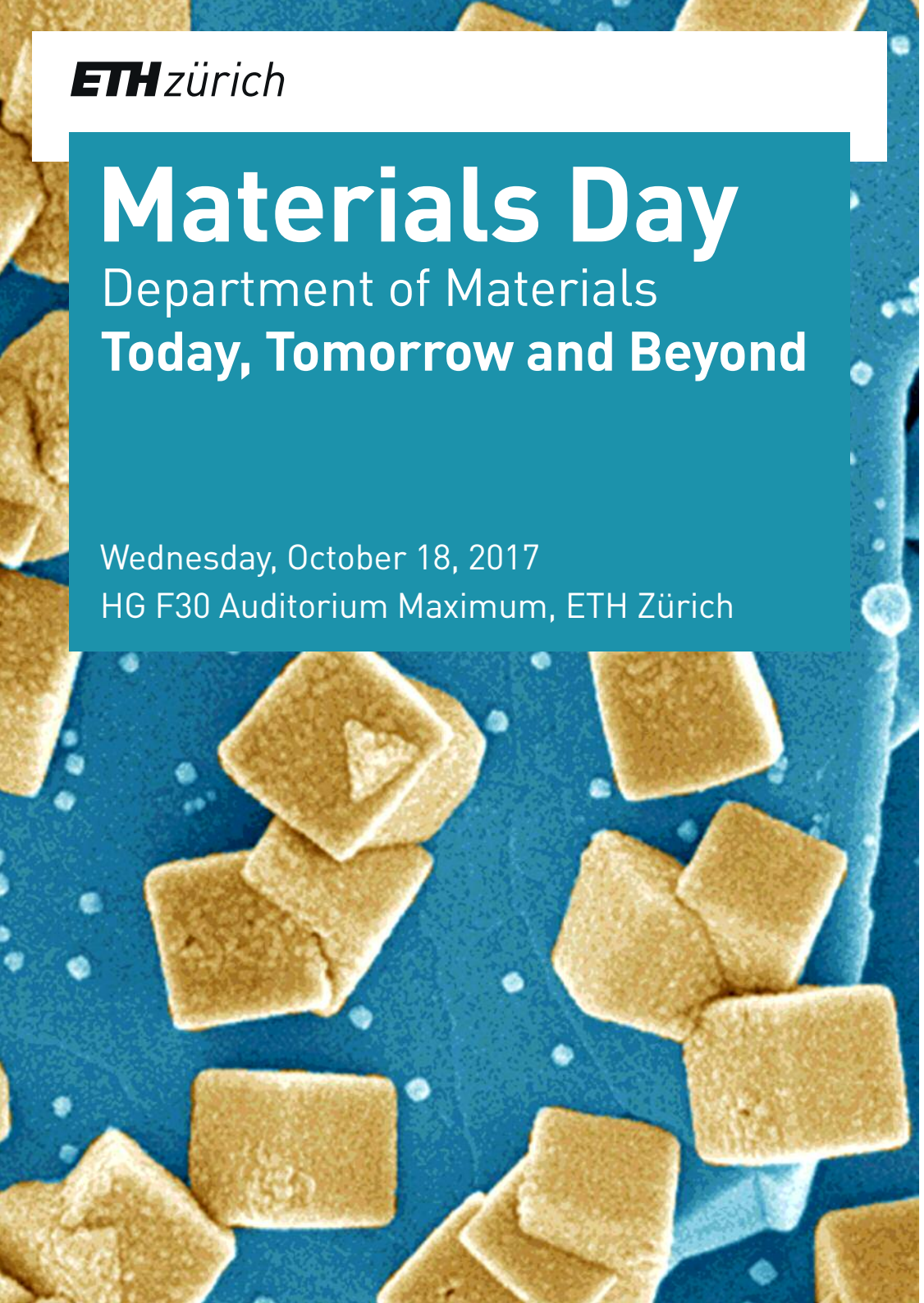


ETH zürich

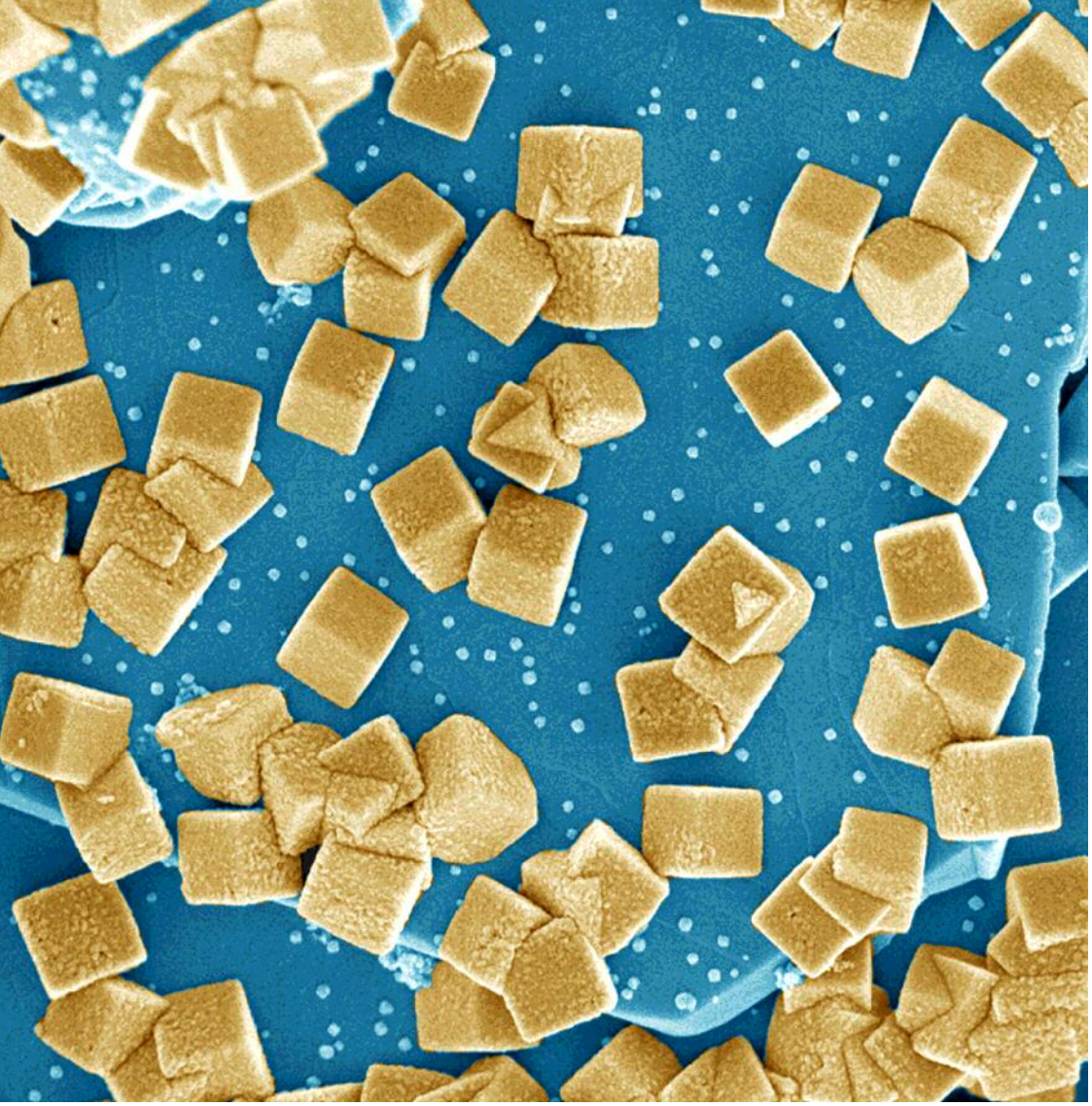
Materials Day

Department of Materials

Today, Tomorrow and Beyond

Wednesday, October 18, 2017

HG F30 Auditorium Maximum, ETH Zürich



Copper oxide nanocrystals grown on alumina microplatelets
Dr. Tobias Niebel (Group Complex Materials / 2016)

General Contact
ETH Zurich
Department of Materials
Leopold-Ruzicka-Weg 4
CH - 8093 Zurich
Switzerland
www.mat.ethz.ch

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Materials Today, Tomorrow, and Beyond
Materials Day: Wednesday, October 18, 2017

Developing materials is essential to addressing the grand technological challenges of the XXIst century. Without new materials and processes, advances in areas that we take for granted, ranging from biomedicine to telecommunications, energy storage, and manufacturing of complex structures will either not happen or not be sustainable.

