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S&T In-Depth

THE LATEST IN SCIENCE AND TECHNOLOGY RESEARCH LITERATURE

FEATURE TOPIC: SPINTRONICS

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Introduction

Spintronic devices combine the advantages of magnetic materials and semiconductors. They are expected to be non-volatile, versatile, fast and capable of simultaneous data storage and processing, while at the same time consuming less energy. They play an increasingly significant role in high density data storage, microelectronics, sensors, quantum computing and biomedical applications. According to a 2016 article US, China and Germany are the top three countries in scientific literature output on spintronics.

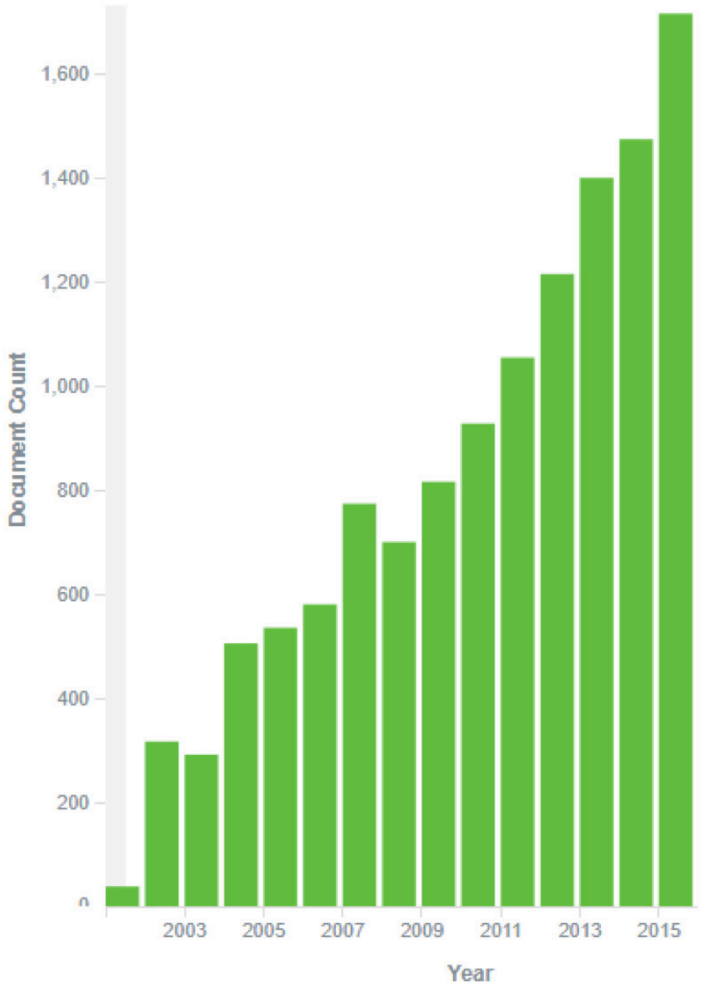
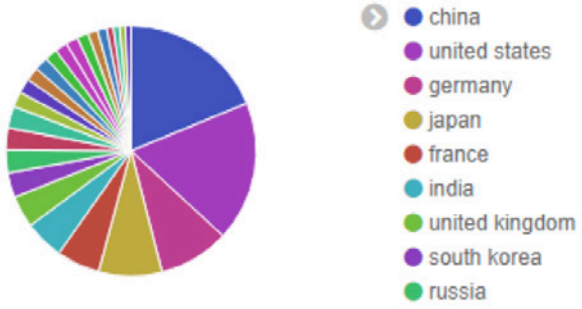


FIGURE 1: Global Publishing Trends in Spintronics: Document Counts versus Year of Publication for 2002–2016. Source: ONTA's TechSight System.



country: Descending	Count	Sum of timescited
china	3,108	41,520
united states	2,996	114,956
germany	1,511	36,600
japan	1,354	28,925
france	925	22,683
india	838	7,523
united kingdom	684	18,500
south korea	527	7,742
russia	494	6,201
spain	469	11,264

FIGURE 2: Country Trends in Spintronics: Documents aggregated by author's country affiliation, sorted by document count for the last 15 years. aAlso listed: total number of citations these documents have collected as of June 2017. Source: ONTA's TechSight System.

continued

Review Articles

Advantages of Prefabricated Tunnel Junction-Based Molecular Spintronics Devices (USA) 2015

Tyagi, P, Friebe, E, Baker, C

Source: NANO, issue 4, volume 10, June 2015; https://doi.org/10.1142/S1793292015300029

ABSTRACT: Molecule-based devices may govern the advancement of the next generation's logic and memory devices. Molecules have the potential to be unmatched device elements as chemists can mass produce an endless variety of molecules with novel optical, magnetic and charge transport characteristics. However, the biggest challenge is to connect two metal leads to a target molecule (s) and develop a robust and versatile device fabrication technology that can be adopted for commercial scale mass production. This paper discusses distinct advantages of utilizing commercially successful tunnel junctions as a vehicle for developing molecular spintronics devices. We describe the use of a prefabricated tunnel junction with the exposed sides as a testbed for molecular device fabrication. On the exposed sides of a tunnel junction molecules are bridged across an insulator by chemically bonding with the two metal electrodes; sequential growth of metal-insulator-metal layers ensures that separation between two metal electrodes is controlled by the insulator thickness to the molecular device length scale. This paper highlights various attributes of tunnel junction-based molecular devices with ferromagnetic electrodes for making molecular spintronics devices. We strongly emphasize a need for close collaboration between chemists and magnetic tunnel junction (MTJ) researchers. Such partnerships will have a strong potential to develop tunnel junction-based molecular devices for futuristic areas such as memory devices, magnetic metamaterials, high sensitivity multi-chemical biosensors, etc.

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Times cited: 3

Tags: Spintronics - Review article, Spintronics

Antiferromagnetic spintronics (England) 2016

Jungwirth, T, Marti, X, Wadley, P, Wunderlich, J

Source: NATURE NANOTECHNOLOGY, issue 3, volume 11, pages 231-241; March 2016; DOI: 10.1038/nnano.2016.18

ABSTRACT: Antiferromagnetic materials are internally magnetic, but the direction of their ordered microscopic moments alternates between individual atomic sites. The resulting zero net magnetic moment makes magnetism in antiferromagnets externally invisible. This implies that information stored in antiferromagnetic moments would be invisible to common magnetic probes, insensitive to disturbing magnetic fields, and the antiferromagnetic element would not magnetically affect its neighbours, regardless of how densely the elements are arranged in the device. The intrinsic high frequencies of antiferromagnetic dynamics represent another property that makes antiferromagnets distinct from ferromagnets. Among the outstanding questions is how to manipulate and detect the magnetic state of an antiferromagnet efficiently. In this Review we focus on recent works that have addressed this question. The field of antiferromagnetic spintronics can also be viewed from the general perspectives of spin transport, magnetic textures and dynamics, and materials research. We briefly mention this broader context, together with an outlook of future research and applications of antiferromagnetic spintronics.

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Times cited: 55

Tags: Spintronics - Review article, Spintronics

Equiatomic quaternary Heusler alloys: A material perspective for spintronic applications (India) 2016

Bainsla, L, Suresh, KG

Source: APPLIED PHYSICS REVIEWS, issue 3, volume 3; September 2016;

ABSTRACT: This review is dedicated to almost all reported materials belonging to EQHAs family. The electronic structure and hence the physical properties of Heusler alloys strongly depend on the degree of structural order and distribution of the atoms in the crystal lattice. A variety of experimental techniques has been used to probe the structural parameters and degree of order in these alloys. Their magnetic properties have been investigated using the conventional methods, while the spin polarization has been probed by point contact Andreev reflection technique. The experimentally obtained values of saturation magnetization are found to be in agreement with those estimated using the Slater-Pauling rule in most of the cases. Electrical resistivity and Hall measurements are being used to distinguish between SGS and HMF nature in detail. The current spin polarization value, P = 0.70 +/- 0.01, for

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CoFeMnGe is found to be highest among the EQHAs. CoFeMnSi and CoFeCrGa are found to show SGS behavior with high Curie temperatures, thus making them suitable substitutes for diluted magnetic semiconductors. CoRuFeSi is found to have the highest TC among EQHAs. Theoretical prediction of magnetic properties on the basis of electronic structure calculations has also been reported in a few systems, which are also discussed in this review. Thus, this review presents a consolidated picture of the magnetic and spintronic properties of this important, but relatively new class of Heusler alloys. It is expected that this will stimulate further interest in these alloys, thereby paving the way for the identification of more HMF and SGS materials. As a result of this, it is expected that more efficient spintronic devices using these alloys would emerge in the near future. Published by AIP Publishing.

Author(s) affiliation: Indian Inst Technol, Dept Phys, Magnet Mat Lab, Bombay 400076, Maharashtra, India, Tohoku Univ, WPI Adv Inst Mat Res, Sendai, Miyagi 9808577, Japan

Times cited: 3

Tags: Spintronics - Review article, Spintronics- Applications, Spintronics - Materials, Spintronics

First-principles design of spintronics materials (China) 2016

Li, XX, Yang, JL

Source: NATIONAL SCIENCE REVIEW, issue 3, volume 3, pages 365-381; September 1st 2016; https://doi.org/10.1093/nsr/nww026

ABSTRACT: Spintronics faces a number of challenges, including spin generation and injection, long distance spin transport, and manipulation and detection of spin orientation. In solving these issues, new concepts and spintronics materials were proposed one after another, such as half metals, spin gapless semiconductors, and bipolar magnetic semiconductors. Topological insulators can also be viewed as a special class of spintronics materials, with their surface states used for pure spin generation and transportation. In designing these spintronics materials, first-principles calculations play a very important role. This article attempts to give a brief review of the basic principles and theoretical design of these materials. Meanwhile, we also give some attentions to the antiferromagnetic spintronics, which is mainly based on antiferromagnets and has aroused much interest in recent years.

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Times cited: 0

Tags: Spintronics - Review article, Spintronics - Materials, Spintronics

Magnon spintronics (Germany) 2015

Chumak, AV, Vasyuchka, VI, Serga, AA, Hillebrands, B

Source: NATURE PHYSICS, issue 6, volume 11, pages 453-461, June 2015; doi:10.1038/nphys3347

ABSTRACT: Magnon spintronics is the field of spintronics concerned with structures, devices and circuits that use spin currents carried by magnons. Magnons are the quanta of spin waves: the dynamic eigen-excitations of a magnetically ordered body. Analogous to electric currents, magnon-based currents can be used to carry, transport and process information. The use of magnons allows the implementation of novel wave-based computing technologies free from the drawbacks inherent to modern electronics, such as dissipation of energy due to Ohmic losses. Logic circuits based on wave interference and nonlinear wave interaction can be designed with much smaller footprints compared with conventional electron-based logic circuits. In this review, after an introduction into the basic properties of magnons and their handling, we discuss the inter-conversion between magnon currents and electron-carried spin and charge currents; and concepts and experimental studies of magnon-based computing circuits.

