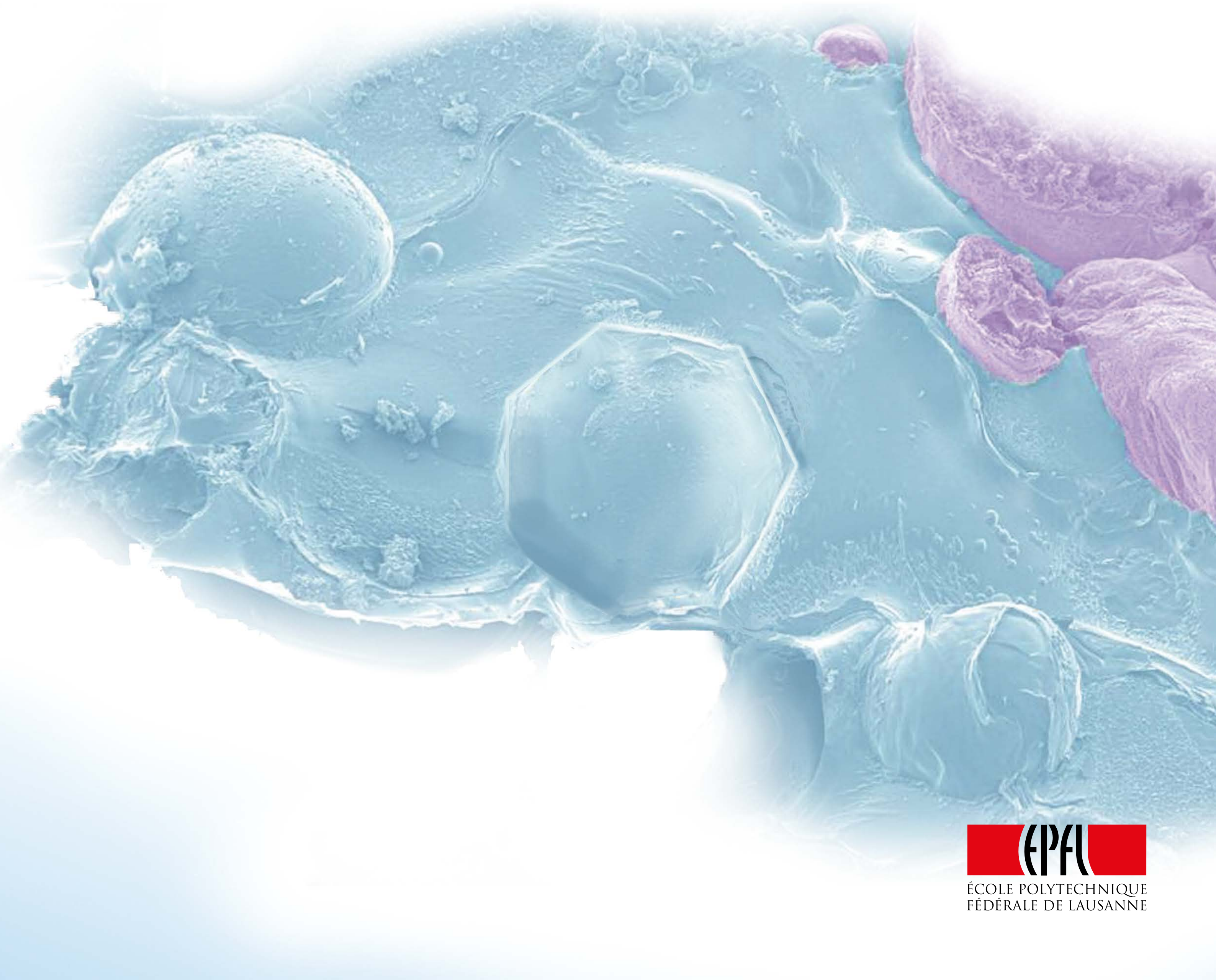
MATERIALS SCIENCE AND ENGINEERING



ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

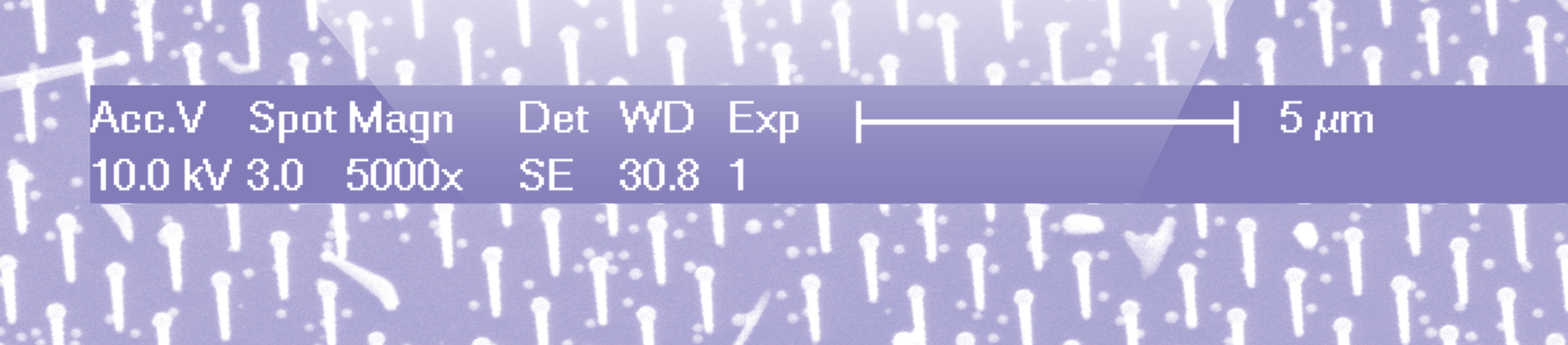
Materials very often set the bounds for what can be achieved by man. Materials Science and Engineering aims to push these bounds by investigating, understanding and engineering the relations that exist