

# Spin Dependent Transport in Magnetic Nanostructures

Edited by

**Sadamichi Maekawa and Teruya Shirogo**

*Advances in Condensed Matter Physics, Volume 10*



# Spin Dependent Transport In Magnetic Nanostructures

**Sadamichi Maekawa, Teruya Shinjo**



## **Spin Dependent Transport In Magnetic Nanostructures:**

*Spin Dependent Transport in Magnetic Nanostructures* Sadamichi Maekawa, Teruya Shinjō, 2002 In magnetic systems of nano meter size the interplay between spin and charge of electrons provides unique transport phenomena In magnetic superlattices magnetic and non magnetic metallic thin films with thickness of the order of one nano meter are piled up alternately Since the discovery of giant magnetoresistance GMR in these superlattices in 1988 spin dependent transport phenomena in magnetic nanostructures have received much attention from both academic and technological points of view Ferromagnetic tunnel junctions made of ferromagnetic metal electrodes and a very thin insulating barrier between them are also of current interest as magnetoresistive devices where the tunneling current depends on the relative orientation of magnetization TMR In addition to magnetic superlattices and magnetic tunnel junctions magnetic granular systems and magnetic dots have been studied extensively as magnetoresistive systems Edited by two of the world s leading authorities *Spin Dependent Transport in Magnetic Nanostructures* introduces and explains the basic physics and applications of a variety of spin dependent transport phenomena in magnetic nanostructures with particular emphasis on magnetic multilayers and magnetic tunnel junctions *Spin-dependent Transport Phenomena in Magnetic Nanostructures* A. S. Sahakyan, R. M. Movsesyan, A. N. Kocharian, 2017 **Spin-dependent Transport in Semiconductor-based Magnetic Nanostructures** Athanasios N. Chantis, 2002 *Handbook of Spin Transport and Magnetism* Evgeny Y. Tsymbal, Igor Zutic, 2016-04-19 In the past several decades the research on spin transport and magnetism has led to remarkable scientific and technological breakthroughs including Albert Fert and Peter Grunberg s Nobel Prize winning discovery of giant magnetoresistance GMR in magnetic metallic multilayers *Handbook of Spin Transport and Magnetism* provides a comprehensive bal *Nanooptics, Nanophotonics, Nanostructures, and Their Applications* Olena Fesenko, Leonid Yatsenko, 2018-06-26 This book presents some of the latest achievements in nanotechnology and nanomaterials from leading researchers in Ukraine Europe and beyond It features selected peer reviewed contributions from participants in the 5th International Science and Practice Conference Nanotechnology and Nanomaterials NANO2017 held in Chernivtsi Ukraine on August 23-26 2017 The International Conference was organized jointly by the Institute of Physics of the National Academy of Sciences of Ukraine Ivan Franko National University of Lviv Ukraine University of Tartu Estonia University of Turin Italy and Pierre and Marie Curie University France Internationally recognized experts from a wide range of universities and research institutions share their knowledge and key results on topics ranging from nanooptics and nanoplasmonics to interface studies This book s companion volume also addresses topics such as energy storage and biomedical applications **Transport Phenomena in Micro- and Nanoscale Functional Materials and Devices** Joao B. Sousa, Joao O. Ventura, Andre Pereira, 2021-03-26 *Transport Phenomena in Micro and Nanoscale Functional Materials and Devices* offers a pragmatic view on transport phenomena for micro and nanoscale materials and devices both as a research tool and as a means to implant new functions in materials

Chapters emphasize transport properties TP as a research tool at the micro nano level and give an experimental view on underlying techniques The relevance of TP is highlighted through the interplay between a micro nanocarrier s characteristics and media characteristics long short range order and disorder excitations couplings and in energy conversions Later sections contain case studies on the role of transport properties in functional nanomaterials This includes transport in thin films and nanostructures from nanogranular films to graphene and 2D semiconductors and spintronics and from read heads MRAMs and sensors to nano oscillators and energy conversion from figures of merit micro coolers and micro heaters to spin caloritronics Presents a pragmatic description of electrical transport phenomena in micro and nanoscale materials and devices from an experimental viewpoint Provides an in depth overview of the experimental techniques available to measure transport phenomena in micro and nanoscale materials Features case studies to illustrate how each technique works Highlights emerging areas of interest in micro and nanomaterial transport phenomena including spintronics