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Times cited: 145

Tags: Spintronics - Review article, Spintronics

Majorana zero modes in spintronics devices (USA) 2017

Wu, CT, Anderson, BM, Hsiao, WH, Levin, K

Source: PHYSICAL REVIEW B Issue 1, volume 95; 2017;

ABSTRACT: We show that topological phases should be realizable in readily available and well-studied heterostructures. In particular we identify a new class of topological materials which are well known in spintronics: helical ferromagnet-superconducting junctions. We note that almost all previous work on topological heterostructures has focused on creating Majorana modes at the proximity interface in effectively two-dimensional or one-dimensional systems. The particular heterostructures we address exhibit finite-range proximity effects leading to nodal superconductors with Majorana modes localized well away from this interface. To show this, we implement a Bogoliubov-de Gennes (BdG) proximity numerical scheme, which importantly involves two finite dimensions in a three-dimensional junction. Incorporating this level of numerical complexity serves to distinguish ours from alternative numerical

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BdG approaches which are limited by generally assuming translational invariance or periodic boundary conditions along multiple directions. With this access to the edges, we are then able to illustrate in a concrete fashion the wave functions of Majorana zero modes and, moreover, address finite-size effects. In the process we establish consistency with a simple analytical model.

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Times cited:

Tags: Spintroncis - Review article, Spintronics

Opportunities at the Frontiers of Spintronics (USA) 2015

Hoffmann, A, Bader, SD

Source: PHYSICAL REVIEW APPLIED, issue 4, volume 4, October 2015; DOI: 10.1103/PhysRevApplied.4.047001

ABSTRACT: The field of spintronics, or magnetic electronics, is maturing and giving rise to new subfields. These new directions involve the study of collective spin excitations and couplings of the spin system to additional degrees of freedom of a material, as well as metastable phenomena due to perturbations that drive the system far from equilibrium. The interactions lead to possibilities for future applications within the realm of energy-efficient information technologies. Examples discussed herein include research opportunities associated with (i) various spin-orbit couplings, such as spin Hall effects, (ii) couplings to the thermal bath of a system, such as in spin Seebeck effects, (iii) spin-spin couplings, such as via induced and interacting magnon excitations, and (iv) spin-photon couplings, such as in ultrafast magnetization switching due to coherent photon pulses. These four basic frontier areas of research are giving rise to new applied disciplines known as spin orbitronics, spin caloritronics, magnonics, and spin photonics, respectively. These topics are highlighted in order to stimulate interest in the new directions that spintronics research is taking and to identify open issues to pursue.

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Times cited: 78

Tags: Spintronics - Review article, Spintronics

Radiation effects on the magnetism and the spin dependent transport in magnetic materials and nanostructures for spintronic applications (USA) 2015

Lu, JW, Poon, SJ, Wolf, SA, Weaver, BD, McMarr, PJ, Hughes, H, Chen, E

Source: JOURNAL OF MATERIALS RESEARCH, issue 9, volume 30, pages 1430-1439, 2015; DOI:10.1557/jmr.2014.413

ABSTRACT: Spintronics utilizes spin or magnetism to provide new ways to store and process information and is primarily associated with the utilization of spin polarized currents in memory and logic devices. With the end of silicon transistor technology in sight, spintronics can provide new paradigms for information processing and storage. Compared to charge based electronics, the advantages of magnetism/spin based devices are nonvolatility and ultra low power. In particular, magnetoresistive random access memories (MRAMs) are known to be Rad Hard [HXNV0100 64K x 16 Non-Volatile Magnetic RAM (www.honeywell.com/aerospace), S. Gerardin and A. Paccagnella, IEEE Trans. Nucl. Sci.57(6), 3016-3039 (2010), R.R. Katti, J. Lintz, L. Sundstrom, T. Marques, S. Scoppettuolo, and D. Martin, Proceedings of IEEE Radiation Effects Data Workshop, 103-105 (2009)] and are considered to be critical components for space and military systems due to their very low power consumption and nonvolatility. However, advances in the magnetic nanostructures and new materials for the scalability of MRAM and other potential applications require a re-evaluation of their radiation hardness. This review focuses mainly on recent progress in understanding the effects of irradiation on the magnetic materials and magnetic structures that are related to MRAM technology. Up to date, the most pronounced effects on the microstructures and the properties are linked to the displacement damage associated with heavy ion irradiation; however, the thermal effect is also important as it acts as an annealing process to recover the damage partially. Critical metrics for the magnetic tunnel junctions for postmortem characterizations will also be discussed. Finally, with the introduction of new perpendicular magnetic layers and the very thin MgO barrier layer in the next generation MRAM, the effects of the ionization damage shall be studied in the future.

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Times cited: 0

Tags: Spintronics - Review article, Spintronics- Applications, Spintronics - Devices, Spintronics - Materials, Spintronics

continued

Silicon spintronics: Progress and challenges (Austria) 2015

Sverdlov, V, Selberherr, S

Source: PHYSICS REPORTS-REVIEW SECTION OF PHYSICS LETTERS, volume 585, pages 1-40, July 2015; DOI: 10.1016/j.physrep.2015.05.002

ABSTRACT: Electron spin attracts much attention as an alternative to the electron charge degree of freedom for low-power reprogrammable logic and non-volatile memory applications. Silicon appears to be the perfect material for spin-driven applications. Recent progress and challenges regarding spin-based devices are reviewed. An order of magnitude enhancement of the electron spin lifetime in silicon thin films by shear strain is predicted and its impact on spin transport in SpinFETs is discussed. A relatively weak coupling between spin and effective electric field in silicon allows magnetoresistance modulation at room temperature, however, for long channel lengths. Due to tunneling magnetoresistance and spin transfer torque effects, a much stronger coupling between the spin (magnetization) orientation and charge current is achieved in magnetic tunnel junctions. Magnetic random access memory (MRAM) built on magnetic tunnel junctions is CMOS compatible and possesses all properties needed for future universal memory. Designs of spin-based non-volatile MRAM cells are presented. By means of micromagnetic simulations it is demonstrated that a substantial reduction of the switching time can be achieved. Finally, it is shown that any two arbitrary memory cells from an MRAM array can be used to perform a logic operation. Thus, an intrinsic non-volatile logic-in-memory architecture can be realized. (C) 2015 Elsevier B.V. All rights reserved.

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Times cited: 17

Tags: Spintronics - Review article, Spintronics - Materials, Spintronics

Spin-polarized supercurrents for spintronics: a review of current progress (England) 2015

Eschrig, M

Source: REPORTS ON PROGRESS IN PHYSICS, issue 10, volume 78, October 2015; DOI: 10.1088/0034-4885/78/10/104501

ABSTRACT: During the past 15 years a new field has emerged, which combines superconductivity and spintronics, with the goal to pave a way for new types of devices for applications combining the virtues of both by offering the possibility of long-range spin-polarized supercurrents. Such supercurrents constitute a fruitful basis for the study of fundamental physics as they combine macroscopic quantum coherence with microscopic exchange interactions, spin selectivity, and spin transport. This report follows recent developments in the controlled creation of long-range equal-spin triplet supercurrents in ferromagnets and its contribution to spintronics. The mutual proximity-induced modification of order in superconductor-ferromagnet hybrid structures introduces in a natural way such evasive phenomena as triplet superconductivity, odd-frequency pairing, Fulde-Ferrell-Larkin-Ovchinnikov pairing, long-range equal-spin supercurrents, pi-Josephson junctions, as well as long-range magnetic proximity effects. All these effects were rather exotic before 2000, when improvements in nanofabrication and materials control allowed for a new quality of hybrid structures. Guided by pioneering theoretical studies, experimental progress evolved rapidly, and since 2010 triplet supercurrents are routinely produced and observed. We have entered a new stage of studying new phases of matter previously out of our reach, and of merging the hitherto disparate fields of superconductivity and spintronics to a new research direction: super-spintronics.

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Times cited: 24

Tags: Spintronics - Review article, Spintronics - Materials, Spintronics

Spintronics technology: past, present and future (USA) 2016

Lu, JW, Chen, E, Kabir, M, Stan, MR, Wolf, SA

Source: INTERNATIONAL MATERIALS REVIEWS, issue 7, volume 61, pages 456-472, January 2016; DOI: 10.1080/09506608.2016.1204097

ABSTRACT: Spintronics has emerged in the last two decades as both an extremely fruitful direction of research into the properties and usefulness of the spin degree of freedom of the electron as it can apply to the exponentially expanding world of electronics. Spintronics has infiltrated almost every household in the form of the read head sensors for the hard drives that inhabit every desktop and most laptop computers. Embedded magnetic random access memory (MRAM) and inplane STT-RAM are rapidly replacing SRAM in a host of applications that do not require ultra-dense memories. Soon these embedded spintronic memories will permeate the cell phone market because they are much denser than SRAM, offer lower power at only slightly lower speed and are non-volatile. The present work in spintronics at most of the mainstream semiconductor companies and foundaries is focused on the development of perpendicular STT-MRAM, as a universal memory that can compete with the mainstream memories and surpass them in several key metrics. Several innovative ideas are presented where spintronics may have an impact because of the uniqueness

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of the approach. Nanomagnetic logic and storage may offer extremely high densities at very low power. Spin-torque oscillators are a very novel approach to pattern recognition that may be relevant for handling massive data sets. The spin of the electron may also be on the critical path for quantum computation or communication, another revolutionary change in how we process information.

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Times cited: 2

Tags: Spintronics - Review article, Spintronics - Applications, Spintronics

Applications

Design Requirements for a Spintronic MTJ Logic Device for Pipelined Logic Applications (USA) 2016

Kang, Y, Bokor, J, Stojanovic, V

Source: IEEE Transactions on Electron Devices (Volume: 63, Issue 4, pages 1754-1761, April 2016; DOI: 10.1109/TED.2016.2527046

ABSTRACT: Spintronic devices have been spotlighted due to their nonvolatility and potential for low-voltage operation. However, their potential performance and energy efficiency require greater scrutiny. In this paper, a circuit-level energy-performance analysis is used to derive the design requirements for a spintronic magnetic tunnel junction logic device, mLogic, for pipelined logic applications. An analytical equation for the domain wall mobility of mLogic is derived to predict the performance of future designs and used to point to key directions for further device improvement. We show that the energy dissipation of a logic pipeline under delay constraints is a convex function of the write/read-path resistance ratio and the supply voltage. Scaling the supply voltage can reduce the energy dissipation at the expense of switching speed, but is limited by an extrinsic pinning effect and thermal noise. The energy reduction by maximizing the tunnel magnetoresistance (TMR) will be saturated for TMR larger than 100. But maximizing TMR can mitigate the thermal noise limit of scaling the supply voltage. The energy gap between MOSFETs and mLogic gets smaller for more advanced technology nodes. With 32-nm technology, a future mLogic design can be more optimal than MOSFETs in low-power and low-performance applications, such as emerging Internet-of-Things devices.

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Times cited: 0

Tags: Spintronics - Applications, Spintronics

Direct Epitaxial Integration of the Ferromagnetic Semiconductor EuO with Silicon for Spintronic Applications (Russia) 2015

Averyanov, DV, Sadofyev, YG, Tokmachev, AM, Primenko, AE, Likhachev, IA, Storchak, VG

Source: ACS APPLIED MATERIALS & INTERFACES, issue 11, volume 7, pages 6146-6152, 2015; DOI:10.1021/am5089007

ABSTRACT: Following a remarkable success of metallic spintronics, tremendous efforts have been invested into the less developed semiconductor spintronics, in particular, with the aim to produce three-terminal spintronic devices, e.g., spin transistors. One of the most important prerequisites for such a technology is an effective injection of spin-polarized carriers into a nonmagnetic semiconductor, preferably one of those currently used for industrial applications such as Si a workhorse of modern electronics. Ferromagnetic semiconductor EuO is long believed to be the best candidate for integration with Si. Although EuO proved to offer optimal conditions for effective spin injection into silicon and in spite of considerable efforts, the direct epitaxial stabilization of stoichiometric EuO thin films on Si Without any buffer layer has not been demonstrated to date. Here we report a new technique for control of EuO/Si interface on submonolayer level. Using this technique we solve a long-standing problem of direct epitaxial growth on silicon of thin EuO films which exhibit structural and magnetic properties of EuO bulk material. This result opens up new possibilities in developing all-semiconductor spintronic devices.

