TUT 2: Tutorial: Ferroics (DF with MA/TT)

This tutorial introduces the field of domain and domain-wall engineering, key concepts and materials, and launches our 3-days focus on ferroic domain walls. The tutorial will provide a forum for non-specialists to get informed / involved and, at the same time, aims at inspiring topical discussions to stimulate a vivid scientific exchange during the following Sypmosium (SYDW), the three Focus Sessions and a Poster Session.

Organizers: Elisabeth Soergel (Universität Bonn) and Dennis Meier (ETH Zürich)

Time: Sunday 16:00–18:30 Location: H 0107

Tutorial TUT 2.1 Sun 16:00 H 0107

Fundamentals of ferroelectric materials — •Susan Trolier-McKinstry — Penn State University, University Park, PA, USA

This tutorial will cover the fundamental phenomena that underpin the field of ferroelectricity, with an emphasis on the relationship between crystal structure and the allowed domain states. An introduction will be made to ferroelectricity, pyroelectricity, piezoelectricity, and the origins of the dielectric response. The crystal structures of key materials, including perovskites, $LiNbO_3$, the tungsten bronzes, and polymer ferroelectrics will be introduced, along with the link between the loss of symmetry elements and the allowed domain states. The tutorial will conclude with an introduction to the movement of domain walls, and the influence that this has on the properties of ferroelectric materials.

Tutorial TUT 2.2 Sun 16:50 H 0107

Domain walls in multiferroics as functional oxide interfaces — •Manfred Fiebig — Department of Materials, ETH Zürich, Vladimir-Prelog-Weg 4, 8093 Zurich, Switzerland

The functionality of any ferroic material depends on its domains. Consequently, their shape and manipulation in external fields are of major research interest. In compounds uniting magnetic and electric order in the same phase, the magnetoelectric coupling on the level of the domains is, however, largely unexplored. For such so-called multiferroics it is therefore not known how exactly electric or magnetic fields affect the multiferroic domains and their walls. In my talk I will discuss this issue and focus on the influence of the multiferroic order on the ferroelectric state and its domain walls. Examples I will include are: (i) multiferroics with geometric ferroelectricity such as hexagonal $YMnO_3$ where the domain walls exhibit anisotropic conductance and can therefore be regarded as "tunable oxide interfaces"; (ii) multiferroics with magnetically induced ferroelectricity such as $MnWO_4$ or $TbMnO_3$ where the electric polarization within the wall is expected to rotate instead of passing through zero, as in conventional displacive ferroelectrics; (iii) multiferroics with strain-induced ferroelectricity like $SrMnO_3$ where the interplay of strain and oxygen vacancies leads to polar state in which domain walls act as insulating boundaries to the conducting domains.

Tutorial TUT 2.3 Sun 17:40 H 0107

Ferroelastic templates for multiferroic domain boundaries — •Ekhard Salje — University of Cambridge, Cambridge, UK

The field of Domain Boundary Engineering is introduced. Ferroelastic domain pattern are derived and their dynamical behaviour is deducted from experimental observations and computer simulations. It is then shown that twin boundaries are particularly easily modified to possess functional properties that do not exist in the bulk. Such functional properties include (super-) conductivity, ferroelectricity, and ferromagnetism. In addition, chemical mixing inside domain walls can generate novel chemical compounds. This effect is refereed to as 'Chemical Mixing in Confined Spaces'. Functionalities often generate chiralities and vortex structures in domain boundaries. It is shown that chirality (in order parameter space) leads to Bloch lines and vortex points as one- and zero-dimensional domain walls embedded in two-dimensional ferroelastic domain walls and are hence walls in walls. Examples in $CaTiO_3$ and $SrTiO_3$ are discussed.

[1] E.K.H. Salje, Ferroelastic Materials, Annual Review of Materials Research, 42, 265-283 (2012)
[2] E.K.H. Salje and K.A. Dahmen, Crackling Noise in Disordered Materials, Annual Review of Condensed Matter Physics, 5, 233-254 (2014)
[3] E.K.H. Salje, Multiferroic Domain Boundaries as Active Memory Devices: Trajectories Towards Domain Boundary Engineering, Chem. Phys. Chem., 11, 940-950 (2010)
[4] D.D. Viehland and E.K.H. Salje, Domain boundary-dominated systems: adaptive structures and functional twin boundaries, Advances in Physics, 63, 267-326 (2014)