**Spintronics Handbook, Second Edition: Spin Transport and Magnetism** Evgeny Y. Tsymbal,Igor Žutić,2019-05-09 Spintronics Handbook Second Edition offers an update on the single most comprehensive survey of the two intertwined fields of spintronics and magnetism covering the diverse array of materials and structures including silicon organic semiconductors carbon nanotubes graphene and engineered nanostructures It focuses on seminal pioneering work together with the latest in cutting edge advances notably extended discussion of two dimensional materials beyond graphene topological insulators skyrmions and molecular spintronics The main sections cover physical phenomena spin dependent tunneling control of spin and magnetism in semiconductors and spin based applications

**Magnetic Nanostructures in Modern Technology** Bruno Azzerboni,Giovanni Asti,Luigi Pareti,Massimo Ghidini,2007-10-22 In this book a team of outstanding scientists in the field of modern magnetic nanotechnologies illustrates the state of the art in several areas of advanced magneto electronic devices magnetic micro electromechanical systems and high density information storage technologies Providing a unique source of information for the young physicist chemist or engineer the book also serves as a crucial reference for the expert scientist and the teacher of advanced university courses

**Nonequilibrium Carrier Dynamics in Semiconductors** Marco Saraniti,Umberto Ravaioli,2007-12-14 Nonequilibrium Carrier Dynamics in Semiconductors is a well established specialist conference held every 2 years covering a range of topics of current interest to R D in semiconductor physics materials optoelectronics nanotechnology quantum information processing Papers accepted for publication are selected and peer reviewed by members of the Program Committee during the conference to ensure both rapid and high quality processing The proceedings of this series of conferences constitute a comprehensive source of reference of the acknowledged state of the art in the field

*Spintronics* Jean-Philippe Ansermet,2024-08-13 A sound understanding of magnetism transport theory spin relaxation mechanisms and magnetization dynamics is necessary to engage in spintronics research In this primer special effort has been made to give straightforward explanations for these advanced concepts This

book will be a valuable resource for graduate students in spintronics and related fields Concepts of magnetism such as exchange interaction spin orbit coupling spin canting and magnetic anisotropy are introduced Spin dependent transport is described using both thermodynamics and Boltzmann's equation including Berry curvature corrections Spin relaxation phenomenology is accounted for with master equations for quantum spin systems coupled to a bath Magnetic resonance principles are applied to describe spin waves in ferromagnets cavity mode coupling in antiferromagnets and coherence phenomena relevant to spin qubits applications Key Features A pedagogical approach to foundational concepts in spintronics with simple models that can be calculated to enhance understanding Nineteen chapters each beginning with a historical perspective and ending with an outlook on current research 1200 references ranging from landmark papers to frontline publications Jean Philippe Ansermet is Professor Emeritus at cole Polytechnique F d rale de Lausanne EPFL where he pioneered experiments on giant magnetoresistance current induced magnetization switching heat driven spin torque and nuclear magnetic resonance He taught mechanics thermodynamics and spin dynamics for more than twenty years A fellow of the American Physical Society and recipient of the 2022 Credit Suisse Teaching Award he was an executive board member of the European Physical Society president of the Swiss Physical Society and teaching director at EPFL He has authored or co authored textbooks on mechanics and thermodynamics and published more than two hundred articles

Ferromagnetic Microwire Composites Hua-Xin Peng, Faxiang Qin, Manh-Huong Phan, 2016-02-10 Situated at the forefront of interdisciplinary research on ferromagnetic microwires and their multifunctional composites this book starts with a comprehensive treatment of the processing structure properties and applications of magnetic microwires Special emphasis is placed on the giant magnetoimpedance GMI effect which forms the basis for developing high performance magnetic sensors After defining the key criteria for selecting microwires for various types of GMI sensors the book illustrates how ferromagnetic microwires are employed as functional fillers to create a new class of composite materials with multiple functionalities for sensing and microwave applications Readers are introduced to state of the art fabrication methods microwave tunable properties microwave absorption and shielding behaviours as well as the metamaterial characteristics of these newly developed ferromagnetic microwire composites Lastly potential engineering applications are proposed so as to highlight the most promising perspectives current challenges and possible solutions

