Preface

During the past two decades, revolutionary breakthroughs have occurred in the understanding of ferroelectric materials, both from the perspective of theory and of experiment. First principles approaches, including the Berry phase formulation of ferroelectricity, now allow accurate, quantitative predictions of material properties, and single crystalline thin films are now available for fundamental studies of these materials. In addition, the need for high dielectric constant insulators and nonvolatile memories in semiconductor applications has motivated a renaissance in the investigation of these materials.

In this book, we present the modern physics of ferroelectricity in oxides through a set of chapters on topics that collectively represent some of the key advances and innovations over the last thirty years. After the introductory chapter, the next four contributions by *Resta* and *Vanderbilt*, *Chandra* and *Littlewood*, *Rabe* and *Ghosez*, and *Spaldin* together cover the main recent theoretical developments in the field. In contrast, the following three contributions by *Posadas* et al., *Lichtensteiger* et al. and *Paruch* et al. comprise a highly selective presentation of experimental developments, giving illustrations of what can be achieved using the high quality epitaxial oxide films that can be obtained using the advanced deposition techniques described in the contribution by *Posadas* et al. We have chosen to focus on this particular area, as it is not possible in one book to cover the entire large body of recently obtained results on new materials using new experimental techniques. At the end of this book, the interested reader will find handy tables containing key material properties and useful substrates and growth methods.

We would like to emphasize that this book should not be regarded as covering the same breadth of subject matter as the classic book by *Lines* and *Glass* (*Principles and Applications of Ferroelectrics and Related Materials*) which so definitively codified the knowledge of the first "Golden Age" of research in ferroelectric oxides, but rather as a complement that brings the reader from that sound foundation up to the present. Completely new topics include the modern theory of polarization (*Resta* and *Vanderbilt*), first principles studies of ferroelectrics (*Rabe* and *Ghosez*), and the novel physics of nanoscale ferroelectric structures and probes, including ultrathin ferroelectric films and short-period superlattices (*Posadas* et al., *Lichtensteiger* et al., *Paruch* et al. and Appendix B). New perspectives transform the presentation of the phenomenological Landau-Devonshire theory in the contribution of *Chandra* and *Littlewood* and in Appendix A, and the discussion of the relationship between ferroelectricity and ferromagnetism by *Spaldin*. Indeed, in this latter contribution, we will see that reexamination of the physics of magnetic ferroelectrics in the current context has led to a lively renaissance for research in the design, synthesis, characterization and theory of so-called “multiferroic” materials.

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Rutgers University, Piscataway NJ, USA *Karin M. Rabe*
Yale University, New Haven CT, USA *Charles H. Ahn*
University of Geneva, Geneva, Switzerland *Jean-Marc Triscone*

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