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Times cited: 11

Tags: Spintronics- Applications, Spintronics

continued

Effective Doping of Monolayer Phosphorene by Surface Adsorption of Atoms for Electronic and Spintronic Applications (India) 2017

Rastogi, P, Kumar, S, Bhowmick, S, Agarwal, A, Chauhan, YS

Source: IETE JOURNAL OF RESEARCH, issue 2, volume 63, pages 205-215, 2017; DOI: 10.1080/03772063.2016.1243020

ABSTRACT: We study the effect of surface adsorption of 27 different adatoms on the electronic and magnetic properties of monolayer black phosphorus using density functional theory. Choosing a few representative elements from each group, ranging from alkali metals (group I) to halogens (group VII), we calculate the band structure, density of states, magnetic moment and effective mass for the energetically most stable location of the adatom on monolayer phosphorene. We predict that group I metals (Li, Na, K), and group III adatoms (Al, Ga, In) are effective in enhancing the n-type mobile carrier density, with group III adatoms resulting in lower effective mass of the electrons, and thus higher mobilities. Furthermore, we find that the adatoms of transition metals Ti and Fe produce a finite magnetic moment (1.87 and 2.31 (B)) in monolayer phosphorene, with different band gap and electronic effective masses (and thus mobilities), which approximately differ by a factor of 10 for spin-up and spin-down electrons, opening up the possibility for exploring spintronic applications.

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Times cited: 0

Tags: Spintronics - Applications, Spintronics

Fabrication of MnGa/GaAs contacts for optoelectronics and spintronics applications (Russia) 2016

Dorokhin, MV, Pavlov, DA, Bobrov, AI, Danilov, YA, Lesnikov, VP, Zvonkov, BN, Zdoroveyshchev, AV, Kudrin, AV, Demina, PB, Usov, YV, Nikolichev, DE, Kryukov, RN, Zubkov, SY

Source: SEMICONDUCTORS, issue 11, volume 50, pages 1443-1448, 2016; DOI: 10.1134/S1063782616110087

ABSTRACT: The crystal structure, composition, and magnetic, and electric-transport properties of Mn (x) Ga (y) layers deposited onto a GaAs surface by pulsed laser deposition in a hydrogen atmosphere, pulsed laser deposition in vacuum, and electron-beam evaporation in vacuum are investigated. It is shown that the features of each technique affect the composition and crystal structure of the formed layers, and the degree of abruptness and crystalline quality of the heterointerface. Apparently, the composition and crystal structure are responsible for modification of the ferromagnetic properties. The defects in the heterointerface affect the properties of the Mn (x) Ga (y) /GaAs diode structure, in particular, the height of the Schottky diode potential barrier.

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Times cited: 0

Tags: Spintronics - Applications, Spintronics

First-principles study of the double perovskites Sr2XOsO6 (X = Li, Na, Ca) for spintronics applications (Pakistan) 2016

Faizan, M, Murtaza, G, Khan, SH, Khan, A, Mehmood, A, Khenata, R, Hussain, S

Source: BULLETIN OF MATERIALS SCIENCE, issue 6, volume 39, pages 1419-1425, 2016; 10.1007/s12034-016-1288-6

ABSTRACT: We investigated double perovskite compounds of the form Sr (2) XOsO (6) (X = Li, Na, Ca) using the full-potential linearized augmented plane wave (FP-LAPW) method. For the exchange-correlation energy, Wu and Cohen generalized gradient approximation (WC-GGA), Perdew, Burke and Ernzerhof GGA (PBE-GGA), Engel and Vosko GGA (EV-GGA), and GGA plus Hubbard U-parameter (GGA + U) were used. The calculated structural parameters are in good agreement with the existing experimental results. Calculation of different elastic constants and elastic moduli reveals that these compounds are elastically stable and possess ductile nature. The GGA + U approach yields quite accurate results of the bandgap as compared with the simple GGA schemes. The density of states plot shows that Sr-4d, Os-5d and O-2p states predominantly contribute to the conduction and valence bands. Further, our results regarding to the magnetic properties of these compounds reveal their ferromagnetic nature. In addition, these compounds seem to possess half-metallic properties, making them useful candidates for applications in spintronics devices.

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Times cited: 0

Tags: Spintronics - Applications, Spintronics

continued

Graphene-multiferroic interfaces for spintronics applications (Germany) 2016

Zanolli, Z

Source: SCIENTIFIC REPORTS, volume 6, 2016; DOI: 10.1038/srep31346

ABSTRACT: Graphene and magnetoelectric multiferroics are promising materials for spintronic devices with high performance and low energy consumption. A very long spin diffusion length and high carrier mobility make graphene attractive for spintronics. The coupling between ferroelectricity and magnetism, which characterises magnetoelectrics, opens the way towards unique device architectures. In this work, we combine the features of both materials by investigating the interface between graphene and BaMnO3, a magnetoelectric multiferroic. We show that electron charge is transferred across the interface and magnetization is induced in the graphene sheet due to the strong interaction between C and Mn. Depending on the relative orientation of graphene and BaMnO3, a quasi-half-metal or a magnetic semiconductor can be obtained. A remarkably large proximity induced spin splitting of the Dirac cones (similar to 300 meV) is achieved. We also show how doping with acceptors can make the high-mobility region of the electronic bands experimentally accessible. This suggests a series of possible applications in spintronics (e.g. spin filters, spin injectors) for hybrid organic-multiferroic materials and reveals hybrid organic-multiferroics as a new class of materials that may exhibit exotic phenomena such as the quantum anomalous Hall effect and a Rashba spin-orbit induced topological gap.

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Times cited: 1

Tags: Spintronics - Applications, Spintronics

Group IV semiconductor Ge integration with topological insulator Sb2Te3 for spintronic application (China) 2017

Zheng, BN, Sun, Y, Wu, J, Han, M, Wu, XF, Huang, KK, Feng, SH

Source: JOURNAL OF PHYSICS D-APPLIED PHYSICS, issue 10, volume 50, 2017; DOI: 10.1088/1361-6463/aa57a0/meta

ABSTRACT: Sb2Te3/Ge heterojunctions were grown on deoxidized GaAs (001) substrates by molecular beam epitaxy to explore a new type of spin torque device. Despite the large lattice mismatch between Ge and Sb2Te3, the films display highly uniform fabrication and good crystallinity, which have been confirmed by structural characterization. The band structures of Sb2Te3/Ge heterojunctions were investigated by x-ray photoemission spectroscopy and ultraviolet photoemission spectroscopy. Small chemical shift of Sb 3d(5/2) indicates that TI conducting surface is not destroyed, and Ge valence band bending contributes to Fermi level depinning. The band offset of Sb2Te3/Ge heterojunctions is different from common gate dielectric/Ge heterojunctions. The integral quality of the heterostructure reveals the potential of combining topological insulators with semiconductors for the advancement of spintronic devices.

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Times cited: 0

Tags: Spintronics - Applications, Spintronics

Highly ferromagnetic, transparent conducting electrode based on Ce1-xCuxO2 thin film for spintronic applications (Saudi Arabia) 2015

Mahmoud, WE, Al-Ghamdi, AA, Al-Agel, FA, Al-Arfaj, E, Shokr, FS, Al-Gahtany, SA, Alshahrie, A, Shirbeeny, W, Bronstein, LM, Beall, GW

Source: CERAMICS INTERNATIONAL, issue 7, volume 41, pages 9101-9106, 2015; DOI: 10.1016/j.ceramint.2015.03.308

ABSTRACT: Here, we report, for the first time, syntheses of ferromagnetic transparent conducting electrodes based on Ce1-xCuxO2 ($0.01 < x < 0.17$). These electrodes were synthesized using an ethylene glycol modified sol gel spin coating technique. To assess the properties of the transparent conducting electrodes, we studied the influence of the amount of the Cu dopant on the structural, optical, electrical and magnetic properties of the CeO2 films. The films were characterized using X-ray powder diffraction, scanning electron microscopy combined with energy dispersive spectroscopy, atomic force microscopy, electrical and magnetic measurements. The data obtained demonstrate that the structure and composition govern the performance characteristics of these films as transparent electrodes. An efficient ferromagnetic transparent conducting electrode with the high transparency (87%), low sheet resistance (0.8 Omega/cm(2)) and the high magnetic moment (1.63 mu(B)/Cu) was obtained by doping CeO2 with 9 at% of Cu ions. (C) 2015 Elsevier Ltd and Techna Group S.r.l. All rights reserved.

Author(s) affiliation: King Abdulaziz Univ, Fac Sci, Dept Phys, Jeddah, Saudi Arabia, Suez Canal Univ, Fac Sci, Dept Phys, Ismailia, Egypt, Hail Univ, Dept Phys, Coll Sci, Hail, Saudi Arabia, Umm Alqura Univ, Dept Phys, Mecca, Saudi Arabia, Qaseem Univ, Dept Phys, Qaseem, Saudi Arabia, King Abdulaziz Univ, Fac Sci & Arts, Dept Phys, Rabigh, Saudi Arabia, King Abdulaziz Univ, Fac Sci Girls, Dept Phys, Jeddah 21413, Saudi Arabia, Univ Alexandria, Fac Sci, Dept Phys, Alexandria, Egypt, Indiana Univ, Dept Chem, Bloomington, IN 47405 USA, Texas State Univ San Marcos, Dept Chem & Biochem, San Marcos, TX 78666 USA

Times cited: 2

Tags: Spintronics - Applications, Spintronics

continued

Low temperature magneto transport features of rare earth element functionalized carbon nanotube network devices for spintronic applications (South Africa) 2017

Ncube, S, Naicker, A, Coleman, C, de Souza, A, Flahaut, E, Strydom, A, Bhattacharyya, S, DuPlessis, M

Source: FOURTH CONFERENCE ON SENSORS, MEMS, AND ELECTRO-OPTIC SYSTEMS, volume 10036, 2017: DOI: 10.1117/12.2245405

ABSTRACT: In this paper we report on the fabrication of a spintronic device based on multiwalled carbon nanotubes functionalized/ coupled with a rare earth element complex. The spin valve behavior is verified by magneto-resistance fluctuations at low temperatures. We report the magneto-transport features of spin valve devices based on multiwalled carbon nanotube covalently functionalized with a gadolinium complex. The switching is encoded in the composite from which devices are fabricated by di-electrophoresis. The magnetic field dependent electronic transport characteristics are investigated through the Cryogenic high field measurement system at 300 mK. Structural characterization of the material through transmission and scanning electron microscopy and Raman spectroscopy of the pristine and composite is done. The electronic transport shows a magnetic field dependence which is characteristic of spin valve at 300 mK and furthermore this spin valve feature is temperature dependent.

