DF 2: Symposium on Ferroic Domain Walls

Time: Monday 9:30–12:30 Location: H 0105

Invited Talk DF 2.1 Mon 9:30 H 0105

Domain walls: from conductive paths to technology roadmaps — •Gustau Catalan — ICREA-Institucio Catalana de Recerca i Estudis Avançats, Barcelona — ICN2-Institut Catala de Nanociencia i Nanotecnologia, Campus UAB, Bellaterra, Barcelona

In this talk, I would like to give a bird's eye view of the field of domain wall nanoelectronics, starting from some basic physics, through a summary of the state of the art, and finishing with a brief and non-exhaustive discussion of unresolved problems. Topics will include the origin(s) of conductivity in perovskite domain walls, the internal phase diagram of domain walls, the interaction of domain walls with other interfaces, how much do we (not) know about the structure, energy cost and dynamics of domain walls, and some strategies for controlling their nucleation and motion.

Disclaimer: The talk will cover much ground in a short time, and will include many results and ideas that are not mine; important works may be misrepresented or underrepresented. I apologize in advance.

Invited Talk DF 2.2 Mon 10:00 H 0105

Domain walls and oxygen vacancies - towards reversible control of domain wall conductance — •Patrycja Paruch — Department of Quantum Matter Physics, University of Geneva, Switzerland

In ferroelectric materials, domain walls separate regions with different polarisation orientation, and can present novel functional properties quite different from those of the parent phase. The extreme localisation of such properties at these intrinsically nanoscale features makes them potentially useful as active components in future miniaturized electronic devices.

Particularly exciting has been the discovery of domain-wall-specific electrical conductivity, shown first in multiferroic $BiFeO_3$. I will present our observation of conductance at 180° domain walls in the simpler ferroelectric $Pb(Zr,Ti)O_3$, using a range of scanned probe microscopy techniques at different time scales.

Our measurements highlight the key role of surface adsorbates and oxygen vacancies, and show how their density and distribution can be modulated to reversibly control domain wall transport. Exploring the conductance of the domain walls under both direct and alternating current regimes, we also address the question of maximum packing density of individual current channels in epitaxial ferroelectric thin films.

Invited Talk DF 2.3 Mon 10:30 H 0105

Novel mechanisms of domain-wall formation — •Andres Cano — CNRS, Univ. Bordeaux, ICMCB, F-33600 Pessac, France

Domain walls in ferroic materials are inherent interfaces separating different ordered regions. They can exhibit specific properties radically different from those of the corresponding domains. I will discuss two novel (and, achtung!, unrelated) mechanisms for the formation of domain walls in (multi-)ferroics:

- In conventional ferroelectrics like $BaTiO_3$, the desirable enhancement of ferroelectricity at metal-oxide interfaces can in fact promote the appearance of ferroelectric domain walls in nanoscale capacitors. I will discuss the various factors that control the physics behind this surprising phenomenon (e.g. interfacial energy vs. ferroelectric stiffness).
- In improper ferroelectrics like the hexagonal $RMnO_3$ manganites, I will show that the emergence of multiferroic domain walls (and more complex topological defects) can be rationalized in terms of different residual-symmetry-breaking mechanisms associated to the primary order parameter.

Coffee break

Invited Talk DF 2.4 Mon 11:30 H 0105

Novel materials at domain walls — •Beatriz Noheda — Zernike Institute for Advanced Materials, Groningen, The Netherlands

There is a growing need to control and improve the physical responses of useful electronic materials, as well as to induce additional functionalities of significance for applications. Domain wall nanoelectronics has been proposed as a suitable route to achieve such control at the smallest scales. Addressing the domain wall functionalities, in particular those of ferroelastic domain walls, we take advantage not only the intrinsic symmetry breaking that takes place at the wall but also of the strain gradients that are associated to these walls. The possibility to generate periodic arrays of domain walls by self-assembly during epitaxial growth is an added benefit. I will show that, depending of the chosen thin film material, the local stresses that develop locally around ferroelastic domain walls can either trigger local electrochemistry or give rise to atomic arrangements that cannot be obtained by other existing routes, generating novel 2D materials with distinct nanoscale functionalities.

The works presented here are in collaboration with S. Farokhipoor, C.J.M. Daumont, D. Rubi, C. Magén, E. Snoeck, S. Venkatesan, A. Müller, M. Döblinger, C. Scheu, J. Íñiguez, M. Mostovoy and C. de Graaf.

Invited Talk DF 2.5 Mon 12:00 H 0105

Controlling and mapping domain wall behaviour in ferroelectrics — •John Martin Gregg[1], Jonathan Whyte[1], Raymond McQuaid[1], Michael Campbell[1], Amit Kumar[1], and Roger Whatmore[2] — [1]Queens University Belfast, Belfast, Northern Ireland, UK — [2]Imperial College London, London, England

Over the last decade there has been an explosion of interest in sheet conductors, such as surface states in topological insulators [1], $LaAlO_3$-$SrTiO_3$ interfaces [2] and graphene. Recent research has shown that ferroic domain walls constitute another exciting group of 2D conductors, with probably even greater potential than those already known: after all, domain walls have special properties in that they are mobile, can be controllably shunted from point to point, and can be spontaneously created, or made to disappear. Luckily for the research community, the field of domain wall nanoelectronics [3] is still young and there is consequently a great deal left to discover.

In this talk, the extent to which ideas developed in the nanomagnetics community can be adapted to allow domain wall injection [4] and motion control in ferroelectrics, as needed for domain wall-based devices, will be discussed. In addition, results from experiments to determine the fundamental nature of conduction in both boracite and manganite domain walls will be presented.

[1] H. Zhang et al. Nature Physics 5, 438 (2009)
[2] A. Ohtomo and H. Y. Hwang, Nature 427, 423 (2004)
[3] G. Catalan et al. Rev. Mod. Phys. 84 119 (2012)
[4] J. R. Whyte et al. 26, 293 (2014)