INTERNATIONAL WORKSHOP ON RECENT ADVANCEMENTS IN MAGNETISM AND MAGNETIC MATERIALS 2024 (I-READ MAGMA 24)

ABSTRACT BOOK

CONVENER

Dr Prabhakaran Thandapani

Co-CONVENERS

Dr Senthil K

Dr Nallamuthu S

Dr Muneeswaran M

Organized by

Department of Physics

School of Advanced Sciences

VIT-AP University, Amaravati, Andhra Pradesh – 522 237, India

VIT-AP UNIVERSITY

iReAd MAGMA24

JNCASR

जवाहरलाल नेहरू उन्नत वैज्ञानिक अनुसंधान केंद्र
Jawaharlal Nehru Centre For Advanced Scientific Research

October 8, 2024

प्रोफेसर सी. एन. आर. राव, F.R.S.
लीनस पौलिङ्ग अनुसंधान प्रोफेसर तथा
मानद अध्यक्ष

Professor C.N.R. Rao, F.R.S.
Linus Pauling Research
Professor and
Honorary President

जक्कूर पोस्ट, बेंगलूरु - 560064
कर्नाटक, भारत
Jakkur P.O., Bengaluru - 560064
Karnataka, INDIA

+91 80 23653075; 22082761 (Off)
+91 80 23601410 (Res)

cnrrao@jncasr.ac.in

www.jncasr.ac.in/cnrrao

विज्ञान एवं प्रौद्योगिकी विभाग,
भारत सरकार के अधीन
An Autonomous Institution
under Department of Science
and Technology, Govt. of India.

An Institution
Deemed-to- be-University

Message

I am delighted that School of Advanced Sciences, VIT-AP University Amaravati has organized an international workshop on Recent Advancements in Magnetism and Magnetic Materials during November 26-30, 2024.

I am glad that the workshop aims to bring together researchers, scientists, and industry professionals working in the field of recent advancement in magnetism and magnetic materials. It is good that participants will get an opportunity to exchange knowledge and discuss recent developments and explore collaborative opportunities. I note that the workshop spans various domains, making it relevant for undergraduates, postgraduates, Ph.D. scholars, and faculty members.

I wish the conference success.

C.N.R. Rao
Linus Pauling Research Professor

VIT-AP UNIVERSITY

iReAd MAGMA24

Vice-Chancellor's message

I am delighted to extend a warm welcome to all participants, speakers, and attendees of the **International Workshop on Recent Advancements in Magnetism and Magnetic Materials 2024**. This esteemed event, hosted online from **November 26 to 30, 2024**, by the **Department of Physics, School of Advanced Sciences (SAS)** at **VIT-AP University**, brings together leading experts and scholars from around the globe to explore the latest breakthroughs in the field of magnetism.

The workshop promises to be an exciting platform for intellectual exchange, featuring a diverse range of topics in magnetism and magnetic materials, with contributions from both national and international speakers. I am confident that the discussions, insights, and ideas shared during this event will not only enrich the global magnetism community but also stimulate innovation and new discoveries that will contribute to the advancement of science and technology, both in India and worldwide.

I would like to commend the **Department of Physics** and the organizing committee for their untiring efforts in making this event a reality. Their commitment to fostering academic collaboration and excellence is truly commendable. I am also pleased to note that the research papers presented at this workshop will be published in the **Journal of Magnetism and Magnetic Materials (JMMM)**, a prestigious Scopus-indexed journal, further enhancing the visibility and impact of the work showcased here.

I extend my best wishes to all the participants and paper presenters. I encourage everyone to make the most of this opportunity to expand their knowledge, forge new collaborations, and contribute to the ongoing evolution of the field of magnetism.

Dr S V Kota Reddy
Vice-Chancellor
VIT-AP University

VIT-AP UNIVERSITY

iReAd MAGMA24

Registrar's message

I am pleased to welcome all participants, speakers, and attendees to the **International Workshop on Recent Advancements in Magnetism and Magnetic Materials 2024**, organized by the **Department of Physics, School of Advanced Sciences (SAS)** at **VIT-AP University**. This online event, taking place from **November 26 to 30, 2024**, offers a valuable platform for experts worldwide to share their latest research in magnetism and magnetic materials.