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Times cited: 0

Tags: Spintronics - Applications, Spintronics

A Novel Theoretical Investigation of Electronic Structure and Half-Metallic Ferromagnetism in 3d (V)-Doped InP for Spintronic Applications (Algeria) 2016

Cherfi, Y, Mokaddem, A, Bensaid, D, Doumi, B, Sayede, A, Dahmane, F, Tadjer, A

Source: JOURNAL OF SUPERCONDUCTIVITY AND NOVEL MAGNETISM, issue 7, volume 29, pages 1813-1819, 2016; DOI: 10.1007/s10948-016-3462-x

ABSTRACT: We have investigated the electronic structure and half-metallic ferromagnetic properties of vanadium (V)-doped InP indium phosphide in the zinc blende structure as ternary In (1-x) V (x) P compounds at concentrations x = 0.25, 0.5, and 0.75 of V, using first-principles calculations of density functional theory with generalized gradient approximation functional of Wu and Cohen (GGA-WC). It is found that In (0.75) V P-0.25, In (0.5) V P-0.5, and In (0.25) V P-0.75 compounds depicted a half-metallic (HM) ferromagnetic character with spin polarization of 100 % at Fermi level. The HM ferromagnetic behavior is confirmed by the integral Bohr magneton of total magnetic moment of 2 mu (B) per V atom of In (1-x) V (x) P, which mainly arises from the 3d (V) states along with less important contributions of induced local magnetic moments at In and P sites. Therefore, the In (1-x) V (x) P material seems to be potential candidate for possible semiconductor spintronics applications.

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Times cited: 1

Tags: Spintronics- Applications, Spintronics - Materials, Spintronics

Physical investigations on perovskite LaMnO3-delta sprayed thin films for spintronic applications (Tunisia) 2016

Boukhachem, A, Ziouche, A, Ben Amor, M, Kamoun, O, Zergoug, M, Maghraoui-Meherzi, H, Yumak, A, Boubaker, K, Amlouk, M

Source: MATERIALS RESEARCH BULLETIN, volume 74, pages 202-211, 2016; DOI: 10.1016/j.materresbull.2015.10.003

ABSTRACT: Oxygen deficient LaMnO3 thin films were successfully grown on glass substrate by spray pyrolysis at 460 degrees C. XRD studies show oxygen vacancies corresponding to the orthorhombic La4Mn4O11 with (040) preferential orientation. Optical properties were investigated through optical band gap and Urbach energy. The dispersion of the refractive index was discussed in terms of both Cauchy and Wemple & Didomenico models. Raman spectroscopy shows the band positions corresponding to LaMnO3 with a shift related to oxygen deficiency. Electrical properties were quantified using impedance spectroscopy technique within frequency range of 5 Hz-13 MHz at various temperatures. Both the DC conductivity and relaxation frequency were thermally activated with activation energy around 0.9 eV. Also, AC conductivity was investigated through Jonscher law. Finally, magnetic measurements at room temperature using vibrating sample magnetometer (VSM) technique show ferromagnetic behavior of these ternary sprayed thin films. (C) 2015 Published by Elsevier Ltd.

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Author(s) affiliation: Univ Tunis El Manar, Fac Sci Tunis, Unite Phys Dispositifs Semicond, Tunis 2092, Tunisia, Welding & NDT Res Ctr, Algiers, Algeria, Univ Tunis El Manar, Fac Sci Tunis, Lab Chim Analyt & Electrochem, Tunis 2092, Tunisia, Marmara Univ, Dept Phys, Kadikoy, Turkey

Times cited: 5

Tags: Spintronics- Applications, Spintronics - Materials, Spintronics

Prospects of asymmetrically H-terminated zigzag germanene nanoribbons for spintronic application (India) 2017

Sharma, V, Srivastava, P, Jaiswal, NK

Source: APPLIED SURFACE SCIENCE, volume 396, pages 1352–1359, 2017; DOI: 10.1016/j.apsusc.2016.11.161

ABSTRACT: First-principles investigations have been performed to explore the spin based electronic and transport properties of asymmetrically H-terminated zigzag germanene nanoribbons (2H-H ZGeNR). Investigations reveal a significant formation energy difference (Delta E-F = EF(2H-H) - EF(H-H) similar to -0.49 eV), highlighting more energetic stability for asymmetric edge termination compared to symmetric edge termination, irrespective of the ribbon width. Further, magnetic moment analysis and total energy calculations were performed to unveil that these structures have a magnetic ground state with preferred ferromagnetic (FM) coupling. The calculated E-k structures project a unique bipolar semiconducting behaviour for 2H-H ZGeNR which is contrast to H-terminated ZGeNR. Half-metallic transformation has also been revealed via suitable p-type or n-type doping for these structures. Finally, transport calculations were performed to highlight the selective contributions of spin-down (spin-up) electrons in the I-V characteristics of the doped 2H-H ZGeNR, suggesting their vitality for spintronic device applications. (C) 2016 Published by Elsevier B.V.

Author(s) affiliation: ABV Indian Inst Informat Technol & Management III, Nanomat Res Grp, Gwalior 474015, India, Indian Inst Informat Technol Design & Mfg, Discipline Phys, Dumna Airport Rd, Jabalpur 482005, India

Times cited: 0

Tags: Spintronics -Applications, Spintronics

Room temperature giant positive junction magnetoresistance of NiFe2O4/n-Si heterojunction for spintronics application (India) 2014

Panda, J, Saha, SN, Nath, TK

Source: PHYSICA B-CONDENSED MATTER, volume 448, pages 184–187, 2014; DOI: 10.1016/j.physb.2014.04.002

ABSTRACT: Electronic- and magnetic-transport properties of NiFe2O4 (NFO)-SiO2-Si heterojunction fabricated by depositing NIFO thin films on silicon substrates with the intermediate native oxide (SiO2) layer have been investigated in details. The current-voltage (I-V) characteristics across the junction have been recorded in the temperature range of 10-300 K. All I-V curves show non-linear behavior throughout the temperature range. The dominating current transport mechanism is found to be temperature dependent tunneling assisted by Frenkel-Poole type emission. In this paper, we report the junction magnetoresistance (JMR) properties of this heterojunction in the temperature range of 10-300 K. With increasing temperature, the JMR of the heterojunction increases accordingly. The high positive JMR (similar to 54%) has been observed at room temperature (RT). The origin of high positive JMR at RT is attributed to efficient spin-polarized carrier transport across the junction. K.) (C) 2014 Elsevier B.V. All rights reserved

Author(s) affiliation: Indian Inst Technol, Dept Phys, Kharagpur 721302, W Bengal, India

Times cited: 5

Tags: Spintronics - Applications, Spintronics - Materials, Spintronics

Single event double node upset tolerance in MOS/spintronic sequential and combinational logic circuits (Iran) 2017

Ramin Rajaei

Source: Microelectronics Reliability, Volume 69, February 2017, Pages 109–114

ABSTRACT: Spin-transfer torque random access memory (STT-RAM) is an emerging storage technology that is considered widely thanks to its attractive features such as low power consumption, nonvolatility, scalability and high density. STT-RAMs are comprised of a hybrid design of CMOS and spintronic units. Magnetic tunnel junction (MTJ) as the basic element of such hybrid technology is inherently robust against radiation induced faults. However, the peripheral CMOS component for sensing the resistance of the MTJs are prone to be affected by energetic particles. This paper proposes low power, nonvolatile and radiation hardened latch and lookup table circuits based on hybrid CMOS/MTJ technology for the next generation integrated circuit devices. Simulation results revealed that, the proposed circuits are fully robust against single event upsets (SEU) and also single event double node upsets (SEDU) that are of the main reliability challenging issues in current sub-nanometer CMOS technologies.

Author(s) affiliation: Department of Electrical Engineering, Shahid Beheshti University, Velenjak, Tehran, Iran

Times cited: 1

Tags: Spintronics - Applications, Spintronics - Devices, Spintronics

continued

Spin-gapless and half-metallic ferromagnetism in potassium and calcium delta-doped GaN digital magnetic heterostructures for possible spintronic applications: insights from first principles (China) 2017

Du, JT, Dong, SJ, Zhou, BZ, Zhao, H, Feng, LF

Source: APPLIED PHYSICS A-MATERIALS SCIENCE & PROCESSING, issue 4, volume 123, 2017, DOI: 10.1007/s00339-017-0864-y

ABSTRACT: The reports previously issued predominantly paid attention to the d-block magnetic elements delta-doped digital magnetic materials. In this work, GaN delta-doped with non-magnetic main group s-block elements K and Ca as digital magnetic heterostructures were purposed and explored theoretically. We found that K-and Ca-embedded GaN digital alloys exhibit spin-gapless and half-metallic ferromagnetic characteristics, respectively. All compounds obey the Slater-Pauling rule with diverse electronic and magnetic properties. For these digital ferromagnetic heterostructures, spin polarization occurs in nitrogen within a confined space around the delta-doped layer, demonstrating a hole-mediated two-dimensional magnetic phenomenon.

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Times cited: 0

Tags: Spintronics - Applications, Spintronics - Materials, Spintronics

Structural and electronic properties of epitaxial multilayer h-BN on Ni(111) for spintronics applications (Russia) 2016

Tonkikh, AA, Voloshina, EN, Werner, P, Blumtritt, H, Senkovskiy, B, Guntherodt, G, Parkin, SSP, Dedkov, YS

Source: SCIENTIFIC REPORTS, volume 6, 2016; DOI: 10.1038/srep23547

ABSTRACT: Hexagonal boron nitride (h-BN) is a promising material for implementation in spintronics due to a large band gap, low spin-orbit coupling, and a small lattice mismatch to graphene and to close-packed surfaces of fcc-Ni(111) and hcp-Co(0001). Epitaxia I deposition of h-BN on ferromagnetic metals is aimed at small interface scattering of charge and spin carriers. We report on the controlled growth of h-BN/Ni(111) by means of molecular beam epitaxy (MBE). Structural and electronic properties of this system are investigated using cross-section transmission electron microscopy (TEM) and electron spectroscopies which confirm good agreement with the properties of bulk h-BN. The latter are also corroborated by density functional theory (DFT) calculations, revealing that the first h-BN layer at the interface to Ni is metallic. Our investigations demonstrate that MBE is a promising, versatile alternative to both the exfoliation approach and chemical vapour deposition of h-BN.