between the microstructure, the synthesis and processing, the properties, and the performance of all materials, i.e. of what we make all engineered structures from. It is a highly multi-disciplinary field, situated at the forefront of modern science and technology.

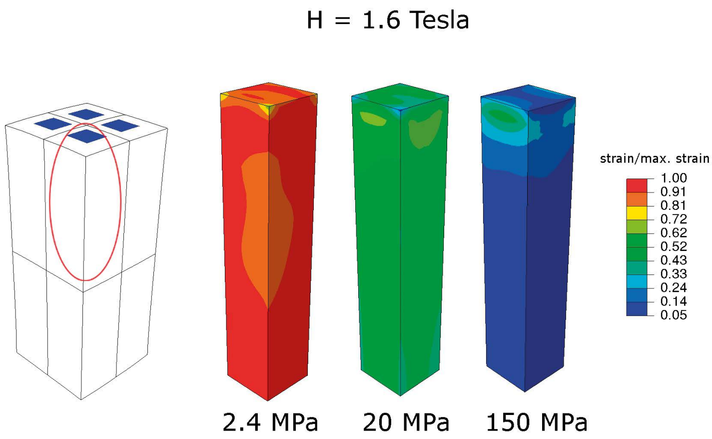
Semiconductor nanowires for next generation electronics and solar cells

