

Alexander K. Tagantsev  
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# Domains in Ferroic Crystals and Thin Films



Springer

# Domains In Ferroic Crystals And Thin Films

**Subi J George, Chandrabhas  
Narayana, C N R Rao**



## **Domains In Ferroic Crystals And Thin Films:**

*Domains in Ferroic Crystals and Thin Films* Alexander Tagantsev, L. Eric Cross, Jan Fousek, 2010-04-28 At present the marketplace for professionals researchers and graduate students in solid state physics and materials science lacks a book that presents a comprehensive discussion of ferroelectrics and related materials in a form that is suitable for experimentalists and engineers This book proposes to present a wide coverage of domain related issues concerning these materials This coverage includes selected theoretical topics which are covered in the existing literature in addition to a plethora of experimental data which occupies over half of the book The book presents experimental findings and theoretical understanding of ferroic non magnetic domains developed during the past 60 years It addresses the situation by looking specifically at bulk crystals and thin films with a particular focus on recently developed microelectronic applications and methods for observations of domains with techniques such as scanning force microscopy polarized light microscopy scanning optical microscopy electron microscopy and surface decorating techniques Domains in Ferroic Crystals and Thin Films covers a large area of material properties and effects connected with static and dynamic properties of domains which are extremely relevant to materials referred to as ferroics In other textbooks on solid state physics one large group of ferroics is customarily covered those in which magnetic properties play a dominant role Numerous books are specifically devoted to magnetic ferroics and cover a wide spectrum of magnetic domain phenomena In contrast Domains in Ferroic Crystals and Thin Films concentrates on domain related phenomena in nonmagnetic ferroics These materials are still inadequately represented in solid state physics textbooks and monographs

**Domains in Ferroic Crystals and Thin Films** Alexander Tagantsev, L. Eric Cross, Jan Fousek, 2010-03-10 At present the marketplace for professionals researchers and graduate students in solid state physics and materials science lacks a book that presents a comprehensive discussion of ferroelectrics and related materials in a form that is suitable for experimentalists and engineers This book proposes to present a wide coverage of domain related issues concerning these materials This coverage includes selected theoretical topics which are covered in the existing literature in addition to a plethora of experimental data which occupies over half of the book The book presents experimental findings and theoretical understanding of ferroic non magnetic domains developed during the past 60 years It addresses the situation by looking specifically at bulk crystals and thin films with a particular focus on recently developed microelectronic applications and methods for observations of domains with techniques such as scanning force microscopy polarized light microscopy scanning optical microscopy electron microscopy and surface decorating techniques Domains in Ferroic Crystals and Thin Films covers a large area of material properties and effects connected with static and dynamic properties of domains which are extremely relevant to materials referred to as ferroics In other textbooks on solid state physics one large group of ferroics is customarily covered those in which magnetic properties play a dominant role Numerous books are specifically devoted to magnetic ferroics and cover a wide spectrum of magnetic domain phenomena In

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**Multiferroics** Andres Cano, Dennis Meier, Morgan Trassin, 2021-06-21 Multiferroics materials with a coexistence of magnetic and ferroelectric order provide an efficient route for the control of magnetism by electric fields The authors cover multiferroic thin film heterostructures device architectures and domain interface effects They critically discuss achievements as well as limitations and assess opportunities for future applications

*Toroidal Order in Magnetic Metamaterials* Jannis Lehmann, 2021-11-15 The scope of this work is to provide an extensive experimental investigation of ferrotoroidicity the most recently established type of ferroic order that is based on the uniform unit cell sized alignment of magnetic whirls This is achieved by transferring basic spin configurations pertinent for the emergence of toroidal order to mesoscopic length scales An engineering of and access to the system's magnetic degrees of freedom is made possible by using nanomagnetic arrays as model systems The work reveals microscopic and macroscopic aspects of toroidally ordered matter beyond the reach of natural materials