Author(s) affiliation: Max Planck Inst Microstruct Phys, Weinberg 2, D-06120 Halle, Saale, Germany, RAS, Inst Phys Microstruct, GSP-105, Nizhnii Novgorod, Russia, Humboldt Univ, Inst Chem, D-10099 Berlin, Germany, Tech Univ Dresden, Inst Solid State Phys, D-01062 Dresden, Germany, St Petersburg State Univ, St Petersburg 198504, Russia, Rhein Westfal TH Aachen, Inst Phys 2, D-52074 Aachen, Germany, Rhein Westfal TH Aachen, JARA FIT, D-52074 Aachen, Germany, SPECS Surface Nano Anal GmbH, Voltastr 5, D-13355 Berlin, Germany, Osram OS, Leibnitz Str 4, D-93055 Regensburg, Germany, IHP, Technol Pk 25, D-15236 Frankfurt, Oder, Germany

Times cited: 6

Tags: Spintronics - Applications, Spintronics -Materials, Spintronics

Towards fully compensated ferrimagnetic spin gapless semiconductors for spintronic applications (China) 2015

Zhang, YJ, Liu, ZH, Liu, EK, Liu, GD, Ma, XQ, Wu, GH

Source: EPL, issue 3, volume 111, 2015; DOI: 10.1209/0295-5075/111/37009

ABSTRACT: Extensive first-principles calculations suggest that inverse Heusler compounds Mn2Si, Cr2ZnGe, Cr2ZnSn, Ti2VP and Ti2VSb0.5As0.5 are the candidates to achieve fully compensated ferrimagnetic spin gapless semiconductors. It is shown that only the holes can be 100% spin polarized in Mn-2 Si, while both the excited electrons and the holes around the Fermi level 100% spin polarized in the others. A simple rule for searching potential fully compensated ferrimagnetic spin gapless semiconductors in Heusler compounds is proposed. Due to the spin gapless semiconducting and the fully compensated ferrimagnetic properties, these compounds offer distinct advantage towards the development of the practical spintronic devices. Copyright (C) EPLA, 2015

Author(s) affiliation: Univ Sci & Technol Beijing, Dept Phys, Beijing 100083, Peoples R China, Hebei Univ Technol, Sch Mat Sci & Engn, Tianjin 300130, Peoples R China, Chinese Acad Sci, Beijing Natl Lab Condensed Matter Phys, Inst Phys, State Key Lab Magnetism, Beijing 100190, Peoples R China

Times cited: 3

Tags: Spintronics - Applications, Spintronics - Materials, Spintronics

continued

Two-dimensional monolayer designs for spintronics applications (China) 2016

Li, XL, Wu, XJ

Source: WILEY INTERDISCIPLINARY REVIEWS-COMPUTATIONAL MOLECULAR SCIENCE, issue 4, volume 6, pages 441–455; July 2016; DOI: 10.1002/wcms.1259

ABSTRACT: The continuous reduction in the size of spintronic devices highly requires new low-dimensional magnetic materials to mimic the traditional structures of spintronics in nanoscale. Since the discovery of graphene, two-dimensional (2D) crystalline materials with atomic thickness have attracted extraordinary interests, partly due to their novel properties and potential applications in spintronics. In the past decades, many theoretical understandings and designs of 2D materials have been proposed for spintronics, indicating that the combination of spintronics and two-dimensional crystals electronics should be an ideal evolution toward nanoscale spintronics devices and make for the bottom-up spintronics nanoengineering. (C) 2016 John Wiley & Sons, Ltd WIREs Comput Mol Sci 2016, 6:441-455. doi: 10.1002/wcms.1259

Author(s) affiliation: Univ Sci & Technol China, CAS Key Lab Mat Energy Convers, Hefei, Anhui, Peoples R China, Univ Sci & Technol China, Dept Mat Sci & Engn, Hefei, Anhui, Peoples R China, Univ Sci & Technol China, Hefei Natl Lab Phys Sci Microscale, Hefei, Anhui, Peoples R China, Univ Sci & Technol China, Dept Mat Sci & Engn, CAS Key Lab Mat Energy Convers, Hefei, Anhui, Peoples R China, Univ Sci & Technol China, CAS Ctr Excellence Nanosci, Hefei, Anhui, Peoples R China, Univ Sci & Technol China, Synerget Innovat Ctr Quantum Informat & Quantum P, Hefei, Anhui, Peoples R China

Times cited: 0

Tags: Spintronics - Applications, Spintronics

Devices

CMOS-compatible spintronic devices: a review (Austria) 2016

Makarov, A, Windbacher, T, Sverdlov, V, Selberherr, S

Source: Semicond. Sci. Technol. 31 (2016) 113006 (25pp) doi:10.1088/0268-1242/31/11/113006

ABSTRACT: For many decades CMOS devices have been successfully scaled down to achieve higher speed and increased performance of integrated circuits at lower cost. Today's charge-based CMOS electronics encounters two major challenges: power dissipation and variability. Spintronics is a rapidly evolving research and development field, which offers a potential solution to these issues by introducing novel 'more than Moore' devices. Spin-based magnetoresistive random-access memory (MRAM) is already recognized as one of the most promising candidates for future universal memory. Magnetic tunnel junctions, the main elements of MRAM cells, can also be used to build logic-in-memory circuits with non-volatile storage elements on top of CMOS logic circuits, as well as versatile compact on-chip oscillators with low power consumption. We give an overview of CMOS-compatible spintronics applications. First, we present a brief introduction to the physical background considering such effects as magnetoresistance, spin-transfer torque (STT), spin Hall effect, and magnetoelectric effects. We continue with a comprehensive review of the state-of-the-art spintronic devices for memory applications (STT-MRAM, domain wallmotion MRAM, and spin–orbit torque MRAM), oscillators (spin torque oscillators and spin Hall nano-oscillators), logic (logic-in-memory, all-spin logic, and buffered magnetic logic gate grid), sensors, and random number generators. Devices with different types of resistivity switching are analyzed and compared, with their advantages highlighted and challenges revealed. CMOScompatible spintronic devices are demonstrated beginning with predictive simulations, proceeding to their experimental confirmation and realization, and finalized by the current status of application in modern integrated systems and circuits. We conclude the review with an outlook, where we share our vision on the future applications of the prospective devices in the area.

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Times cited: n/a

Tags: Spintronics - Devices, Spintronics

Design of Molecular Spintronics Devices Containing Molybdenum Oxide as Hole Injection Layer (Spain) 2017

Prieto-Ruiz, JP, Miralles, SG, Grossmann, N, Aeschlimann, M, Cinchetti, M, Prima-Garcia, H, Coronado, E

Source: ADVANCED ELECTRONIC MATERIALS, issue 2, volume 3, 2017; DOI: 10.1002/aelm.201600366

ABSTRACT: Molybdenum oxide (MoOx) is a very promising material, as it creates an interfacial dipole that increases the metal work function of the electrode. In organic electronic devices, this causes an improvement of the injection of carriers from the metal electrode into the HOMO of the organic semiconductor. However, up to now, MoOx has never been employed in molecular spintronics.

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Times cited: 0

Tags: Spintronics - Devices, Spintronics

continued

Dynamic Circuit Model for Spintronic Devices (Saudi Arabia) 2017

Meshal Alawein, Hossein Fariborzi

Source: Procedia Engineering, Volume 168, 2016, Pages 966-970: DOI: 10.1016/j.proeng.2016.11.317

ABSTRACT: In this work we propose a finite-difference scheme based circuit model of a general spintronic device and benchmark it with other models proposed for spintronic switching devices. Our model is based on the four-component spin circuit theory and utilizes the widely used coupled stochastic magnetization dynamics/spin transport framework. In addition to the steady-state analysis, this work offers a transient analysis of carrier transport. By discretizing the temporal and spatial derivatives to generate a linear system of equations, we derive new and simple finite-difference conductance matrices that can, to the first order, capture both static and dynamic behaviors of a spintronic device. We also discuss an extension of the spin modified nodal analysis (SMNA) for time-dependent situations based on the proposed scheme.

Author(s) affiliation: Computer, Electrical and Mathematical Sciences and Engineering Division, King Abdullah University of Science and Technology, 4700 Thuwal, Saudi Arabia

Times cited: 0

Tags: Spintronics - Devices, Spintronics

Engineering the magnetic coupling and anisotropy at the molecule-magnetic surface interface in molecular spintronic devices (France) 2017

Campbell, VE, Tonelli, M, Cimatti, I, Moussy, JB, Tortech, L, Dappe, YJ, Riviere, E, Guillot, R, Delprat, S, Mattana, R, Seneor, P, Ohresser, P, Choueikani, F, Otero, E, Koprowiak, F, Chilkuri, VG, Suaud, N, Guihery, N, Galtayries, A, Miserque, F, Arrio, MA, Sainctavit, P, Mallah, T

Source: NATURE COMMUNICATIONS, volume 7, 2017; DOI: 10.1038/ncomms13646

ABSTRACT: A challenge in molecular spintronics is to control the magnetic coupling between magnetic molecules and magnetic electrodes to build efficient devices. Here we show that the nature of the magnetic ion of anchored metal complexes highly impacts the exchange coupling of the molecules with magnetic substrates. Surface anchoring alters the magnetic anisotropy of the cobalt(II)-containing complex (Co(Pyipa)(2)), and results in blocking of its magnetization due to the presence of a magnetic hysteresis loop. In contrast, no hysteresis loop is observed in the isostructural nickel(II)-containing complex (Ni(Pyipa)(2)). Through XMCD experiments and theoretical calculations we find that Co(Pyipa)(2) is strongly ferromagnetically coupled to the surface, while Ni(Pyipa)(2) is either not coupled or weakly antiferromagnetically coupled to the substrate. These results highlight the importance of the synergistic effect that the electronic structure of a metal ion and the organic ligands has on the exchange interaction and anisotropy occurring at the molecule-electrode interface.

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Times cited: 2

Tags: Spintronics - Devices, Spintronics

Hybrid Spintronic-CMOS Spiking Neural Network with On-Chip Learning: Devices, Circuits, and Systems (USA) 2016

Abhronil Sengupta, Aparajita Banerjee, and Kaushik Roy

Source: Physical Review Applied, issue 6, volume 6, 2016; DOI: 10.1103/PhysRevApplied.6.064003

ABSTRACT: Over the past decade, spiking neural networks (SNNs) have emerged as one of the popular architectures to emulate the brain. In SNNs, information is temporally encoded and communication between neurons is accomplished by means of spikes. In such networks, spike-timing-dependent plasticity mechanisms require the online programing of synapses based on the temporal information of spikes transmitted by spiking neurons. In this work, we propose a spintronic synapse with decoupled spike-transmission and programing-current paths. The spintronic synapse consists of a ferromagnet-heavy-metal heterostructure where the programing current through the heavy metal generates spin-orbit torque to modulate the device conductance. Low programing energy and fast programing times demonstrate the efficacy of the proposed device as a nanoelectronic synapse. We perform a simulation study based on an experimentally benchmarked device-simulation framework to demonstrate the interfacing of such spintronic synapses with CMOS neurons and learning circuits operating in the transistor subthreshold region to form a network of spiking neurons that can be utilized for pattern-recognition problems.

Author(s) affiliation: Purdue Univ, Sch Elect & Comp Engn, W Lafayette, IN 47907 USA

Times cited: 1

Tags: Spintronics - Devices, Spintronics

continued

Ion beam etching process for high-density spintronic devices and its damage recovery by the oxygen showering post-treatment process (Japan) 2017

Jeong, J, Endoh, T

Source: JAPANESE JOURNAL OF APPLIED PHYSICS, issue 4, volume 56, supplement S, 2017; DOI: 1347-4065/56/4S/04CE09

ABSTRACT: The electric short fail trend of the perpendicular magnetic tunnel junctions (p-MTJs) caused by the ion beam etching (IBE) process is studied at various ion beam angles and cell-to-cell space widths. The number of electric short fails increases markedly at an ion beam angle greater than 35 degrees and a cell-to-cell space width less than 30 nm at the assumed MTJ height including a hard mask (HM) of 20 nm. In order to recover these electric short fails, we propose the selective oxidation process called the oxygen showering post-treatment (OSP). By the OSP process, the number of electric short fails in sub-30-nm-spaced MTJ arrays is reduced from 25 to 0.8%, and the magnetoresistance (MR) is increased from 99 to 120%. By this result, we can verify that the damaged layer is recovered successfully by the OSP, and that the OSP can be a universal post-treatment process even beyond the 20nm design rule for use in both reactive ion etching and IBE schemes. (C) 2017 The Japan Society of Applied Physics

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Times cited: 0

Tags: Spintronics - Devices, Spintronics

Low-Power and Compact Analog-to-Digital Converter Using Spintronic Racetrack Memory Devices (USA) 2017

Dong, Q, Yang, KY, Fick, L, Fick, D, Blaauw, D, Sylvester, D

Source: IEEE TRANSACTIONS ON VERY LARGE SCALE INTEGRATION (VLSI) SYSTEMS, issue 3, volume 25, pages 907-918, 2017; DOI: 10.1109/TVLSI.2016.2622224

ABSTRACT: Current-induced domain wall (DW) motion in spintronic racetrack memory promises energy-efficient analog computation using compact magnetic nanowires. This paper explores the feasibility of analog-to-digital converter (ADC) based on current-induced DW motion and introduces an n-bit ADC using n racetrack magnetic nanowires. With each magnetic nanowire having a different configuration granularity, an n-bit binary or gray code is generated simultaneously. The proposed ADC structure achieves 21 fJ/conversion-step at 20 MHz with an area of about 10 mu m(2). The racetrack ADC is suitable for applications requiring dense ADC arrays, such as image sensors. This paper describes one ultrahigh speed digital pixel sensor imaging system benefiting from the racetrack ADC.

