Preface

Multiferroic materials exhibit significant potential applications in the fields of novel multifunctional magnetic-electric devices, spintronics devices, and high performance information storage and processing, etc. Besides, multiferroic has become a hot topic due to its rich connotation in condensed matter physics concerning charge, spin, orbital, and lattice.

The possibility of an intrinsic magnetoelectric (ME) effect in some crystals had been predicted by Pierre Curie in 1894. The research on magnetoelectric physics and materials was quite slow in the whole twentieth century due to the rare of magnetoelectric materials and the poor magnetoelectric performance. Schmid coined a new terminology of multiferroics in 1994, which denotes the coexistence of multiple ferroic (ferroelectric, ferromagnetic and ferroelastic) orders in a single-phase material. The research on multiferroic materials resurged because of the two unexpected breakthroughs (epitaxy $BiFeO_3$ thin films and $TbMnO_3$) in 2003. It stimulated numerous subsequent investigations on single-phase multiferroic, multiferroic composites, and multiferroic heterostructures (oxides and metallic/ferroelectric).

What is this Book?

The book presents a unified summary of multiferroic materials, multiferroic simulations and multiferroic prototype devices. Specifically, it covers a broad variety of multiferroic materials, including single phase multiferroic, oxides and metallic/ferroelectric multiferroic heterostructures, bulk, thin film and nanostructure multiferroic materials. And for each family of materials, their magnetoelectric coupling mechanisms and multiferroic simulations (first-principle calculation, phase simulation and theoretical modes of ME coupling in multiferroic heterostructures) are also extensively discussed. Some prototype devices, including tunable RF/microwave devices (antenna, inductor, bandpass/stop filters and phase shifter), multiferroic memories, multiferroic sensors and integration of multiferroics on chip were presented. Novel multiferroic composites and devices were also prospected. Given these rich contents, it provides readers an introductory overview of multiferroic materials and devices, both beneficial for beginner and experienced researchers. I believe that such a book will invaluable reference for the multiferroic community.

Meanwhile, there are numerous reviews on single-phase multiferroic, multiferroic composites, or multiferroic heterostructures, respectively. Theoretical

modes and prototype devices were briefly mentioned in these reviews. Books introducing widespread multiferroic materials and prototype devices together with the required basics and theory are rare. With this book, we fill this gap.

Why this Book?

The book is aimed at advanced undergraduate and graduate students of the materials science, electronic devices design and physics. Since these are usually recruited from most natural sciences, i.e. physics, materials, electronic devices, we addressed the book to this readership. Readers would definitely profit from a sound knowledge of materials and physics. However, all authors are engaged in materials science, physics and electronic devices for many years and achieved outstanding achievements in these field. Hopefully, you will find that they came upon good solutions. In case you see room for improvement, please let me know.

Is this Book for You?

Students, who require an in-depth knowledge, should begin at their level of knowledge, either in Chapters 1 (Introduction to multiferroics and its application) or 2 (Multiferroics materials). To deeply understand the physical mechanism of magnetoelectric coupling effect and simulations of multiferroic materials. Then, they should proceed through Chapters 3 (Mechanisms of multiferroic material) and 4 (Multiferroic simulations). Chapters 5–8 introduce the application and prototype devices of multiferroic materials and Chapter 9 prospects the novel multiferroic composites and devices. They should be studied according to interest and requirement.

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