The Materials Day is an opportunity to get to know the most advanced research directions in the Department of Materials at ETH Zürich during a one day symposium, which includes talks, prize, and poster sessions, as well as convivial opportunities for discussion over lunch and coffee.

Join us for a day of exciting insights into Materials Science!

Prof. Dr. Ralph Spolenak
Head of Department of Materials

Prof. Nicola Spaldin
Head of Materials Theory

09:10 – 09:30

Looking Beyond the Silicon Age

Every advance in human civilization, starting from the Stone Age through the Iron Age to the Silicon Age of today, has been driven by a development in materials. On a smaller time-scale, the ever-increasing standards of living that we are enjoying during our Silicon Age are enabled by ongoing improvements in the quality of the silicon material that forms the core of our microelectronic devices. But we face a crisis: Worldwide use of microelectronics is expanding so rapidly, that by many projections, silicon-based devices will consume half of our global energy supply within a few decades. And this is not sustainable.

I will describe new materials that we are developing in the Materials Department at ETH to circumvent this energy bottleneck in human progress, and to answer the question "What lies beyond the silicon age?"

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Materials Day, October 18, 2017

Prof. Markus Niederberger
Head of Laboratory for Multifunctional Materials

09:30 – 09:50

Nanoparticle-Based Aerogels: New Materials for Energy Storage and Conversion

Aerogels with their low densities, high porosities and large surface areas are unique and fascinating materials. Traditionally, they are synthesized by molecular routes based on aqueous sol-gel chemistry. In the last few years, the assembly of preformed nanoparticles as building blocks became a viable alternative to improve the crystallinity and to expand the structural, morphological and compositional complexity of aerogels. Unfortunately, the high brittleness strongly limits their use in the form of monoliths.

To solve this problem, the Laboratory for Multifunctional Materials pursues two strategies: Improvement of the mechanical properties by preparing composite aerogels and development of a flow reactor, which enables the use of aerogel samples in gas phase reactions under full preservation of the monolithic structure. The talk will present two illustrative examples for both strategies. Composite aerogels prepared from graphene oxide and molybdenum sulfide are structurally flexible and can be used as anode materials in lithium and sodium ion batteries. Aerogels composed of gold and titania nanoparticles are translucent and fragile, but can directly be studied as monoliths in a home-made flow reactor for photocatalytic CO2 reduction.

Notes

Prof. Manfred Fiebig

09:50 – 10:10

Head of Laboratory for Multifunctional Ferroic Materials

Shining Light on Oxide Electronics

Oxides can now be grown with an accuracy matching those of semiconductors. At the same time, they possess inherent functionalities that semiconductors can never develop, like long-range magnetic or electric order, superconductivity, "colossal" magnetoresistance and a profound oxygen chemistry. In our lab, we possess the tools to manufacture oxide heterostructures with atomic precision and well-tailored magnetoelectric properties, supported by advanced characterization and simulation tools. In particular, we apply laser-optical techniques for both probing and manipulating the multifunctional ferroic state. Rigorous consolidation of light-matter interaction and oxide electronics could become the key for leaving the semiconductor age behind.

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Materials Day, October 18, 2017

Prof. Nicholas Spencer

10:10 – 10:30

Head of Surface Science and Technology

Imitating Cartilage with Polymers

Cartilage represents an exquisite, natural tribological structure. It can withstand substantial loads (e.g. in our knees after Christmas), ensures low friction and negligible wear for decades, and does this without a blood supply! We don't yet know all the subtle secrets of cartilage, but those we know, we would like to imitate with synthetic polymers.

The short-term goal is that we will come up with new, highly lubricious materials that could have industrial applications. The long-term hope is that we will enable the fabrication of materials that can be implanted, to replace cartilage in knees and hips that has been damaged by injury or disease.