The workshop will cover a broad range of topics and attract participants from both India and abroad. I am confident that the insights from our distinguished speakers will foster innovation and contribute to advancing the field of magnetism globally.

I extend my sincere thanks to the organizing team for their dedicated efforts in making this event a success, and I am pleased that the research presented will be published in the **Journal of Magnetism and Magnetic Materials (JMMM)**.

Wishing all participants a productive and enriching experience.

Dr. Jagadish Chandra Mudiganti
Registrar
VIT-AP University

VIT-AP UNIVERSITY

iReAd MAGMA24

VIT-AP UNIVERSITY

Dean, SAS's Message

It is my pleasure to warmly welcome all participants, speakers, and attendees to the **International Workshop on Recent Advancements in Magnetism and Magnetic Materials 2024**, organised by the Department of Physics, School of Advanced Sciences (SAS) at VIT-AP University.

This online event, from **November 26 to 30, 2024**, provides a valuable platform for experts worldwide to share their latest research in the dynamic fields of magnetism and magnetic materials. We are excited to host participants from India and abroad and look forward to a diverse exchange of ideas.

The workshop will cover a broad range of topics, and I am confident that the discussions and insights shared by our distinguished speakers will inspire innovation and contribute to advancing research in magnetism globally.

I would also like to sincerely thank the organizing committee for their tireless efforts in bringing this event to fruition. Additionally, I am pleased to inform you that the research presented during the workshop will be considered for the **review process** in the **Journal of Magnetism and Magnetic Materials (JMMM)**.

I wish all participants a productive, engaging, and enriching experience throughout the workshop.

Prof. Srinivas S.
Dean, School of Advanced Sciences,
VIT-AP University

Apply Knowledge. ImproveLife!

VIT-AP UNIVERSITY

iReAd MAGMA24

Program schedule

INDIAN STANDARD TIME (IST)

Day 1 (Tuesday, 26 Nov 2024)	
10:00 – 10:45	Inauguration ceremony
10:00 – 10:0	Welcome address by Dean SAS
10:05 – 10:10	About the workshop – Workshop Convenor
10:10 – 10:15	Address by Registrar
10:15 – 10:25	Address by Vice Chancellor
10:25 – 10:35	Address by Chief Guest
10:35 – 10:40	Vote of thanks – Associate Dean, SAS

Day 1 (Tuesday, 26 Nov 2024)	
10:45 – 11:45	Keynote speaker (D1IT1) **Prof. John Philip,** Emeritus Professor, Department of Physics. Cochin University of Science and Technology, Kochi and Former Associate Director at the Indira Gandhi Centre for Atomic Research, Department of Atomic Energy, Kalpakkam, Chennai, India *Synthesis, capping and applications of superparamagnetic magnetic nanoparticles*
11:45 – 12:30	Invited Talk – 2 (D1IT2) **Prof. Venkateswaran C**, Department of Nuclear Physics, University of Madras, Chennai *The Effect of Epitaxial and Non-Epitaxial Substrates on the Magnetic Properties of GdMnO3 films and the Influence of Mn in ferroelectric* $Bi_{0.5}Na_{0.5}TiO_3$
12:30 – 14:00	**Break**
14:00 – 14:50	Foreign Invited Talk – 1 (D1ITA1) **Prof. Nicola Morley**, University of Sheffield *Materials Informatics for Magnetic Materials Discovery*
15:00 – 16:20	Oral Presentation (Parallel session)
	Parallel Session 1

	Paper IDs (16, 61, 52, 32, 49, 15)
	Parallel Session 2 Paper IDs (51, 55, 24, 56, 78, 81)
	Parallel Session 3 Paper IDs (91, 33, 26, 98, 48, 109, 79)
16:30 – 17:20	Foreign Invited Talk – 2 (D1ITA2) **Prof. Hari Srikanth**, Department of Physics, University of South Florida, Tampa FL 33620, USA *Thermally generated spin transport and spin Seebeck effect in thin film heterostructures*
	End of Day 1