Author(s) affiliation: Univ Michigan, Ann Arbor, MI 48105 USA, Univ Michigan, Elect Engn & Comp Sci, Ann Arbor, MI 48105 USA

Times cited: 0

Tags: Spintronics - Devices, Spintronics

Metallosupramolecular approach toward multifunctional magnetic devices for molecular spintronics (Spain) 2015

Castellano, M, Ruiz-Garcia, R, Cano, J, Ferrando-Soria, J, Pardo, E, Fortea-Perez, FR, Stiriba, SE, Barros, WP, Stumpf, HO, Canadillas-Delgado, L, Pasan, J, Ruiz-Perez, C, de Munno, G, Armentano, D, Journaux, Y, Lloret, F, Julve, M

Source: COORDINATION CHEMISTRY REVIEWS, volume 303, pages 110-138, November 2015;

ABSTRACT: The work presented in this review constitutes a successful extension of our group's research on the chemistry and physics of dinuclear copper(II) metallacyclophanes with aromatic polyoxalamide ligands. The design and synthesis of metallacyclic complexes that contain multiple electro- and photoactive (either metal- or ligand-based) spin carriers and the study of their spectroscopic and magnetic properties as well as their redox and photochemical activity are of large interest in the multidisciplinary field of metallosupramolecular chemistry. In doing this, a ligand design approach has been followed which is based on the copper(II)-mediated self-assembly of bis(oxamato) bridging ligands possessing potentially electro- and photoactive, extended pi-conjugated aromatic spacers. This strategy benefits from the inherent physical and chemical properties of aromatic organic molecules by functionalizing them with two oxamato donor groups to get dinucleating ligands that are then able to self-assemble with square planar Cu-II ions affording the targeted oxamato-based dicopper(II) metallacyclophanes. The organic functionalization in this new class of metallacyclic systems constitutes a unique example of ligand design for the supramolecular control of the structure and magnetic properties, as well as the electro- and photochemical activities.

Author(s) affiliation: Univ Valencia, nst Ciencia Mol ICMol, Valencia, Spain, FGUV, Valencia, Spain, Univ Cadi Ayyad, Fac Polydisciplinaire Safi, Equipe Chim Mol Mat & Modelisat C3M, Safi, Morocco, Univ Fed Minas Gerais, Dept Quim ICEx, Lab Quim Mat Mol LQMMol, Belo Horizonte, MG, Brazil, Ctr Univ Def Zaragoza, Zaragoza 50090, Spain, Univ La Laguna, Fac Ciencias, Dept Fis, Lab Rayos & Mat Mol

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Times cited: 10

Tags: Spintronics - Devices, Spintronics

Multifunctional Optoelectronic-Spintronic Device Based on Hybrid Organometal Trihalide Perovskites (USA) 2017

Zhang, C, Sun, DL, Vardeny, ZV

Source: ADVANCED ELECTRONIC MATERIALS, issue 2, volume 3, 2017; DOI: 10.1002/aelm.201600426

ABSTRACT: A novel "hybrid" optoelectronic-spintronic (O-S) device that contains an organometal trihalide perovskite (OTP)-based solar cell or light-emitting diode coupled to an inorganic spin valve is presented. The synergy between the OTP and spin valve components results in two new functionalities: nonlinear magnetophotoconductivity and hysteretic magnetoelectroluminescence.

Author(s) affiliation: Univ Utah, Dept Phys & Astron, Salt Lake City, UT 84112 USA

Times cited: 0

Tags: Spintronics -Devices, Spintronics

Overview of emerging memristor families from resistive memristor to spintronic memristor (China) 2015

Wang, L, Yang, CH, Wen, J, Gai, S, Peng, YX

Source: JOURNAL OF MATERIALS SCIENCE-MATERIALS IN ELECTRONICS, issue 7, volume 26, special_issue SI, pages 4618-4628, July 2015; DOI: 10.1007/s10854-015-2848-z

ABSTRACT: Memristor is a fundamental circuit element in addition to resistor, capacitor, and inductor. As it can remember its resistance state even encountering a power off, memristor has recently received widespread applications from non-volatile memory to neural networks. The current memristor family mainly comprises resistive memristor, polymeric memristor, ferroelectric memristor, manganite memristor, resonant-tunneling diode memristor, and spintronic memristor in terms of the materials the device is made of. In order to help researcher better understand the physical principles of the memristor, and thus to provide a promising prospect for memristor devices, this paper presents an overview of memristor materials properties, switching mechanisms, and potential applications. The performance comparison among different memristor members is also given.

Author(s) affiliation: Nanchang Hang Kong Univ, Sch Informat Engn, Nanchang 330063, Peoples R China

Times cited: 11

Tags: Spintronics - Devices, Spintronics

A spintronic memristor bridge synapse circuit and the application in memrisitive cellular automata (China) 2015

Wang, LD, Wang, XD, Duan, SK, Li, HF

Source: NEUROCOMPUTING, volume 167, pages 346-351, 2015; DOI: 10.1016/j.neucom.2015.04.061

ABSTRACT: Spintronic memristor is a new nonlinear circuit element which has property of memory and similar synapse, and the memristive effect can be realized by the spin-torque-induced magnetization switching or the magnetic domain wall motion. In this paper, a simple and compact memristor bridge synapse circuit which is able to perform signed synaptic weighting was proposed. The synaptic model have the good matching features in the system and is verified by matlab simulation experiment on the cellular automata, so this memristor synapse circuit is expected to be applied to neuromorphic system such as cellular neural network.

Author(s) affiliation: Southwest Univ, Sch Elect & Informat Engn, Chongqing 400715, China

Times cited: 5

Tags: Spintronics - Devices, Spintronics

Spintronics: A contemporary review of emerging electronics devices (India) 2016

Vinod Kumar Joshi

Engineering Science and Technology, an International Journal, Volume 19, Issue 3, September 2016, Pages 1503-1513; DOI: 10.1016/j.jestch.2016.05.002

ABSTRACT: Spintronics is a new field of research exploiting the influence of electron spin on the electrical conduction (or current is spin dependent). The major problem is the realization and fabrication of spintronics based devices. To meet the objective scientific community is developing the novel kind of materials that relies on magnetism instead of flow of current through electron. This paper illustrates and reviews one of the emerging technologies known as spintronics by putting few low power computing techniques

continued

altogether based on spintronics to provide a basic and meaningful understanding to the reader. The challenges of spintronics devices that has to meet for the success of electronics future are summarized.

Author(s) affiliation: Department of Electronics and Communication Engineering, Manipal Institute of Technology, Manipal University, Manipal 576104, India

Times cited: 1

Tags: Spintronics - Devices, Spintronics

Spintronics technology and device development (Japan) 2015

Ando, Y

Source: JAPANESE JOURNAL OF APPLIED PHYSICS, issue 7, volume 54, July 2015;

ABSTRACT: Spintronics is an emerging field of research that has made great advances in the last two decades. During this period, various new outstanding spintronics-related phenomena and devices using these phenomena have been proposed. In recent years, the period from the discovery of new spintronics-related materials and phenomena to the development and commercialization of devices using such materials and phenomena has markedly shortened. The importance of understanding the fundamental principles of spintronics has been increasing. In this review, I will first overview the features of spintronics technologies. Then, I will summarize the key technologies applied in the development of spintronic devices and describe their future prospects. (C) 2015 The Japan Society of Applied Physics

Author(s) affiliation: Tohoku Univ, Grad Sch Engn, Dept Appl Phys, Sendai, Miyagi 9808579, Japan

Times cited: 2

Tags: Spintronics - Devices, Spintronics

Materials

Computational investigation of half-Heusler compounds for spintronics applications (USA) 2017

Ma, JH, Hegde, VI, Munira, K, Xie, YK, Keshavarz, S, Mildebrath, DT, Wolverton, C, Ghosh, AW, Butler, WH

Source: PHYSICAL REVIEW B, issue 2, volume 95, 2017; DOI: 10.1103/PhysRevB.95.024411

ABSTRACT: We present first-principles density functional calculations of the electronic structure, magnetism, and structural stability of 378 XYZ half-Heusler compounds (with X = Cr, Mn, Fe, Co, Ni, Ru, Rh; Y = Ti, V, Cr, Mn, Fe, Ni; Z = Al, Ga, In, Si, Ge, Sn, P, As, Sb). We find that a “Slater-Pauling gap” in the density of states (i.e., a gap or pseudogap after nine states in the three atom primitive cell) in at least one spin channel is a common feature in half-Heusler compounds. We find that the presence of such a gap at the Fermi energy in one or both spin channels contributes significantly to the stability of a half-Heusler compound. We calculate the formation energy of each compound and systematically investigate its stability against all other phases in the open quantum materials database (OQMD). We represent the thermodynamic phase stability of each compound as its distance from the convex hull of stable phases in the respective chemical space and show that the hull distance of a compound is a good measure of the likelihood of its experimental synthesis. We find low formation energies and mostly correspondingly low hull distances for compounds with X = Co, Rh, or Ni, Y = Ti or V, and Z = P, As, Sb, or Si. We identify 26 18-electron semiconductors, 45 half-metals, and 34 near half-metals with negative formation energy that follow the Slater-Pauling rule of three electrons per atom. Our calculations predict several new, as-yet unknown, thermodynamically stable phases, which merit further experimental exploration-RuVAs, CoVGe, FeVAs in the half-Heusler structure, and NiScAs, RuVP, RhTiP in the orthorhombic MgSrSi-type structure. Further, two interesting zero-moment half-metals, CrMnAs andMnCrAs, are calculated to have negative formation energy. In addition, our calculations predict a number of hitherto unreported semiconducting (e.g., CoVSn and RhVGe), half-metallic (e.g., RhVSb), and near half-metallic (e.g., CoFeSb and CoVP) half-Heusler compounds to lie close to the respective convex hull of stable phases, and thus may be experimentally realized under suitable synthesis conditions, resulting in potential candidates for various semiconducting and spintronics applications.