Notes

Prof. Ralph Spolenak

11:00 – 11:20

Head of Laboratory for Nanometallurgy

Self Organisation on the Nanoscale – A Pathway to Large Area Applications

In the past decade many advances in both mechanical as well as optical metamaterials have been made with feature sizes approaching the length scale of tens of nanometers. Most of these materials have been created by advanced lithography techniques making it too expensive in terms of cost and time to scale them up to industrially relevant areas. This contribution focuses on self organization to form nanostructures to enhance mechanical, electrical and optical properties with applications ranging from wear resistant coatings over arc resistant materials to epsilon-near-zero materials. The dominant principles of phase separation will be demonstrated on systems such as Ta-Cu, W-Cu, W-Mg, W-Al, Cu-Al, Ni-Au and Ag-Ge.

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Materials Day, October 18, 2017

Prof. Eric Dufresne

11:20 – 11:40

Head of Soft and Living Materials

Surface Stresses and Self-Assembly in Soft Solid Composites

The properties of materials are usually determined by the properties of molecules in the bulk. However, soft solids can be so weakly connected that their surface properties play a central role. I will describe two examples of the interplay of surface and bulk elastic stresses in soft solid composites. In the first, surface forces dominate the mechanical response of a solid composite. In the second, the competition of bulk and elastic forces drives the self-assembly of composite materials with a well-defined length scale.

Notes

Prof. Lucio Isa

14:00 – 14:20

Head of Interfaces, Soft Materials and Assembly

Active Colloids: Breaking the Symmetry to Introduce Propulsion

Breaking symmetry is at the very core of achieving propulsion at the microscale, and nature has perfected a range of different strategies to reach this goal for swimming microorganisms. Scientist continue to take inspiration from these examples to produce artificial micro-swimmers. A common way to achieve propulsion at the colloidal scale is to produce artificial particles that have asymmetric shapes and surface properties. We developed a new fabrication strategy to create micro-swimmers with full control on their geometrical and compositional asymmetry. The method is based on the sequential deposition of microspheres on topographical templates, where we independently define the swimmers' shape by defining the shape of template, and we program their composition by fixing the deposition sequence. I will show how we can use this fabrication strategy to design and obtain particles that translate, rotate, switch between these two modes of motion and even perform drag-and-drop tasks in crowded environments, propelled by uniform AC electric fields. These results show how the design of micro-swimmers can enable the development of active components for the realization of autonomous miniaturized machines working in complex environments.

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Materials Day, October 18, 2017

Prof. Jörg F. Löffler

14:20 – 14:40

Head of Metal Physics and Technology

Correlated Atomic-Scale Analysis Drives the Future of Materials Development

The development of new materials and the understanding of their microstructure-property relations often rely on studies where atomic resolution can be achieved. Apart from atom-probe tomography, such resolution is nowadays also obtained by transmission electron microscopy thanks to the advent of spherical aberration corrections coupled to large-angle X-ray detectors. New MEMS-based experimental capabilities also allow for atomic-scale in situ investigations in dependence of temperature, chemistry, etc. We will illustrate how a basic understanding of the structure and dynamics on the atomic scale via correlated microscopy and tomography can drive the future of materials development. Examples will be given primarily from the metals area, involving metastable phase formation for new materials creation, detailed understanding of age-hardening in light metals, improvement of magnetic systems, and the generation of new biomaterials.

Notes

Prof. Hans Christian Öttinger
Head of Polymer Physics

14:40 – 15:00

Do Interfacial Material Properties Exist?

Considering coexisting phases, say a liquid and its vapor, one can ask the following questions: Can the temperature of an interface be different from the temperatures of the adjacent bulk phases, even if they are less than a nanometer away? Can the interface possess a viscosity that is independent of the properties of the surrounding bulk fluids? Conceptual clarifications are of obvious importance for guiding both modeling efforts and experiments at interfaces.