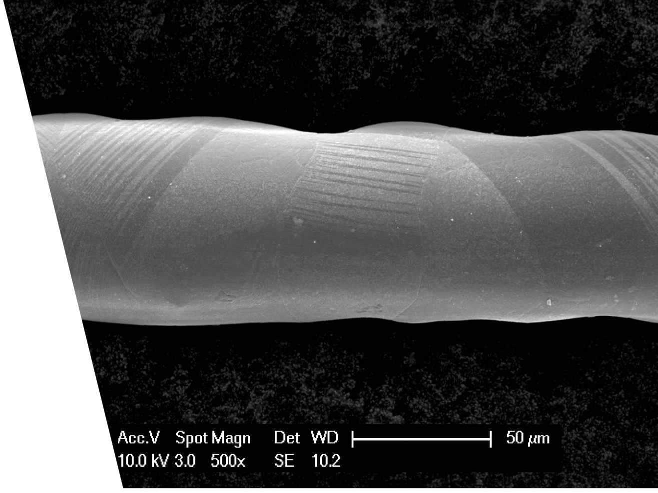
Our laboratory synthesizes semiconductor materials in the form of nanostructures, which can be nanowires, nanoscale membranes, quantum wells and quantum dots. We then investigate the novel properties arising from the nanoscale nature of our materials. For the synthesis we use molecular beam epitaxy, which serves us as a model to understand the key issues for producing high quality materials. For the characterization we use photoluminescence, Raman spectroscopy, electronic transport and high resolution transmission electron microscopy related techniques.

Semiconductor nanostructures find applications in the area of optoelectronics, information science and technology, biotechnology, and energy harvesting. Our principal interest lies in the use of nanoscale materials for next generation of energy harvesting devices.

Anna Fontcuberta
Assistant Professor



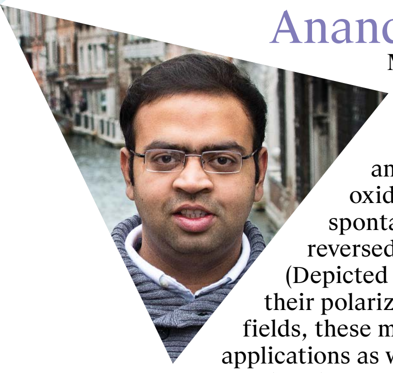




Susanne Glock

Shape memory alloys are able to change their shape in a controlled manner when subjected to an external stimulation. This behaviour generally results from a solid state phase change from a parent phase at higher temperature to a martensitic phase at lower temperature. The slow kinetics of heat transfer, however, limit the thermal activation to a range of 1Hz. Magnetic shape memory alloys are a sub-group of thermal shape memory alloys that can change their shape under magnetic activation and damp well as mobile twins are present , making them promising candidates for applications requiring damping or isothermal, high frequency actuation. An interesting candidate is Ni-Mn-Ga with a magnetic field induced strain (MFIS) caused by twinning of up to 10 %. Polycrystalline Ni-Mn-Ga, however, is brittle and grain boundaries hinder twinning and suppress MFIS. Single crystals of Ni-Mn-Ga, on the other hand, are expensive to produce. In my thesis, the limitations of polycrystals are overcome by developing composites of Ni-Mn-Ga wires or powders embedded in a polymer matrix. In wires or powders with grains as large as the element diameter, twin boundaries span across entire grains and are mobile, resulting in a large MFIS. Such elements can then be embedded in a polymer matrix to form a material that can be handled and shaped easily. Several main aspects are addressed both experimentally and through modelling: optimisation of the composite microstructure, processing, damping and actuation. Interfacial properties are analysed and showed that a silane treatment of the wires improves adhesion, in turn leading to a more durable material response. Wire based composites are shown to be more efficient for damping and energy dissipation than powder based composites, as the loss ratio is high and the overall storage modulus of wire composites is higher than of powder composites. Model systems with single crystal rods have shown a good potential for actuation and illustrated the requirement of a careful matching of the matrix stiffness to allow large deformations.

Anand Chandrasekaran



Multifunctional oxides have a broad range of physical properties that are being studied for possible use in memory and logic devices, solar energy conversion, actuators, sensors and energy harvesting devices. Many of these oxides exhibit ferroelectricity; i.e. they have a spontaneous electric polarization which can be reversed by the application of an external electric field (Depicted in Fig. 1). Owing to the large coupling between their polarization/strain states and external electric/stress fields, these materials are of great interest for technological applications as well as fundamental research.