	Day 2 (Wednesday, 27 November 2024)
10:00 – 10:50	Invited Talk – 3 (D2IT3) **Prof. Perumal Alagarsamy** Department of Physics, Indian Institute of Technology Guwahati, Guwahati – 781 039, India *Tunable entropy systems: Ambient synthesis and role of chemical disorder for harvesting energy and future magnetoelectronics*
10:50 – 11:40	Invited Talk – 4 (D2IT4) **By Prof. Murugavel P**, Department of Physics, IIT, Madras *'Spin Reorientation, Exchange-bias Effect and Magnetic Switching Studies in Modified Rare-earth Chromite System'*
11:40 – 12:30	Invited Talk – 5 (D2IT5) **Dr. Sujit Das**, Materials Research Centre, Indian Institute of Science, Bangalore, Karnataka, India Advances of polar and multiferroic topology
12:30 – 14:00	**Break**
14:00 – 14:50	Foreign Invited Talk – 3 (D2ITA3) **Prof. Del Atkinson**, Department of Physics, Durham University, UK

	Magnetic Thin-Films and Multilayers: The Role of Interfaces and Bulk Film Variations on Magnetic and Spintronic Behaviour
15:00 – 16:20	Oral Presentation (Parallel session)
	Parallel Session 1 Paper IDs (10, 20, 27, 100, 31, 60, 62)
	Parallel Session 2 Paper IDs (47, 50, 40, 68, 97, 89, 111)
	Parallel Session 3 Paper IDs (92, 99, 29, 104, 35, 3)
16:30 – 17:20	Invited Talk – 6 (D2IT6) **Prof. Sundarakannan B,** *Department of Physics, Manonmaniam Sundaranar University, Tirunelveli - 627012* *Absorption of Positive Magnetostriction in CFO-LCO Composites and ME Coefficient in Self-composite CFO-NBT Particulates*
	End of Day 2

	Day 3 (Thursday, 28 November 2024)
10:00 – 10:50	Invited Talk – 7 (D3IT7) **Prof. Subhash Thota**, Department of Physics, Indian Institute of Technology Guwahati, Assam, India Frustration Dirven Magneto-Structural Quantum Phases in Spinels
10:50 – 11:40	Invited Talk – 8 (D3IT8) **Prof. Koteswara rao B** Department of Physics, Indian Institute of Technology, Tirupati, India *Unconventional Magnetism in Highly Frustrated Spin Chains*
11:40 – 12:30	Invited Talk – 9 (D3IT9) **Prof. Nirmala N** Associate Professor, Department of Physics, IIT, Madras, India *Studies on magnetocaloric materials: Effect of synthesis conditions on microstructure and magnetism*
12:30 – 14:00	**Break**
14:00 – 14:50	Invited Talk – 10 (D3IT10)

	Prof. Balakumar S, National Centre for Nanoscience and Nanotechnology, University of Madras, Chennai *Enhanced Microwave Absorption Using Magnetic Nanostructures and Functional Carbon Nanoarchitectures*
15:00 – 16:20	Oral Presentation (Parallel session)
	Parallel Session 1 Paper IDs (7, 11, 14, 44, 5, 77, 112)
	Parallel Session 2 Paper IDs (46, 57, 58, 67, 73, 110)
	Parallel Session 3 Paper IDs (59, 22, 103, 82, 88, 108, 9)
16:30 – 17:20	Foreign Invited Talk – 4 (D3ITA4) **Prof. Marcelo Knobel**, Instituto de Física Gleb Wataghin, UNICAMP, Campinas, Brazil *Basic concepts of Nanomagnetism*
	End of Day 3