Notes

Materials Day, October 18, 2017

Prof. Laura Heyderman
Head of Mesoscopic Systems

15:00 – 15:20

The Magic of Mesoscopic Magnets

Reducing a magnet's size to below a micrometre can result in surprising behaviour. For example, a magnet has a north and a south pole and, if you cut it in half, you get two magnets, each with its own north and south pole. However, in artificial spin systems made from nanoscale magnets arranged on various lattices, it is possible to separate the poles using a magnetic field, and let them travel through the system along a one-dimensional path. This and other curious phenomena involving mesoscopic magnets will be presented. Such effects are not only of fundamental interest, but can be harnessed for a wide variety of applications, including data storage and transfer, communications, sensors and actuators.

Notes

Prof. Pietro Gambardella

16:10 – 16:30

Head of Magnetism and Interface Physics

The Art of Magnetic Writing

Modern computing technology is based on our ability to write, store, and retrieve digital information as efficiently as possible. Magnetic bits miniaturized to less than a millionth part of a human hair allow us to store Terabytes of digital information for a period of years. The state of a magnetic bit, however, is still controlled by means of magnetic fields produced by wires and coils, a 200-year old methodology that has severe limitations in scalability and energy efficiency. In this talk, I will describe a paradigmatic change in magnetic switching, which emerges in materials with strong spin-orbit interaction. Our findings have applications in ultrafast magnetic random access memories with high endurance.

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Prof. André Studart

16:30 – 16:50

Head of Complex Materials

3D Printing of Biologically-Inspired Composites

Composite materials in nature exhibit heterogeneous architectures that are tuned to fulfill the functional demands of the surrounding environment. Examples range from the cellulose-based organic structure of plants to highly mineralized collagen-based skeletal parts like bone and teeth. Because they are often utilized to combine opposing properties such as strength and low-density or stiffness and wear resistance, the heterogeneous architecture of natural materials can potentially address several of the technical limitations of artificial homogeneous composites. However, current man-made manufacturing technologies do not allow for the level of composition and structural control found in natural heterogeneous systems. In this talk, I will show that 3D Printing offers a new exciting pathway for the fabrication of biologically-inspired composite materials with unprecedented heterogeneous architectures and functionalities.

Notes

Prof. Jan Vermant
Head of Soft Materials

16:50 – 17:10

Engineering Soft Materials: Interfacial Design

Foams, emulsions, polymer-polymer systems as well as biological cells all rely on the presence of a stabilising interface. In this talk we will discuss the advances made to study and describe the mechanical and rheological properties of such interfaces and how novel processing techniques enable us to generate materials with designer interfaces. Such materials have applications from classical materials science, over food and biomedical technology to the field of materials for energy. We will give a few examples of hopefully eye-catching applications.

Notes

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October 2017

Programm

08.00 **Registration** Participation is free of charge but registration is required
09.00 **Opening address** Prof. Ralph Spolenak
09.10 **Looking Beyond the Silicon Age** Prof. Nicola Spaldin
09.30 **Nanoparticle-Based Aerogels: New Materials for Energy Storage and Conversion** Prof. Markus Niederberger
09.50 **Shining Light on Oxide Electronics** Prof. Manfred Fiebig
10.10 **Imitating Cartilage with Polymers** Prof. Nicholas Spencer
10.30 *Coffee Break*
11.00 **Self Organisation on the Nanoscale-A Pathway to Large Area Applications** Prof. Ralph Spolenak
11.20 **Surface Stresses and Selb-Assembly in Soft Solid Composites** Prof. Eric Dufresne
11.40 **ETH Materials Research Prize**
12.30 *Lunch & Poster Session*
14.00 **Active Colloids: Breaking the Symetry to Introduce Propulsion** Prof. Lucio Isa
14.20 **(Talk by Dr. Robert Schäublin) Correlated Atomic-Scale Analysis Drives the Future of Materials Development** Prof. Jörg F. Löffler
14.40 **Do Interfacial Material Properties Exist?** Prof. Hans Christian Öttinger
15.00 **The Magic of Mesoscopic Magnets** Prof. Laura Heyderman
15.20 *Coffee Break & Poster Session*
16.10 **The Art of Magnetic Writing** Prof. Pietro Gambardella
16.30 **3D Printing of Biologically-Inspired Composites** Prof. André R. Studart
16.50 **Engineering Soft Materials: Interfacial Design** Prof. Jan Vermant
17.10 **Closing remarks** Prof. Ralph Spolenak
17.20 *Apéro*