Domains in Ferroic Crystals and Thin Films

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Preface

With much excitement and great enthusiasm I introduce this thorough treatise on the major aspects of domain and domain wall phenomena in ferroics, mostly ferroelectrics, a major achievement for which there has been a long-standing need.

Ferroelectric materials possess spontaneous electrical polarization which is stable in more than one orientation and can be reoriented (switched) by an applied electric field. This property and its typical derivative characteristics, e.g., high piezoelectric response and large permittivity, make ferroelectrics exceedingly useful in diverse applications such as non-volatile memories, ultrasonic medical imaging, micro-electromechanical systems, and reconfigurable high-frequency electronics.

Typically, a ferroelectric material is divided into domains, which are regions in the material that are polarized in one of the symmetry-permitted polarization directions. The interfaces between adjacent domains, the domain walls, have a typical thickness of 1–2 unit cells. The behaviors of domains and domain walls are fundamental to ferroelectrics and dominate their properties: poling of ferroelectric ceramics, namely electrical aligning of the polar direction of ferroelectric domains, is essential for piezoelectric activity; periodically poled crystals are used as nonlinear optic materials for which the width of the inverted domains controls the desired wavelength of operation. The high permittivity of ferroelectrics widely used in capacitors is dominated by domain wall contributions, and domain wall dynamics is responsible for some 50% of the piezoelectric response in standard transducers and actuators.

Considering the vital role of domains and domain walls, the substantial body of data, and the resultant theoretical knowledge, it is surprising how limited is the space given to this subject in the classical books on ferroelectric materials. Even recent books rarely dedicate entire chapters to this topic. Meanwhile the importance of domains and domain walls is growing. Thus the study and manipulation of domain walls can be achieved with much enhanced detail using new techniques such as piezoelectric force microscopy; new thin-film growth techniques allow the control of their position, spacing, and response, and new computation methods aid in revealing their further potential.

It is therefore very timely for the ferroelectric community and for students and researchers interested in the field of ferroelectrics that the three most prominent authorities in the field have united to write this major book on ferroelectric domains in single crystals, ceramics, and thin films, covering all the important aspects of the field: basic theoretical descriptions of structural phase transitions that emphasize the symmetry and phenomenological aspects of their classifications, an overview of typical ferroic materials, a survey of experimental methods used to visualize domain patterns, aspects of domain formation and their typical shapes, and the static properties of domain walls are all addressed. A large section of the book covers theoretical and experimental aspects of switching and polarization response and overviews comprehensively domain-related properties of ferroelectric thin films.

This book will be of central importance to anyone interested in ferroelectrics and their applications: graduate students of materials science, physics, chemistry, mechanical and electrical engineering, as well as scientists and engineers, whether new to the field or simply in need of a systematic and thorough review of the vast, useful, and fascinating field of ferroic domains.

Nava Setter
7.2009, Lausanne

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