**Encyclopedia of Interfacial Chemistry**, 2018-03-29 Encyclopedia of Interfacial Chemistry Surface Science and Electrochemistry Seven Volume Set summarizes current fundamental knowledge of interfacial chemistry bringing readers the latest developments in the field As the chemical and physical properties and processes at solid and liquid interfaces are the scientific basis of so many technologies which

enhance our lives and create new opportunities its important to highlight how these technologies enable the design and optimization of functional materials for heterogeneous and electro catalysts in food production pollution control energy conversion and storage medical applications requiring biocompatibility drug delivery and more This book provides an interdisciplinary view that lies at the intersection of these fields Presents fundamental knowledge of interfacial chemistry surface science and electrochemistry and provides cutting edge research from academics and practitioners across various fields and global regions *Heterogeneous Ferroelectric Solid Solutions* Vitaly Yu. Topolov, 2018-03-16 This book systematizes data on the heterophase states and their evolution in perovskite type ferroelectric solid solutions It also provides a general interpretation of heterophase and domain structures on changing temperature composition or electric field as well as the complete analysis of interconnections domain structures unit cell parameters changes heterophase structures and stress relief The description of numerous examples of heterophase states in lead free ferroelectric solid solutions is also included Domain state interface diagrams contribute to the interpretation of heterophase states in perovskite type ferroelectric solid solutions and describe the stress relief in the presence of polydomain phases the behavior of unit cell parameters of coexisting phases the effect of external electric field etc This 2nd edition generalizes the results on the heterophase ferroelectric solid solutions and the stress relief and presents new results on heterophase domain structures and phase contents in lead free ferroelectric solid solutions

**Nanoscale Ferroelectrics and Multiferroics** Miguel Alguero, J. Marty Gregg, Liliana Mitoseriu, 2016-03-21 Dieses Buch beleuchtet die wichtigsten Aspekte der Verarbeitung und Charakterisierung von Ferroelektrika und Multiferroika auf Nanoebene pr sentiert eine umfassende Beschreibung der jeweiligen Eigenschaften und legt dabei den Schwerpunkt auf die Unterscheidung von Gr eneffekten bei extrinsischen Eigenschaften wie Rand oder Interface Effekte Eingegangen wird auch auf neuartige Nanoebene Das Fachbuch ist in drei Abschnitte unterteilt und beschreibt die Verarbeitung Nanostrukturierung Charakterisierung nanostrukturierter Materialien und Nanoeffekte Unter R ckgriff auf die Synergien zwischen Nano Ferroelektrika und Multiferroika werden Materialien behandelt die auf allen Ebenen einer Nanostrukturierung unterzogen werden von Technologien f r keramische Materialien wie ferroelektrische Nanopulver nanostrukturierte Keramiken und Dickschichten sowie magnetoelektrische Nanokomposit Materialien bis hin zu freistehenden Nanoobjekten mit spezifischen Geometrien wie Nanodr hte und Nanor hren auf verschiedenen Entwicklungsstufen Grundlage des Buches ist die europ ische Wissensplattform im Wissenschaftsbereich innerhalb der Aktion von COST Europ ische Zusammenarbeit in Wissenschaft und Technik zu ein und mehrphasigen Ferroika und Multiferroika mit begrenzten Geometrien SIMUFER Ref MP0904 Die Autoren der Kapitelbeitr ge wurden sorgf ltig ausgew hlt haben allesamt ganz wesentlich zur Wissensbasis f r das jeweilige Thema beigetragen und geh ren vor allem zu den renommiertesten Wissenschaftlern des Fachgebiets