	Day 4 (Friday, 29 November 2024)
10:00 – 10:50	Invited Talk – 11 (D4IT11) **Prof. R. Justin Joseyphus,** Department of Physics, National Institute of Technology, Tiruchirappalli 620015, Tamil Nadu, India *Structure and Magnetic Properties of Fe-based Alloys Obtained Through Instant Chemical Reduction*
10:50 – 11:40	Invited Talk – 12 (D4IT12) **Prof. Pankaj Poddar**, Senior Scientist National Chemical Laboratory, Pune 411 008, India *Nanomagnetism: spin polarized electron transport, memories, rare earth free hard magnets, and nanomedicines*
11:40 – 12:30	Invited Talk – 13 (D4IT13) **Prof. Gokul Raj,** Department of Physics, Puducherry University, Puducherry, India

	Phase Analysis And Crystallization Kinetics of Rare Earth Magnetic Garnets (RE3Fe5O12) For High Frequency Applications
12:30 – 14:00	**Break**
14:00 – 14:50	Foreign Invited Talk – 5 (D4ITA5) **Prof. RNDr. Marián Reiffers,** DrSc. Institute of Experimental Physics, Slovak Republic *Searching For New Materials With Application Options*
15:00 – 16:20	Oral Presentation
	Parallel Session 1 Paper IDs (34, 18, 63, 21, 96, 28)
	Parallel Session 2 Paper IDs (2, 36, 37, 38, 19, 69, 23)
	Parallel Session 3 Paper IDs (94, 102, 80, 25, 83)
16:30 – 17:20	Foreign Invited Talk – 6 (D4ITA6) **Prof. Andris Bakuzis**, Institute of Physics, Federal University of Goiás, Goiânia, Brazil *Biomimetic Hybrid Magnetic Nanocarrier for MRI-Guided and Real-Time Monitoring of Cancer Thermal Therapy*
	End of day 4

	Day 5 (Saturday, 30 November 2024)
10:00 – 10:50	Invited Talk – 14 (D4IT14) **Prof. A. Taraphder**, Department of Physics, Indian Institute of Technology Kharagpur, India *Metamagnetism from Correlation*
10:50 – 11:40	Foreign Invited Talk – 7 (D5ITA7) **Dr. Carlos Romero-Muñiz**, Física de la Materia Condensada, Universidad D Sevilla, Spain. *Computationally Driven Synthesis and Optimization of Magnetocaloric Materials*
11:50 – 13:30	Oral Presentation

	Parallel Session 1 Paper IDs (17, 43, 53, 70, 72)
	Parallel Session 2 Paper IDs (93, 71, 74, 76, 84)
13:30 – 14:30	**Break**
14:30 – 15:20	Invited Talk – 8 (D5IT15) **Prof. Jyoti Ranjan Mohanty** Department of Physics, IIT Hyderabad *Anisotropy Engineered Magnetic Thin Film For Possible Application*
15:20 – 15:45	Closing ceremony and announcement of prizes/awards

Technical Sessions (Oral Presentation)

List of papers

Time (IST) hh:mm	Paper ID	Day 1 (Tuesday, 26 Nov 2024)
Day 1: Parallel Session 1 (15:00 – 16:20) Paper IDs (16, 61, 52, 32, 49, 15)		
15:00 - 15:10	16	*Erbium-Doped CuS Nanostructures: Effects on Structural, Optical and Magnetic Behaviour* Presenting Author: Babbilapati Sree Sesha Sudha Gayatri, VIT-AP University, India
15:10 - 15:20	61	*Structural and Magnetic Properties of Europium Substituted Zinc Ferrite Nanoparticles Prepared Via Co-precipitation Method,* Presenting Author: B. Uday Kumar, Palamuru University, India
15:20 - 15:30	52	*Nickel Ferrite: Advances in the Synthesis Methods and Their Impact on Structural and Magnetic Properties* Presenting Author: Jayashree Patra, VIT-AP University, India