Author(s) affiliation: Univ Virginia, Dept Elect & Comp Engn, Charlottesville, VA 22904 USA, Northwestern Univ, Dept Mat Sci & Engn, Evanston, IL 60208 USA, Univ Alabama, Ctr Mat Informat Technol, Tuscaloosa, AL 35401 USA, Univ Alabama, Dept Phys & Astron, Tuscaloosa, AL 35401 USA

Times cited: 0

Tags: Spintronics - Materials, Spintronics - Applications, Spintronics

continued

Ferromagnetic MnGaN thin films with perpendicular magnetic anisotropy for spintronics applications (Japan) 2015

Lee, H, Sukegawa, H, Liu, J, Ohkubo, T, Kasai, S, Mitani, S, Hono, K

Source: APPLIED PHYSICS LETTERS, issue 3, volume 107, 2015; DOI: 10.1063/1.4927097

ABSTRACT: Perpendicularly magnetized flat thin films of antiperovskite Mn67Ga24N9 were grown on an MgO(001) substrate by reactive sputtering using an argon/1% nitrogen gas mixture and a Mn70Ga30 target. The films showed a saturation magnetization of 80-100 kA/m, an effective perpendicular magnetic anisotropy (PMA) energy of 0.1-0.2 MJ/m(3), and a Curie temperature of 660-740 K. Upon increasing the N composition, the films transformed from ferromagnetic to antiferromagnetic as expected in the stoichiometric Mn3GaN phase. Point contact Andreev reflection spectroscopy revealed that the ferromagnetic MnGaN has a current spin polarization of 57%, which is comparable to D0(22)-MnGa. These findings suggest that MnGaN is a promising PMA layer for future spintronics devices. (C) 2015 AIP Publishing LLC.

Author(s) affiliation: NIMS, Tsukuba, Ibaraki 3050047, Japan, Univ Tsukuba, Grad Sch Pure & Appl Sci, Tsukuba, Ibaraki 3058577, Japan, NIMS, 1-2-1 Sengen, Tsukuba, Ibaraki 3050047, Japan

Times cited: 4

Tags: Spintronics - Materials, Spintronics

Heavy ion induced modifications on morphological, magnetic and magneto-transport behaviour of exchange-biased Fe/NiO and NiO/Fe bilayers with Si substrate for spintronic applications (India) 2015

Srivastava, N, Srivastava, PC

Source: JOURNAL OF MATERIALS SCIENCE, issue 23, volume 50, pages 7610-7626, 2015; DOI: 10.1007/s10853-015-9321-5

ABSTRACT: Exchange-coupled interfacial structures of Fe/NiO and NiO/Fe with pSi substrate have been studied and also the effect of swift heavy ion irradiation on the morphological, structural, transport and magnetic behaviour is reported. The interfacial structures have been characterised from X-ray diffraction (XRD), magnetic force microscopy/atomic force microscopy, X-ray photoelectron spectroscopy and magnetisation characteristics. XRD and X-ray photoelectron spectroscopy studies have shown the formation of various silicide and oxide phases due to the interfacial intermixing across the interfaces which is found to affect the transport and magnetic behaviour. A significant enhancement in exchange bias field and coercivity has been observed for Fe/NiO/pSi interfacial structure on the irradiation (as compared to unirradiated ones). The observed enhanced exchange bias and coercivity on the irradiation has been understood due to creation of uncompensated surface/pinned interfacial spins. Magnetic field-induced enhanced current has been observed at low temperatures (50-250 K) for the irradiated structure suggesting the spin-mixing effect. Low temperature magneto-transport study across the irradiated interface has shown negative magnetoresistance (MR) as compared to unirradiated ones for which positive MR is observed. The observed change in MR at low temperatures has been understood in terms of diffuse scattering at grain boundaries/spin-disorder scattering and/or magnetic polarons. Role of interfacial modification/changes in chemical environment across the interfaces is invoked for the observed changes in magnetic and transport behaviour of the structures. A possible explanation for the observed changes is given.

Author(s) affiliation: Banaras Hindu Univ, Dept Phys, Varanasi 221005, Uttar Pradesh, India, Univ Stuttgart, IHFG, D-70569 Stuttgart, Germany

Times cited: 2

Tags: Spintronics - Materials, Spintronics

Indium oxide: A transparent, conducting ferromagnetic semiconductor for spintronic applications (India) 2016

Babu, SH, Kaleemulla, S, Rao, NM, Krishnamoorthi, C

Source: JOURNAL OF MAGNETISM AND MAGNETIC MATERIALS, volume 416, pages 66-74, 2016; DOI: 10.1016/j.jmmm.2016.05.007

ABSTRACT: The optical and electrical properties are the two important dimensions of Indium oxide and its derivatives (indium tin oxide) and were well studied to understand the origin of wide electronic band gap and high electrical conductivity at room temperature. In2O3 and its derivatives find many applications in electronic and optoelectronic domains based on the above properties. The recent discovery of ferromagnetism in In2O3 at room temperature become a third dimension and lead to intensive research on enhancement of ferromagnetic strength by various means such as dopants and synthesis protocols and extrinsic parameters. The research lead to enormous experimental data and theoretical models proliferation over the past one decade with diverse insights into the origin of ferromagnetism in In2O3 based dilute magnetic semiconductors. The experimental data and theoretical models of ferromagnetism in In2O3 has been thoroughly surveyed in the literature and compiled all the data and

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presented for easy of understanding in this review. We have identified best chemical composition, geometry and synthesis protocols for strongest ferromagnetic strength and suitable theoretical model of magnetism has been presented in this review. (C) 2016 Elsevier B.V. All rights reserved.

Author(s) affiliation: VIT Univ, Dept Phys, Thin Films Lab, Vellore 632014, Tamil Nadu, India

Times cited: 4

Tags: Spintronics - Materials, Spintronics- Applications, Spintronics

Li-doped graphene for spintronic applications (Iran) 2016

Kheirabadi, N

Source: RSC ADVANCES, issue 22, volume 6, pages 18156–18164, 2016; DOI: 10.1039/C5RA27922D

ABSTRACT: Generating spintronic devices has been a goal for nanoscience. Here, Li-doped graphene flakes are proposed for spintronic applications. To achieve this goal, density functional theory has been used to determine the magnetic phases of monolayer and bilayer doped graphene nanoflakes. The adsorption energies, spin polarizations, electronic gaps, magnetic properties and robustness of spin-polarized states have been studied in the presence of dopants and second layers. Based on these results, graphene flakes have been introduced as single molecular magnets and spin amplifiers for room temperature applications. It has been determined that for bilayer flakes with two layers of different sizes, the molecular orbitals switch between the layers around the Fermi level. Based on this switch of the molecular orbitals in a bilayer graphene flake, spin on/off switches and spintronic memory devices could be achievable.

Author(s) affiliation: Iran Univ Sci & Technol, Dept Phys, Tehran 1684613114, Iran, Univ Lancaster, Dept Phys, Lancaster LA1 4YB, England

Times cited: 0

Tags: Spintronics - Materials, Spintronics

Long-range ballistic transport mechanisms in superconducting spintronics (Russia) 2016

Samokhvalov, AV, Mel'nikov, AS, Buzdin, AI

Source: PHYSICS-USPEKHI, issue 6, volume 59, pages 571–576, January 2016; DOI: 10.3367/UFNe.2016.02.037769

ABSTRACT: We review the mechanisms responsible for long-range Josephson transport in ballistic hybrid superconductor/ferromagnet/superconductor (SFS) structures with the exchange field modulated in either coordinate or momentum space. These mechanisms are based on the suppression of the destructive interference of electron and hole waves in a ferromagnet caused by the exchange field. The interference suppression results in a slow decay of the singlet component of the pair correlation function in a ferromagnet and an increase in the Josephson current in SFS structures.

Author(s) affiliation: Russian Acad Sci, Inst Phys Microstruct, GSP 105, Nizhnii Novgorod 603950, Russia, Lobachevsky State Univ Nizhni Novgorod, Prosp Gagarina 23, Nizhnii Novgorod 603950, Russia, Univ Bordeaux, LOMA UMR CNRS 5798, F-33405 Talence, France

Times cited: 0

Tags: Spintronics - Materials, Spintronics

Low energy consumption spintronics using multiferroic heterostructures (Switzerland) 2016

Trassin, M

Source: JOURNAL OF PHYSICS-CONDENSED MATTER, issue 3, volume 28; January 2016: DOI: 10.1088/0953-8984/28/3/033001

ABSTRACT: We review the recent progress in the field of multiferroic magnetoelectric heterostructures. The lack of single phase multiferroic candidates exhibiting simultaneously strong and coupled magnetic and ferroelectric orders led to an increased effort into the development of artificial multiferroic heterostructures in which these orders are combined by assembling different materials. The magnetoelectric coupling emerging from the created interface between the ferroelectric and ferromagnetic layers can result in electrically tunable magnetic transition temperature, magnetic anisotropy or magnetization reversal. The full potential of low energy consumption magnetic based devices for spintronics lies in our understanding of the magnetoelectric coupling at the scale of the ferroic domains. Although the thin film synthesis progresses resulted into the complete control of ferroic domain ordering using epitaxial strain, the local observation of magnetoelectric coupling remains challenging. The ability to imprint ferroelectric domains into ferromagnets and to manipulate those solely using electric fields suggests new technological advances for spintronics such as magnetoelectric memories or memristors.

Author(s) affiliation: ETH, Dept Mat, Vladimir Prelog Weg 4, CH-8093 Zurich, Switzerland

Times cited: 5

Tags: Spintronics - Materials, Spintronics

continued

Nanostructured graphene for spintronics (Denmark) 2017

Gregersen, SS, Power, SR, Jauho, AP

Source: PHYSICAL REVIEW B, issue 12, volume 95, March 2017; https://doi.org/10.1103/PhysRevB.95.121406

ABSTRACT: Zigzag edges of the honeycomb structure of graphene exhibit magnetic polarization, making them attractive as building blocks for spintronic devices. Here, we show that devices with zigzag-edged triangular antidots perform essential spintronic functionalities, such as spatial spin splitting or spin filtering of unpolarized incoming currents. Near-perfect performance can be obtained with optimized structures. The device performance is robust against substantial disorder. The gate-voltage dependence of transverse resistance is qualitatively different for spin-polarized and spin-unpolarized devices, and can be used as a diagnostic tool. Importantly, the suggested devices are feasible within current technologies.

Author(s) affiliation: Tech Univ Denmark, DTU Nanotech, CNG, Dept Micro & Nanotechnol, DK-2800 Lyngby, Denmark, Aalborg Univ, Dept Phys & Nanotechnol, Skjernvej 4A, DK-9220 Aalborg, Denmark, CSIC, Catalan Inst Nanosci & Nanotechnol ICN2, Campus UAB, E-08193 Barcelona, Spain, CSIC, Barcelona Inst Sci & Technol, Campus UAB, E-08193 Barcelona, Spain, Univ Autonoma Barcelona, E-08193 Bellaterra, Cerdanyola Del, Spain

Times cited: 0

Tags: Spintronics - Materials, Spintronics

A new approach towards spintronics-spintronics with no magnets (Israel) 2017

Michaeli, K, Varade, V, Naaman, R, Waldeck, DH

Source: JOURNAL OF PHYSICS-CONDENSED MATTER issue 10, volume 29; 2017;

ABSTRACT: We review a recently discovered phenomenon, the chiral induced spin selectivity (CISS) effect, that can enable a new technology for the injection of spin polarized current without the need for a permanent magnetic layer. The effect occurs in chiral molecules and systems without parity symmetry, i.e. systems that do not have inversion symmetry. The theoretical foundations for the effect are presented first and then followed by several examples of spin valves that are based on chiral systems. The CISS-based spin valves introduce the possibility to inject spin current without the use of a permanent magnet and to achieve relatively large magnetoresistance at room temperature.