*Domain Walls* Dennis Meier, Jan Seidel, Marty Gregg, Ramamoorthy Ramesh, 2020-08-07 Technological evolution and revolution are both driven by the discovery of new

functionalities new materials and the design of yet smaller faster and more energy efficient components Progress is being made at a breathtaking pace stimulated by the rapidly growing demand for more powerful and readily available information technology High speed internet and data streaming home automation tablets and smartphones are now necessities for our everyday lives Consumer expectations for progressively more data storage and exchange appear to be insatiable Oxide electronics is a promising and relatively new field that has the potential to trigger major advances in information technology Oxide interfaces are particularly intriguing Here low local symmetry combined with an increased susceptibility to external fields leads to unusual physical properties distinct from those of the homogeneous bulk In this context ferroic domain walls have attracted recent attention as a completely new type of oxide interface In addition to their functional properties such walls are spatially mobile and can be created moved and erased on demand This unique degree of flexibility enables domain walls to take an active role in future devices and hold a great potential as multifunctional 2D systems for nanoelectronics With domain walls as reconfigurable electronic 2D components a new generation of adaptive nano technology and flexible circuitry becomes possible that can be altered and upgraded throughout the lifetime of the device Thus what started out as fundamental research at the limit of accessibility is finally maturing into a promising concept for next generation technology

*Resistive Switching: Oxide Materials, Mechanisms, Devices and Operations* Jennifer Rupp, Daniele Ielmini, Ilia Valov, 2021-10-15 This book provides a broad examination of redox based resistive switching memories ReRAM a promising technology for novel types of nanoelectronic devices according to the International Technology Roadmap for Semiconductors and the materials and physical processes used in these ionic transport based switching devices It covers defect kinetic models for switching ReRAM deposition fabrication methods tuning thin film microstructures and material device characterization and modeling A slate of world renowned authors address the influence of type of ionic carriers their mobility the role of the local and chemical composition and environment and facilitate readers understanding of the effects of composition and structure at different length scales e g crystalline vs amorphous phases impact of extended defects such as dislocations and grain boundaries ReRAMs show outstanding potential for scaling down to the atomic level fast operation in the nanosecond range low power consumption and non volatile storage The book is ideal for materials scientists and engineers concerned with novel types of nanoelectronic devices such as memories memristors and switches for logic and neuromorphic computing circuits beyond the von Neumann concept

*Physics and Mechanics of New Materials and Their Applications* Ivan A. Parinov, Shun-Hsyung Chang, Erni Puspanantasari Putri, 2024-02-01 This book presents 60 selected peer reviewed contributions from the international conference Physics and Mechanics of New Materials and Their Applications PHENMA 2023 3 8 October 2023 Surabaya Indonesia focusing on processing techniques physics mechanics and applications of advanced materials The book describes a broad spectrum of promising nanostructures crystal structures materials and composites with unique properties It presents nanotechnological design approaches environmental friendly processing

techniques and physicochemical as well as mechanical studies of advanced materials The selected contributions describe recent progress in energy harvesting and piezoelectric materials optimization electromagnetoelastic actuators for nanotechnology research impedance spectroscopy and study of ceramic materials catalyst synthesis and control of morphological characteristics synthesis and study of electrocatalysts for fuel cells The presented results are important for ongoing efforts concerning the theory modelling and testing of advanced materials Other results are devoted to the analysis of technogenic raw materials and different material applications in science technique and industry

**The Electrocaloric Effect** Andrei L. Kholkin, Oleg V. Pakhomov, Alexander A. Semenov, Alexander Tselev, 2023-02-16 The Electrocaloric Effect Materials and Applications reviews the fundamentals of the electrocaloric effect the most relevant electrocaloric materials and electrocaloric measurements and device applications The book introduces the electrocaloric effect along with modeling and simulations of this effect Then it addresses the latest advances in synthesis characterization and optimization of the most relevant electrocaloric materials including ferroelectric materials liquid materials lead free materials polymers and composites Finally there is a review of the latest techniques in measurement and applications in refrigeration and cooling and a discussion of the advantages challenges and perspectives of the future of electrocaloric refrigeration Provides a comprehensive introduction to the electrocaloric effect including experimental techniques to measure model and simulate the effect Reviews the most relevant electrocaloric materials such as composites polymers metal oxides ferroelectric materials and more Touches on the design and application of electrocaloric materials for devices with potential cooling and refrigeration applications