15:30 - 15:40	32	*Investigation of Structural, Morphology, Thermal, And Magnetic Properties of Ni0.90Cu0.10Te2 Single Crystal* Presenting Author: Rajkumar Sokkalingam, Bharathidasan University, Tiruchirappalli, India
15:40 - 15:50	49	*Structural and Magnetic Properties of La0.7Ce0.3-xCaxMnO3 (x = 0.0 and 0.15)* Presenting Author: Mahavir Prasad Sharma, Guru Ghasidas Vishwavidyalaya, Bilaspur (C.G.), India
15:50 - 16:00	15	*Ferrimagnetic Behavior and Low-temperature Anomalies in Nickel Chromate spinel* Presenting Author: Arijit Datta, IIT Guwahati, India
Day 1: Parallel Session 2 Paper IDs (51, 55, 24, 56, 78, 81)		
15:00 - 15:10	51	*Structural, Optical, and Magnetic Properties of Mn-doped, Cu-doped, and (Mn, Cu)-codoped ZnS Nanoparticles and its Applications* Presenting Author: Pujarani Parida, VIT-AP University, India
15:10 - 15:20	55	*Coercivity Enhancement in Al3+ Substituted Barium Hexaferrite Nanoparticles* Presenting Author: Shalini MG, Vellore Institute of Technology, Chennai campus
15:20 - 15:30	24	*Erbium-Doped β-Ga_2O_3: Synthesis, Structural Characterization, and the Role of Doping in Magnetic and Optical Properties* Presenting Author: ANJU BABU, VIT-AP University, India
15:30 - 15:40	56	*C-TAB and magnetic field assisted hydrothermal synthesis of cobalt ferrite for the mid-range 5G frequency band applications* Presenting Author: Sitarama raju, CVR College of Engineering, Hyderabad, Telangana, India
15:40 - 15:50	78	*Magnetic Study of Co3O4-Go and Co3O4 Nanoparticles Synthesized By Polymer Combustion Method* Presenting Author: Surekha S Jogdand, Pratibha College of Commerce and Computer studies, Chinchwad, Pune
15:50 - 16:00	81	*Structural, Optical, and Magnetic Characterizations of Ni Doped ZnSe Nanoparticles* Presenting Author: KANNAPPAN P, Sacred Heart College, *Tirupattur, India*
Day 1: Parallel Session 3 Paper IDs (91, 33, 26, 98, 48, 109, 79)		
15:00 - 15:10	91	*Optimization of Spin-coated Manganese Doped Cobalt Ferrite Coatings.* Presenting Author: Ketankumar R Gayakvad, K.J.Somaiya College of Science and Commerce (Autonomous), Mumbai, 400077
15:10 - 15:20	33	*Structural and Magnetic Properties of Fe100-Xtix Alloys Prepared By Planetary Ball Milling Process* Presenting Author: Harekrushna Behera, Indian Institute of Technology Guwahati, Guwahati, India
15:20 - 15:30	26	*Comprehensive Analysis of the Structural, Optical, and Magnetic Properties of Cr-Doped SnS2 Nanoparticles Synthesized via Hydrothermal Method* Presenting Author: Anjali Bhattacharyya, VIT AP University, AP, India
15:30 - 15:40	98	*Enhancement of Magnetic Properties In Cu-Doped Mn-Mg Nanoparticles Synthesized By Hydrothermal Method* Presenting Author: Pavan Kumar Malladi, National Institute of Technology Warangal, Telangana, India

15:40 - 15:50	48	*Approaching Ferrite-Based Exchange-Coupled (Ba0.5Sr0.5Fe12O19)1-X/(Ni0.3Co0.7Fe2O4)X Synthesised Via One Pot Sol Gel Auto Combustion Method For Permanent Magnet Applications.* Presenting Author: ABARNA S T, Vellore Institute of Technology, 632014, Tamil Nadu, India.
15:50 - 16:00	109	*Effect of Microwave Sintering on Phase Evolution and Magnetic behavior of Barium hexaferrite* Presenting Author: Y. Kalyanalakshmi, University College of Science, Osmania University, Hyderabad, Telangana, India
16:00 - 16:10	79	*Powder X-Ray Diffraction Study & Rietveld Refinement On Prussian Blue, Iron(III) Hexacyanoferrate(II) (Fe4[Fe(CN)6]3.14H2O)* Presenting Author: ELANKUMARAN Kannan, Marudhar Kesari Jain College, Vaniyambadi