Author(s) affiliation: Weizmann Inst Sci, Dept Condensed Matter, IL-76100 Rehovot, Israel, Weizmann Inst Sci, Dept Chem Phys, IL-76100 Rehovot, Israel, Univ Pittsburgh, Dept Chem, Pittsburgh, PA 15260 USA

Times cited: 0

Tags: Spintroncis - Materials, Spintronics

Roadmap for Emerging Materials for Spintronic Device Applications (England) 2015

Hirohata, A, Sukegawa, H, Yanagihara, H, Zutic, I, Seki, T, Mizukami, S, Swaminathan, R

Source: IEEE TRANSACTIONS ON MAGNETICS, issue 10, volume 51, 2015; DOI: 10.1109/TMAG.2015.2457393

ABSTRACT: The Technical Committee of the IEEE Magnetics Society has selected seven research topics to develop their roadmaps, where major developments should be listed alongside expected timelines: 1) hard disk drives; 2) magnetic random access memories; 3) domain-wall devices; 4) permanent magnets; 5) sensors and actuators; 6) magnetic materials; and 7) organic devices. Among them, magnetic materials for spintronic devices have been surveyed as the first exercise. In this roadmap exercise, we have targeted magnetic tunnel and spin-valve junctions as spintronic devices. These can be used, for example, as a cell for a magnetic random access memory and a spin-torque oscillator in their vertical form as well as a spin transistor and a spin Hall device in their lateral form. In these devices, the critical role of magnetic materials is to inject spin-polarized electrons efficiently into a nonmagnet. We have accordingly identified two key properties to be achieved by developing new magnetic materials for future spintronic devices: 1) half-metallicity at room temperature (RT) and 2) perpendicular anisotropy in nanoscale devices at RT. For the first property, five major magnetic materials are selected for their evaluation for future magnetic/spintronic device applications: 1) Heusler alloys; 2) ferrites; 3) rutiles; 4) perovskites; and 5) dilute magnetic semiconductors. These alloys have been reported or predicted to be half-metallic ferromagnets at RT. They possess a bandgap at the Fermi level E-F only for its minority spins, achieving 100% spin polarization at EF. We have also evaluated L1(0) alloys and D0(22)-Mn alloys for the development of a perpendicularly anisotropic ferromagnet with large spin polarization. We have listed several key milestones for each material on their functionality improvements, property achievements, device implementations, and interdisciplinary applications within 35 years time scale. The individual analyses and the projections are discussed in the following sections.

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Times cited: 16

Tags: Spintronics - Materials, Spintronics - Applications, Spintronics

continued

Silicene spintronics — A concise review (China) 2015

Wang, YY, Quhe, RG, Yu, DP, Lu, J

Source: CHINESE PHYSICS B, issue 8, volume 24, August 2015; DOI: 10.1088/1674-1056/24/8/087201

ABSTRACT: Spintronics involves the study of active control and manipulation of spin degrees of freedom in solid-state systems. The fascinating spin-resolved properties of graphene motivate numerous researchers to study spintronics in graphene and other two-dimensional (2D) materials. Silicene, the silicon analog of graphene, is considered to be a promising material for spintronics. Here, we present a review of theoretical advances with regard to spin-dependent properties, including the electric field-and exchange field-tunable topological properties of silicene and the corresponding spintronic device simulations.

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Times cited: 5

Tags: Spintronics - Materials, Spintronics

Spin gapless semiconductor like Ti2MnAl film as a new candidate for spintronics application (China) 2015

Feng, WW, Fu, X, Wan, CH, Yuan, ZH, Han, XF, Quang, NV, Cho, S

Source: PHYSICA STATUS SOLIDI-RAPID RESEARCH LETTERS, issue 11, volume 9, pages 641-645, 2015; DOI: 10.1002/pssr.201510340

ABSTRACT: A novel Heusler ferrimagnet Ti2MnAl film has been grown on Si(001) substrate using magnetron sputtering. Characteristics of its magnetic and transport properties reveal the spin-gapless-semiconductor (SGS) nature of the stoichiometric Ti2MnAl, in agreement with theoretical prediction. The as-grown SGS-like Ti2MnAl film demonstrated high Curie temperature, nearly compensated ferrimagnetic properties with small coercivity and low magnetization. It also showed semiconductor-like behavior at room temperature allowing good compatibility with commercial Si-based semiconductor. In this regards, Ti2MnAl film is a potential candidate material for spintronics application, especially for the minimization of energy consumption of device. (C) 2015 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim

Author(s) affiliation: China Univ Geosci, Sch Mat Sci & Technol, Beijing 100083, Peoples R China, Chinese Acad Sci, Inst Phys, Beijing Natl Lab Condensed Matter Phys, Beijing 100190, Peoples R China, Univ Ulsan, Dept Phys, Ulsan 680749, South Korea

Times cited: 7

Tags: Spintronics - Materials, Spintronics

Spintronics with graphene quantum dots (Germany) 2016

Droth, M, Burkard, G

Source: PHYSICA STATUS SOLIDI-RAPID RESEARCH LETTERS, issue 1, volume 10, pages 75-90, January 2016; DOI: 10.1002/pssr.201510182

ABSTRACT: Thanks to its intrinsic ability to preserve spin coherence, graphene is a prime material for spintronics. In this review article, we summarize recent achievements related to spintronics in graphene quantum dots and motivate this field from a spintronics and a materials science point of view. We focus on theory but also discuss recent experiments. The main sources of spin decoherence are interactions with lattice excitations and the hyperfine interaction with present nuclear spins. We explain effective spin-phonon coupling in detail and present a generic power law for the spin relaxation time T-1 as a function of the magnetic field. For specific cases, we discuss spin relaxation in detail. The Heisenberg exchange interaction is paramount for coherent spin qubit operation and addressed in the context of magnetism in graphene nanoflakes. Nuclear spins in the host and surrounding material can be considered by several means and the influence of C-13 nuclei has been studied in detail. Impressive advances in general spintronics and the fabrication of graphene devices are likely to spark significant advances in spintronics with graphene quantum dots in the near future.

Author(s) affiliation: Univ Konstanz, Dept Phys, D-78457 Constance, Germany

Times cited: 1

Tags: Spintronics - Materials, Spintronics

Strained germanium for applications in spintronics (England) 2016

Morrison, C, Myronov, M

Source: PHYSICA STATUS SOLIDI A-APPLICATIONS AND MATERIALS SCIENCE, issue 11, volume 213, pages 2809–2819, 2016; DOI: http://onlinelibrary.wiley.com/wol1/doi/10.1002/pssa.201600713

ABSTRACT: Germanium (Ge) is another group-IV semiconductor material, which recently started attracting tremendous attention in spintronics following success of silicon (Si). The crystal inversion symmetry of Si and Ge precludes the spin relaxation of conduction electrons by the Dyakonov-Perel mechanism, resulting in a long spin relaxation time. Since the proposal of the spin FET in 1990 by Datta and Das, semiconductor materials have been studied for their spin-orbit (S-O) interactions, particularly those that can be modified by an applied electric field, such as the Rashba S-O interaction, in order to create devices that utilise spin modulation and control to perform logic operations. Since then new proposals have appeared. Nowadays they include spin transistors with several different operating principles, spin-based diodes, spin-based field programmable gate arrays, dynamic spin-logic circuits, spin-only logic, spin communication and others. In this review, the focus will be made on presenting recent progress in Ge spintronics including the key advances made. The absence of Dresselhaus S-O coupling in Ge enables a longer spin diffusion length when compared to III-V semiconductor materials. Evidence of a strong Rashba S-O interaction in strained Ge quantum wells has begun to emerge. Also, the first experimental demonstration of room-temperature spin transport in Ge has recently been reported. (C) 2016 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim

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Times cited: 0

Tags: Spintronics - Materials, Spintronics- Applications, Spintronics

Superconducting spintronics (Norway) 2015

Linder, J, Robinson, JWA

Source: NATURE PHYSICS, issue 4, volume 11, pages 307–315, April 2015;

ABSTRACT: Traditional studies that combine spintronics and superconductivity have mainly focused on the injection of spin-polarized quasiparticles into superconducting materials. However, a complete synergy between superconducting and magnetic orders turns out to be possible through the creation of spin-triplet Cooper pairs, which are generated at carefully engineered superconductor interfaces with ferromagnetic materials. Currently, there is intense activity focused on identifying materials combinations that merge superconductivity and spintronics to enhance device functionality and performance. The results look promising: it has been shown, for example, that superconducting order can greatly enhance central effects in spintronics such as spin injection and magnetoresistance. Here, we review the experimental and theoretical advances in this field and provide an outlook for upcoming challenges in superconducting spintronics.

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Times cited: 125

Tags: Spintronics - Materials, Spintronics

Synthetic hybrid Co2FeGe/Ge(Mn) superlattice for spintronics application (China) 2016

Feng, WW, Tuan, DA, Odkhuu, D, Tsogbadrakh, N, Bao, ZD, Zhao, XX, Quang, NV, Cho, SL

Source: APPLIED PHYSICS LETTERS, issue 17, volume 109; 2016; DOI: 10.1063/1.4965977

ABSTRACT: Herein, we propose and provide evidence for the experimentally and theoretically promising route of exploring spintronics materials with high performance via a synthetic hybrid of half-metallic ferromagnet and diluted magnetic semiconductor. Crystalline and well-ordered [Co2FeGe/Ge(Mn)](n) superlattice, which is free of secondary phase separation, were prepared by the hybridization of end members, Co2FeGe and Ge(Mn), using the molecular beam epitaxy technique. Besides comparable magnetic properties with respect to the Co2FeGe films, the superlattice sample exhibits superior properties in electric conductivity and spin polarization, thus enhancing in favor of the spin injection efficiency. These results demonstrate the high feasibility of spintronics materials with low saturation magnetization, small coercivity, high Curie temperature, and high spin injection efficiency through the proposed route in this work. Published by AIP Publishing.

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Times cited: 0

Tags: Spintronics - Materials, Spintronics - Applications, Spintroncis

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Transition-metal dichalcogenides for spintronic applications (Germany) 2014

Zibouche, N, Kuc, A, Musfeldt, J, Heine, T

Source: ANNALEN DER PHYSIK, issue 9-10, volume 526, special_issue SI, pages 395–401, 2014; DOI: 10.1002/andp.201400137

ABSTRACT: Spin-orbit splitting in transition-metal dichalcogenide monolayers is investigated on the basis of density-functional theory within explicit two-dimensional periodic boundary conditions. The spin-orbit splitting reaches few hundred meV and increases with the size of the metal and chalcogen atoms, resulting in nearly 500 meV for WTe2. Furthermore, we find that similar to the band gap, spin-orbit splitting changes drastically under tensile strain. In centrosymmetric transition metal dichalcogenide bilayers, spin-orbit splitting is suppressed by the inversion symmetry. However, it could be induced if the inversion symmetry is explicitly broken, e.g. by a potential gradient normal to the plane, as it is present in heterobilayers (Rashba-splitting). In such systems, the spin-orbit splitting could be as large as for the heavier monolayer that forms heterobilayer. These properties of transition metal dichalcogenide materials suggest them for potential applications in opto-, spin- and straintronics.

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Times cited: 23

Tags: Spintronics - Materials, Spintronics - Applications, Spintronics

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