Electronic properties of ferroelectric domain walls

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Perovskite oxides, materials with the simple chemical formula ABO_3 (where A and B are positively charged cations), can exhibit a vast range of phenomena, including ferroelectricity, high-temperature superconductivity, and magnetism. Due to their structural compatibility, perovskite oxides can be thought of as LEGO blocks: they can be stacked on top of each other using thin film growth techniques, creating artificial interfaces that can exhibit completely new phenomena that are absent in the bulk materials [1].

As well as these artificially engineered interfaces, ferroelectric perovskite oxides (materials that possess a switchable spontaneous polarisation) can exhibit naturally occurring interfaces, such as ferroelectric domain walls. Domain walls are nanoscale sheets that appear between regions of differently oriented polarisation and can have different properties than the ferroelectric itself, including conductivity in an otherwise insulating bulk material and magnetic order in a non-magnetic matrix. Understanding the fundamental properties of ferroelectric domain walls and developing reproducible methods for their creation and control is therefore imperative for exploitation of their novel properties [2-4].

Despite the interest in the functionality of domain walls, little is known about their intrinsic electronic properties. The aim of this project is to unveil these characteristics of domain walls and understand their fundamental behaviour, to determine whether their behaviour as a function of doping resembles other bulk systems [5,6], and whether unconventional behaviour can be induced in these nanoscale two dimensional sheets.

The research will be carried out in the Physics Department at Warwick, where we will study the fundamental electronic properties of ferroelectric domain walls in oxide single crystals, thin films and multilayers. The PhD student will learn to deposit oxide multilayers using advanced thin film growth techniques, including pulsed laser deposition and off-axis radiofrequency magnetron sputtering. They will characterise these systems using a broad range of state-of-the-art characterisation methods, including x-ray diffraction, electronic transport and magnetic measurements at low temperatures, piezoresponse and magnetic force microscopy, and impedance spectroscopy. The student will also have the opportunity to perform experiments at various large-scale facilities, including Diamond Light Source (Didcot, UK) and the European Synchrotron Radiation Facility (Grenoble, France), and will benefit from numerous international collaborations.

If you are interested in this project, please contact me at marios.hadjimichael@warwick.ac.uk

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[5] Hadjimichael et al., *APL Materials* **10**, 101112 (2022)
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