Time (IST) hh:mm	Paper ID	Day 2 (Wednesday, 27 November 2024)
Day 2: Parallel Session 1 Paper IDs (10, 20, 27, 100, 31, 60, 62)		
15:00 - 15:10	10	*Hierarchical Free Energy model in Investigating the Cluster Spin-Glass behavior in Frustrated Spinel Oxides* Presenting Author: Mouli Roy Chowdhury, IIT Guwahati, India
15:10 - 15:20	20	*Investigation of Crystal Structure, Magnetism and Magnetocaloric Effect of Tb0.33Ho0.33Er0.33Cu2 Compound* Presenting Author: Dame La-ai Wankhar Sutnga, Indian Institute of Technology Madras, Chennai, India
15:20 - 15:30	27	*Magnetocaloric Effect in Rare-earth Intermetallic Compound Er3Al2* Presenting Author: Jeebanjyoti Sahoo, Indian Institute of Technology Madras, Chennai, India
15:30 - 15:40	100	*Magnetic Properties of Co35Cr5Fe10Ni30Ti5Al7.5Mn7.5 High Entropy Alloy* Presenting Author: Priyanka Kumari, Central University of South Bihar, India
15:40 - 15:50	31	*Dynamic pressure effect on robust critical temperature (Tc) of MgB2 superconductor* Presenting Author: Rajkumar Sokkalingam, Bharathidasan University, Tiruchirappalli, India
15:50 - 16:00	60	*Large magnetocaloric effect in TbGd(MoO4)3 polycrystalline compound* Presenting Author: Athira P, NIT Andhra Pradesh
16:00 - 16:10	62	*Magnetocaloric Properties of Ferrimagnetic Mn5-xCoxSn3 (X=0.1&0.2) Alloys Exhibiting Spin Glass Transition* Presenting Author: Mani Barathi A, National Institute of Technology Tiruchirappalli
Day 2: Parallel Session 2 Paper IDs (47, 50, 40, 68, 97, 89, 111)		
15:00 - 15:10	47	*Studies on the Structural, Morphological, Magnetic, and Magnetic Hyperthermia properties of Fe3O4 Nanocomposites with CNT, GO and rGO* Presenting Author: REKHA K, VELLORE INSTITUTE OF TECHNOLOGY
15:10 - 15:20	50	*Insights of The Physical Properties of Multiferroic Bi4Ti3O12 - BiFeO3 Composite Thin Film Fabricated By Pulsed Laser Deposition Technique For Memristor Devices*