*Foundations Of Quantum Mechanics In The Light Of New Technology: Isqm-tokyo '05 - Proceedings Of The 8th International Symposium* Sachio Ishioka, Kazuo Fujikawa, 2006-06-27 The goal of the 8th International Symposium on Foundations of Quantum Mechanics in the Light of New Technology was to link recent advances in technology with fundamental problems and issues in quantum mechanics with an emphasis on quantum coherence decoherence and geometrical phase The papers collected in this volume cover a wide range of quantum physics including quantum information and entanglement quantum computing quantum dot systems the anomalous Hall effect and the spin Hall effect spin related phenomena superconductivity in nano systems precise

measurements and fundamental problems The volume serves both as an excellent reference for experts and a useful introduction for newcomers to the field of quantum coherence and decoherence

**Nanoscale Devices - Fundamentals and Applications** Rudolf Gross,Anatolie Sidorenko,Lenar Tagirov,2007-05-16 Over the last decade the interest in nanoscale materials and their applications in novel electronic devices have been increasing tremendously This is caused by the unique properties of nanoscale materials and the outstanding performance of nanoscale devices The fascinating and often unrivalled properties of nanoscale materials and devices opened new and sometimes unexpected fields of applications Today the widespread applications range from the detection of explosives drugs and fissionable materials to bio and infrared sensors spintronic devices data storage media magnetic read heads for computer hard disks single electron devices microwave electronic devices and many more This book contains a collection of papers giving insight into the fundamentals and applications of nanoscale devices The main focus is on the synthesis and characterization of nanoscale magnetic materials the fundamental physics and materials aspects of solid state nanostructures the development of novel device concepts and design principles for nanoscale devices as well as on applications in electronics with special emphasis on defence against the threat of terrorism

**Nanomagnetism and Spintronics** Jun-ichiro Inoue,2013-10-07 Novel magnetotransport phenomena appear when magnet sizes become nanoscale Typical examples of such phenomena are giant magnetoresistance GMR in magnetic multilayers tunnel magnetoresistance TMR in ferromagnetic tunnel junctions and ballistic magnetoresistance BMR in magnetic nanocontacts In this chapter we first briefly review the relationship between spin dependent resistivity and electronic structures in metals and alloys and describe microscopic methods for investigating electrical transport We then review the essential aspects of GMR TMR and BMR emphasizing the role of the electronic structures of the constituent metals of these junctions and the effects of roughness on the electrical resistivity or resistance The important factors that control GMR are shown to be the spin dependent random potential at interfaces and band matching mismatching between magnetic and nonmagnetic layers For TMR several factors are shown to be important in determining the MR ratio including the shape of the Fermi surface of the electrodes the symmetry of the wave functions electron scattering at interfaces and spin slip tunneling An interpretation of TMR in Fe MgO Fe and of an oscillation of TMR is presented TMR in granular films and in the Coulomb blockade regime is also described We also provide a brief explanation for other MR effects such as normal MR anisotropic MR AMR and colossal MR CMR in order to clarify the essential difference between these MRs and GMR TMR and BMR These MR effects are attributed to the spin dependent electrical currents produced in metallic ferromagnets After the discovery of these different MR effects the role of spin current was proposed for example spin Hall effect and the effects of spin transfer torque which will be briefly explained in this chapter The former originates from the spin orbit interaction and can be observed even in nonmagnetic metals and semiconductors It is closely related to the anomalous Hall effect observed in ferromagnetic metals The spin transfer torque is an inverse effect of the MR The MR is the

resistivity change produced by magnetization rotation in ferromagnetic junctions while the spin transfer torque is an effect in which spin polarized current makes the magnetization rotate Finally we briefly introduce the coupled effects of spin charge and heat transport which are called spin caloritronics

