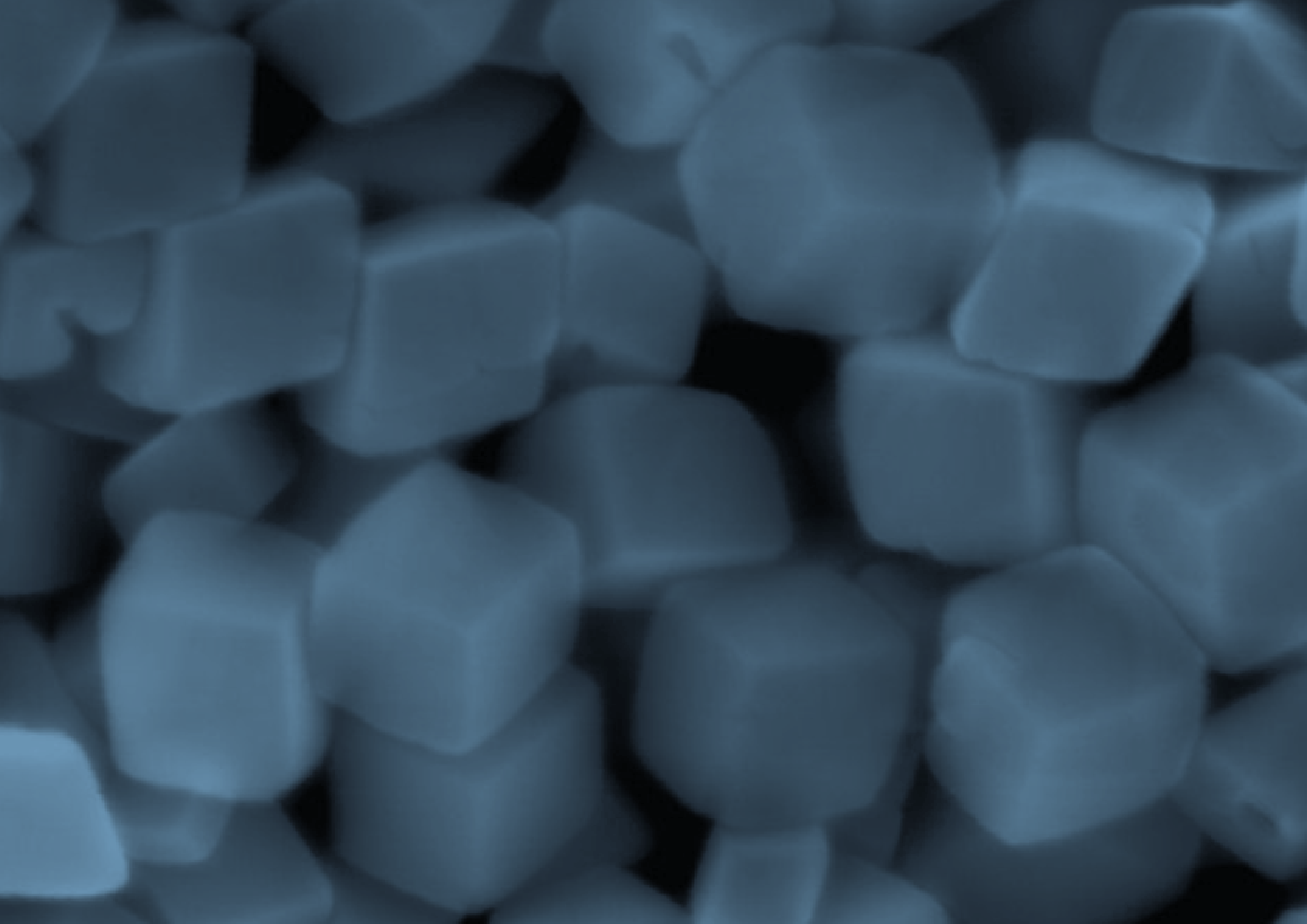
**32.** Tutorial in Scattering Applied to Soft Matter – Aarhus, Denmark:
**Invited talk,** "Applicatons to Soft Matter", P. Schurtenberger
**Invited talk,** "Light Scattering", P. Schurtenberger

**33.** Workshop Bayona, Spain:
**Talk,** "Soft Nanotechnology: Surface modification of colloidal particles as a key step towards agglomerate-free nanocomposites", H. Dietsch

**34.** Workshop on "Modern Light Scattering Technologies" – University Paris Diderot (Paris 7), Paris, France:
**Invited talk,** "Static and dynamic light scattering: Basics", P. Schurtenberger
**Invited talk,**"Static and dynamic light scattering: Turbid systems and applications", P. Schurtenberger

**35.** Zsigmondy Colloquium – Bayreuth, Germany:
**Plenary lecture,** "Gelation of lysozyme in aqueous DMSO solutions", I. K. Voets





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