		Presenting Author: Priyanka Mitra, Birla Institute of Technology & Science-Pilani, Hyderabad Campus
15:20 - 15:30	40	*Studies on Magneto Electric Behavior of (1-X) BaTiO3 - xMgFe2O4 Magnetoelectric Composites* Presenting Author: Padmapriya Durairaj, National Institute of Technology, Tiruchirappalli, India
15:30 - 15:40	68	*Magneto-structural studies of MgFe2O4 synthesized by Combustion method for Magnetic Fluid Hyperthermia (MFH)* Presenting Author: Dhanashri S. Kolte, Rajaram College, Kolhapur, India
15:40 - 15:50	97	*Influence of Fe3+ and Co2+ Co-doping on the Electrical, Magnetodielectric, and Multiferroic Properties of Lead-Free Ba0.7Sr0.3TiO3 Ceramics* Presenting Author: ARBAZ REYAZ KHAN, Chandigarh University
15:50 - 16:00	89	*Effects of Magnetic Field and Temperature on the DC and AC Electrical Properties of Piezo-magnetic $Ni_{0.5}Co_{0.5}Fe_2O_4$ Nanoparticles* Presenting Author: TANMOY MAJUMDER, Vellore Institute of Technology Chennai
16:00 - 16:10	111	*Microwave-Assisted Synthesis and Magnetocaloric Properties of $Zn_{1-x}Gd_xFe_2O_4$ Nanoferrites* Presenting Author: JANJANAM BHARANI LAKSHMI, VIT-AP University, Andhra Pradesh
Day 2: Parallel Session 3 Paper IDs (92, 99, 29, 104, 35, 3)		
15:00 - 15:10	92	*YFeO3 Single Crystals: Metamagnetic Transitions and Spin-Glass Behaviour for Advanced Applications* Presenting Author: SRIMATHY B, Seethalakshmi Ramaswami College, Tiruchirappalli
15:10 - 15:20	99	*Synthesis, characterizations and magnetic properties of different temperatures annealed Co35Fe10Mn5Ni30Ti20 HEA* Presenting Author: Dr Rohit Ranjan Shahi, Central University of South Bihar, India
15:20 - 15:30	29	*Study of the Structural, Surface Morphology, and Magnetic Properties of Europium-doped SrFeO3 Nanomaterials* Presenting Author: Dipak Nath, St Joseph University
15:30 - 15:40	104	*Structural stability and Magnetic properties in hexagonal Lu1-xHoxFeO3 (x = 0 - 0.3)* Presenting Author: SURESH PITTALA, Dayananda Sagar University
15:40 - 15:50	35	*An optical shutter derived from hydrogen bond liquid crystal* Presenting Author: K. Siva Parvathi, Vignan University
15:50 - 16:00	3	*Innovative Synthesis of Fe3O4 Nanoparticles-Loaded Activated Charcoal for Advanced Industrial Wastewater Treatment* Presenting Author: Komal Verma, IIT Guwahati

Time (IST) hh:mm	**Paper ID**	**Day 3 (Thursday, 28 November 2024)**
Day 3: Parallel Session 1 Paper IDs (7, 11, 14, 44, 5, 77, 112)		
15:00 - 15:10	7	*Calcium Induced ferromagnetic behavior in HoCoO3 Perovskite* Presenting Author: Amarjit Das, IIT Guwahati
15:10 - 15:20	11	*Dynamics of Reentrant Spin-Glass in Mixed Spinel Mn1-xTixCo2-yFeyO4* Presenting Author: ARPITA DEB SINGHA, Indian Institute of Technology Guwahati