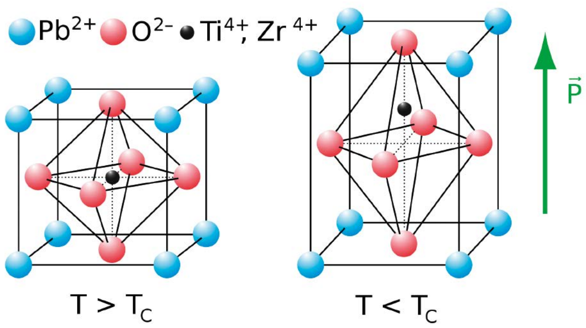


Figure 1. Structural transition from a paraelectric cubic phase to a ferroelectric tetragonal phase in Lead Zirconate Titanate.

Ferroelectric materials used in practical applications exhibit deviations from a perfect crystalline order, and are most often composed of multiple crystalline regions with unique orientations. A domain wall is an interface which separates two such regions having different directions of polarization (Shown in Fig.2). These quasi-two-dimensional objects display uniquely distorted electronic structures and ionic displacement. The movement of these interfaces contributes upto 50% of the dielectric and piezoelectric response and there is an ongoing effort to control the nucleation, motion and properties of these mobile interfaces at the nanoscale level in such a way that they may be used readily in devices.

In my project I investigate the structure and mobility of these domain walls through a combination of experiments and first-principles modelling. Using ab initio calculations, we developed an understanding of the atomistic structure of these domain walls and their interaction with defects. Through experiments, we then observed how these nano-scale interactions dramatically influence macroscopic properties. Using this unique combination of modelling and experiments we hope to unravel the science to inspire the next generation of ferroelectric and piezoelectric domain engineered materials.

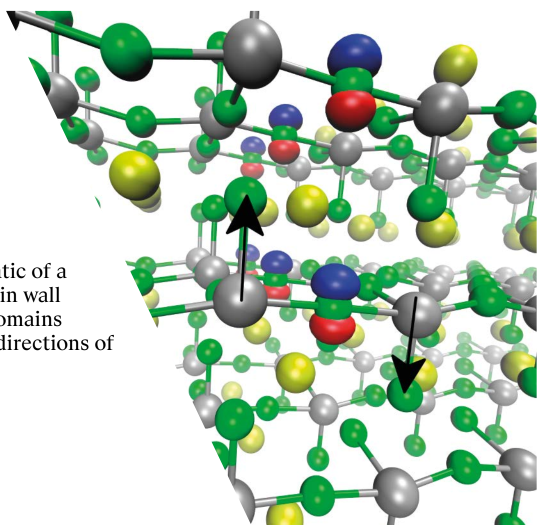


Figure 2. Schematic of a 180 degree domain wall separating two domains having different directions of polarization.

Presentation

Materials Science and Engineering is a strong focus of research at EPFL, and many doctoral candidates are pursuing their thesis in the discipline. The EPFL Doctoral Program in Materials offers the entryway, contacts to interesting research groups in and outside EPFL, and advanced courses for EPFL's doctoral students.

Research

Research in Materials Science and Engineering at EPFL encompasses essentially all classes of materials including metals, ceramics, polymers, construction materials, semiconductors and composites, aimed at a wide array of applications that span from nano-scale devices over hot blades of aircraft turbines to biomedical devices. Laboratories active in Materials Science and Engineering at EPFL comprise the twelve laboratories of EPFL's Institute of Materials and many laboratories within other research Institutes of the School of Engineering Sciences, the School of Basic Sciences, the School of Architecture, Civil and Environmental Engineering.

Approx. 140 doctoral students

Application Process

You need to complete and submit the EPFL doctoral school online application form on the following link:

http://phd.epfl.ch/application

Beforehand, we encourage you to surf the EPFL Doctoral School and EDMX program webpages:

http://phd.epfl.ch/EDMX

Application deadlines: **January 15, July 31**

General Information

The typical duration of the program is four years.
Students can start the program at any time of the year.

Research Areas

- Metallurgy
- Ceramics
- Polymers and composite
- Construction materials
- Structural materials
- Functional materials
- Materials processing
- Modelling and simulation
- Nanostructured materials
- Materials characterisation
- Surface science and engineering
- Biomaterials

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