**Ultrafast Magnetism I** Jean-Yves Bigot, Wolfgang Hübner, Theo Rasing, Roy Chantrell, 2014-08-05 This volume on Ultrafast Magnetism is a collection of articles presented at the international Ultrafast Magnetization Conference held at the Congress Center in Strasbourg France from October 28th to November 1st 2013 This first conference which is intended to be held every two years received a wonderful attendance and gathered scientists from 27 countries in the field of Femtomagnetism encompassing many theoretical and experimental research subjects related to the spins dynamics in bulk or nanostructured materials The participants appreciated this unique opportunity for discussing new ideas and debating on various physical interpretations of the reported phenomena The format of a single session with many oral contributions as well as extensive time for poster presentations allowed researchers to have a detailed overview of the field Importantly one could sense that in addition to studying fundamental magnetic phenomena ultrafast magnetism has entered in a phase where applied physics and engineering are playing an important role Several devices are being proposed with exciting R D perspectives in the near future in particular for magnetic recording time resolved magnetic imaging and spin polarized transport therefore establishing connections between various aspects of modern magnetism Simultaneously the diversity of techniques and experimental configurations has flourished during the past years employing in particular Xrays visible infra red and terahertz radiations It was also obvious that an important effort is being made for tracking the dynamics of spins and magnetic domains at the nanometer scale opening the pathway to exciting future developments The concerted efforts between theoretical and experimental approaches for explaining the dynamical behaviors of angular momentum and energy levels on different classes of magnetic materials are worth pointing out Finally it was unanimously recognized that the quality of the scientific oral and poster presentations contributed to bring the conference to a very high international standard

*Advances in Nanoscale Magnetism* Bekir Aktas, Faik Mikailov, 2008-09-08 The book aims to provide an overview of recent progress in the understanding of magnetic properties in nanoscale through recent results of various theoretical and experimental investigations The papers describe a wide range of physical aspects

*Handbook of Nanostructured Materials and Nanotechnology, Five-Volume Set* Hari Singh Nalwa, 1999-10-29 Nanostructured materials is one of the hottest and fastest growing areas in today s materials science field along with the related field of solid state physics Nanostructured materials and their based technologies have opened up exciting new possibilities for future applications in a number of areas including aerospace automotive x ray technology batteries sensors color imaging printing computer chips medical implants pharmacy and cosmetics The ability to change properties on the atomic level promises a revolution in many realms of science and technology Thus this book details the high level of activity and significant findings are available for those involved in research and development in the field It also

covers industrial findings and corporate support This five volume set summarizes fundamentals of nano science in a comprehensive way The contributors enlisted by the editor are at elite institutions worldwide Key Features Provides comprehensive coverage of the dominant technology of the 21st century Written by 127 authors from 16 countries making this truly international First and only reference to cover all aspects of nanostructured materials and nanotechnology

Nanostructured Materials and Nanotechnology Hari Singh Nalwa,2002 Nanotechnology Provides comprehensive coverage of the dominant technology of the 21st century Written by a truly international list of contributors      *Organic Spintronics* Zeev Valy Vardeny,2010-04-09 Major development efforts in organic materials research has grown for an array of applications Organic spintronics in particular has flourished in the area of organic magneto transport Reflecting the main avenues of advancement in this arena this volume explores spin injection and manipulation in organic spin valves the magnetic field effect in organic light emitting diodes OLEDs the spin transport effect in relation to spin manipulation organic magnets as spin injection electrodes in organic spintronics devices the coherent control of spins in organic devices using the technique of electronically detected magnetic resonance and the possibility of using organic spin valves as sensors      **Alloy Physics** Wolfgang Pfeiler,2008-01-08 Covering the latest research in alloy physics together with the underlying basic principles this comprehensive book provides a sound understanding of the structural changes in metals and alloys ranging from plastic deformation deformation dynamics and ordering kinetics right up to atom jump processes first principle calculations and simulation techniques Alongside fundamental topics such as crystal defects phase transformations and statistical thermodynamics the team of international authors treats such hot areas as nano size effects interfaces and spintronics as well as technical applications of modern alloys like data storage and recording and the possibilities offered by materials design



## Embracing the Beat of Appearance: An Psychological Symphony within **Spin Dependent Transport In Magnetic Nanostructures**

In a world consumed by displays and the ceaseless chatter of quick connection, the melodic elegance and emotional symphony developed by the written term frequently fade in to the backdrop, eclipsed by the persistent sound and distractions that permeate our lives. But, located within the pages of **Spin Dependent Transport In Magnetic Nanostructures** a stunning fictional value brimming with fresh thoughts, lies an immersive symphony waiting to be embraced. Constructed by an elegant musician of language, this fascinating masterpiece conducts visitors on a psychological trip, skillfully unraveling the hidden melodies and profound influence resonating within each cautiously constructed phrase. Within the depths with this touching examination, we will examine the book is key harmonies, analyze their enthralling writing design, and surrender ourselves to the profound resonance that echoes in the depths of readers souls.

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