**Tuneable Film Bulk Acoustic Wave Resonators** Spartak Gevorgian, Alexander Tagantsev, Andrei K Vorobiev, 2013-02-14 To handle many standards and ever increasing bandwidth requirements large number of filters and switches are used in transceivers of modern wireless communications systems It makes the cost performance form factor and power consumption of these systems including cellular phones critical issues At present the fixed frequency filter banks based on Film Bulk Acoustic Resonators FBAR are regarded as one of the most promising technologies to address performance form factor cost issues Even though the FBARs improve the overall performances the complexity of these systems remains high Attempts are being made to exclude some of the filters by bringing the digital signal processing including channel selection as close to the antennas as possible However handling the increased interference levels is unrealistic for low cost battery operated radios Replacing fixed frequency filter banks by one tuneable filter is the most desired and widely considered scenario As an example development of the software based cognitive radios is largely hindered by the lack of adequate agile components first of all tuneable filters In this sense the electrically switchable and tuneable FBARs are the most promising components to address the complex cost performance issues in agile microwave transceivers smart wireless sensor networks etc Tuneable Film Bulk Acoustic Wave Resonators discusses FBAR need physics designs modelling fabrication and applications Tuning of the resonant frequency of the FBARs

is considered Switchable and tuneable FBARs based on electric field induced piezoelectric effect in paraelectric phase ferroelectrics are covered The resonance of these resonators may be electrically switched on and off and tuned without hysteresis The book is aimed at microwave and sensor specialists in the industry and graduate students Readers will learn about principles of operation and possibilities of the switchable and tuneable FBARs and will be given general guidelines for designing fabrication and applications of these devices

*Multifunctional Oxide Heterostructures* Evgeny Y. Tsymlal,Elbio R. A. Dagotto,Chang-Beom Eom,Ramamoorthy Ramesh,2012-08-30 This book is devoted to the rapidly developing field of oxide thin films and heterostructures Oxide materials combined with atomic scale precision in a heterostructure exhibit an abundance of macroscopic physical properties involving the strong coupling between the electronic spin and structural degrees of freedom and the interplay between magnetism ferroelectricity and conductivity Recent advances in thin film deposition and characterization techniques made possible the experimental realization of such oxide heterostructures promising novel functionalities and device concepts The book consists of chapters on some of the key innovations in the field over recent years including strongly correlated oxide heterostructures magnetoelectric coupling and multiferroic materials thermoelectric phenomena and two dimensional electron gases at oxide interfaces The book covers the core principles describes experimental approaches to fabricate and characterize oxide heterostructures demonstrates new functional properties of these materials and provides an overview of novel applications

*Recent Advances in Multifunctional Perovskite Materials* Poorva Sharma,Ashwini Kumar,2022-12-14 This book summarizes current advances in the field of multifunctional perovskite materials including information on their synthesis characterization and properties as well as their use in the fabrication of devices and applications Chapters address such topics as the physiochemical properties of various perovskite materials advances in perovskites for solar cells and multifunctional materials and their numerous applications

**X-Ray Scattering Techniques for Epitaxial Oxide Thin Films** Daniel Sando,Paul G. Evans,Nagarajan Valanoor,2025-09-12 This book acts as a handbook on the topic of x ray scattering as applied to epitaxial complex oxide films providing detailed information to collect the data how to analyze the data and the practical sides of the experiments The first chapter considers laboratory based X ray diffraction XRD methods the indispensable X ray characterization methods used for phase analysis epitaxial relationship determination advanced analytical and data fitting techniques and grazing incidence diffraction The subsequent chapters focus on advanced techniques that are typically performed at large scale facilities such as synchrotrons diffuse scattering and strain mapping coherent X ray methods magnetic X ray scattering and dichroism effects and pump probe techniques In addition detailed characterization methods for complex structures such as oxide superlattices the measurement of oxygen octahedra rotations and probing of domain arrangements are covered The overarching aim of the book is to provide a tutorial style approach to assist experimentalists actually carrying out their experiments and data analysis For instance the nitty gritty techniques of alignment and experimental setup along with



common mistakes and pitfalls are often not discussed in textbooks or instruction manuals The book is an invaluable tool for the wide range of researchers working globally on oxide electronics serves as a reference text for the many and varied techniques applied to such materials systems and showcases new advanced methods in x ray scattering

