Preface

There is a paradigm shift in our understanding of the properties and behaviour of complex functional materials with multiple ordered phases and competing interactions. One novel aspect is that the underlying lattice provides an elastic template on which charge, spin, dipolar and other degrees of freedom couple to provide a number of emergent functionalities. The role of disorder in the presence of long-range dipolar and elastic forces is to lead to nanoscale inhomogeneity, which is responsible for the observed behaviour as well as frustration in the material – thus a strong sensitivity to external perturbations and possibly glassy response in certain regimes as well as anomalous avalanche phenomena.

This book brings together an emerging consensus on our understanding of the complex functional materials including ferroics, perovskites, multiferroics and magnetoelastics. The common theme is the existence of many competing ground states and frustration as a collusion of spin, charge, orbital and lattice degrees of freedom in the presence of disorder and (both dipolar and elastic) long-range forces. An important consequence of the complex unit cell and the competing interactions is that the emergent materials properties are very sensitive to external fields, thus rendering these materials with highly desirable, technologically important applications enabled by cross-response.

The idea for this book was born at the workshop *Jim Krumhansl Symposium: Complex Materials at the Cross-Roads* held at Osaka, Japan, during November 9–13, 2008. This workshop was a sequel to a previous workshop on *Interplay of Magnetism and Structure in Functional Materials* held at Benasque, Spain, during February 9–13, 2004. The Benasque workshop formed the basis of a book (*Magnetism and Structure in Functional Materials*, Springer, 2005), which was dedicated to Jim Krumhansl, a retired professor from Cornell University who passed away in May 2004. Much of the research reported in this as well as in the previous book was inspired by Prof. Krumhansl's overarching vision identifying common themes between solid-state physics, materials science and biology.

The topics covered in the present book are interdisciplinary in nature written by researchers from physics, materials science and engineering backgrounds.

Therefore, the book is addressed to both the experts and researchers getting into the field of functional materials with disorder and glassy behaviour including graduate students. It contributes to the fields of physics, materials science and nanotechnology. In general, the book represents a developing subject.

The carefully chosen 15 chapters written by internationally recognized experts in their respective fields cover general introduction to ferroics and multiferroics, principles of emergent complexity in materials science with a particular emphasis on magnetic shape memory alloys, glassy phenomena including strain glass and martensites, soft electronic matter, hysteresis and avalanches, high-resolution structural and magnetic visualization techniques, neutron scattering and shuffle-based transitions, defects in ferroelectrics and other ferroic materials, precursor phenomena, magnetostrucutral coupling and magnetocaloric properties, Heusler materials and magnetic martensites as well as first principles and mesoscopic modelling. Beyond illustrating some common threads (such as metastability, nonlinearity and disorder) between biological and materials functionality, the book concludes with a chapter that lays out clearly the future research directions.

Each chapter reviews the current state of the topic and provides sufficient background material for a graduate student or a new researcher to get started in this exciting field. At the same time, each chapter provides open questions for the experts to ponder and advance the field further.

Overall, the book provides an emergent paradigm shaped by the many advances made over the past decade in synthesis, characterization, modelling and fundamental understanding as well as technological applications of a variety of complex functional materials.

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