**Handbook On Big Data And Machine Learning In The Physical Sciences (In 2 Volumes)** ,2020-03-10 This compendium provides a comprehensive collection of the emergent applications of big data machine learning and artificial intelligence technologies to present day physical sciences ranging from materials theory and imaging to predictive synthesis and automated research This area of research is among the most rapidly developing in the last several years in areas spanning materials science chemistry and condensed matter physics Written by world renowned researchers the compilation of two authoritative volumes provides a distinct summary of the modern advances in instrument driven data generation and analytics establishing the links between the big data and predictive theories and outlining the emerging field of data and physics driven predictive and autonomous systems

**Ferroelectricity at the Nanoscale** Vladimir Fridkin,Stephen Ducharme,2013-10-25 The investigation of nanosized ferroelectric films and ferroelectric nanocrystals has attracted much attention during the past 15 20 years There is interest in the fundamental and applied aspects The theoretical basis is connected with the development of the Landau Ginzburg Devonshire LGD mean field and the first principles theories to the ultrathin ferroelectric films with thickness in the vicinity of critical size Important potential applications are possible nanosize ferroelectric films in non volatile memories microelectronics sensors pyroelectric and electro optic devices This new area of research of ferroelectricity is still in impetuous development and far from completion Many topics elucidated need generalization The book contains theory and experimental data for a wide range of ferroelectric materials

**Advances In The Chemistry And Physics Of Materials: Overview Of Selected Topics** Subi J George,Chandrabhas Narayana,C N R Rao,2019-10-17 Advances in the Chemistry and Physics of Materials is a compilation of topics on the recent developments in the areas of Materials Science Materials Science has been a subject of major interest which has garnered significant attention over the years Chemists and physicists have contributed extensively to this frontier research area and their synergistic efforts have led to the discovery of many new exciting materials involving novel functions In the light of the growing importance of the field of Materials Science and owing to the fact that it is a subject that holds a lot of promise internationally renowned Materials Chemist Prof C N R Rao along with his colleagues at the School of Advanced Materials at JNCASR have compiled the contents of this book to highlight and showcase the emerging trends in materials science It touches upon topics spanning over nanomaterials and various other classes of energy materials for harvesting storage and conversion The relatively new and exciting range of materials such as supramolecular soft and biomaterials have been introduced and elucidated in the book Special emphasis has been laid on the synthesis phenomena and characterization of these kinds of materials Theoretical and Computational Chemistry has played an important role in the growth of Materials Science as a discipline and the book

covers a special topical session on the theoretical efforts in materials research The book packed with theory and practical aspects in a crisp and concise manner aims to take the reader on an intense scientific expedition The compilation provides an insight into the chemistry and physics of materials and presents up to date status reports which would undoubtedly be useful to practitioners teachers and students

**Topological Structures in Ferroic Materials** Jan Seidel, 2016-02-12 This book provides a state of the art overview of a highly interesting emerging research field in solid state physics nanomaterials science topological structures in ferroic materials Topological structures in ferroic materials have received strongly increasing attention in the last few years Such structures include domain walls skyrmions and vortices which can form in ferroelectric magnetic ferroelastic or multiferroic materials These topological structures can have completely different properties from the bulk material they form in They also can be controlled by external fields electrical magnetic strain or currents which makes them interesting from a fundamental research point of view as well as for potential novel nanomaterials applications To provide a comprehensive overview international leading researches in these fields contributed review like chapters about their own work and the work of other researchers to provide a current view of this highly interesting topic

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