15:20 - 15:30	14	*Detecting Nature of Magnetic Phase Transitions In Ba Doped La0.67Ca0.33MnO3 With Magnetocaloric Effect AS A Tool* Presenting Author: VISHNUBHARATHI J, Vellore Institute of Technology, Vellore
15:30 - 15:40	44	*A Comparative Study on Arc-melted and Solid-State Synthesized Mn2FeSi Heusler Alloy* Presenting Author: R Jayashire, University of Madras, Chennai
15:40 - 15:50	5	*Emergence of Field-Induced Metamagnetic Transitions in (La)A and (Mn)B cosubstituted NdCoO3 Perovskite* Presenting Author: Priyanka Tiwari, Indian Institute of Technology Guwahati
15:50 - 16:00	77	*Optimized Design of Medium-Scale HTS Coil for Power Stability Enhancement Using Multi-Objective Exact Enumeration* Presenting Author: Garkki B, National Institute of Technology Puducherry
16:00 - 16:10	112	*Magnetic and Magnetocaloric Properties of Bulk and Nanostructured MnP: A Dimensionality Study* Presenting Author: Kuraganti Ramesh Babu, VIT-AP University, Amaravati, Andhra Pradesh, India
Day 3: Parallel Session 2 Paper IDs (46, 57, 58, 67, 73, 110)		
15:00 - 15:10	46	*Electronic Structure and Magnetic Properties of S = 1/2 Alternating Spin Chain system KCuGa(PO4)2* Presenting Author: Vaibhav K Singh, Indian institute of Technology Tirupati
15:10 - 15:20	57	*HYbO2: A Jeff = ½ Spatially Anisotropic Triangular Lattice* Presenting Author: Vikas Kumar Sahu, Indian institute of Technology Tirupati
15:20 - 15:30	58	*Observation of Inhomogeneous Magnetic Behaviour and Griffith-Like Phase in La2-xSrxNiMnO6 (X = 0.1, 0.25, 0.4, 0.5)* Presenting Author: Debasmita Bala, NIT, Andhra Pradesh
15:30 - 15:40	67	*Soliton Solution for Quantum Ferromagnetic Spin Chain with Impurities* Presenting Author: NEJA PRINSA N, Vellore Institute Of Technology, Chennai
15:40 - 15:50	73	*Nucleation of Skyrmions in Hm (Pd, Rh, Or Nb)/Fe Bilayer* Presenting Author: Tamali Mukherjee, Birla Institute of Technology & Science, Pilani, Hyderabad Campus
15:50 - 16:00	110	*Signature of spin glass effect in physical properties of $GdNiAl_3$* Presenting Author: Vimaljith A R, VIT-AP University, Amaravati, AP
Day 3: Parallel Session 3 Paper IDs (59, 22, 103, 82, 88, 108, 9)		
15:00 - 15:10	59	*Dynamics of Magnetization Reversal and Enhanced Magnetic properties in FeTaC/SiO2 Multilayer Thin Films* Presenting Author: Camelia Das, ICFAI University Tripura
15:10 - 15:20	22	*Synthesis of Pulsed Laser Deposited (La0.375 Pr0.325 Ca0.3 MnO3 Thin films* Presenting Author: Sahana C S, VIT, Vellore
15:20 - 15:30	103	*Spin disorder state in a site-depleted coupled trillium lattice compound* Pb1.5Fe2(PO4)3 Presenting Author: BOYA KRISHNAMRAJU, Government Polytechnic Satyavedu
15:30 - 15:40	82	*Preparation and Characterization of PVDF/ CoFe2O4/g-C3N4 Nanocomposite Films for electromagnetic shielding applications* Presenting Author: Nirmal R Kumar, National Institute of Technology, Tiruchirappalli

15:40 - 15:50	88	*Magnetic and Thermal Modulation of DC-AC Electrical Properties in $Zn_{0.3}Ni_{0.7}Fe_2O_4$ Nanoparticles* Presenting Author: TANMOY MAJUMDER, Vellore Institute of Technology Chennai
15:50 - 16:00	108	*Single Step Synthesis and Structural Investigations of Nanocrystalline Magnetic Ferrites MFe2O4 (M=Ni, Co and Mn)* Presenting Author: T Shanmugavel, Mahendra Engineering College Mallasamudram Namakkal
16:00 - 16:10	9	*Influence of Microwave Sintering on Erbium Iron Garnet: Structural, Magnetic, and Dielectric Studies* Presenting Author: Deepannita Chakraborty, PSG Institute of Technology and Applied Research, Coimbatore

Time (IST) hh:mm	**Paper ID**	**Day 4 (Friday, 29 November 2024)**
Day 4: Parallel Session 1 Paper IDs (34, 18, 63, 21, 96, 28)		
15:00 - 15:10	34	*Tuning the Properties of MnAl Alloys for Rare Earth Free Magnet Applications* Presenting Author: Sourav Mandal, Indian Institute of Technology Guwahati
15:10 - 15:20	18	*Study of impedance spectroscopic and magnetic properties of LiMn2O4 and LiMn1.98(SmFe)0.02O4 ceramic materials for energy storage applications* Presenting Author: Thirmal Chnithakuntla, VNRVJIET, Hyderabad
15:20 - 15:30	63	*Impact of Chemical Etching on Magneto-Impedance Response of As-Quenched Amorphous Microwires* Presenting Author: Somnath Das, CSIR- National Metallurgical Laboratory, Jamshedpur
15:30 - 15:40	21	*Structural, Magnetic, and Dielectric properties of bulk CoFe2O4 synthesized by Microwave sintering and Solid-state reaction* Presenting Author: ARYA ROSE THOMAS, Vellore Institute of Technology, Vellore
15:40 - 15:50	96	*A High magnetic Permeability Metamaterial Superstrate as a Gradient Index Lens for 2.4 GHz Patch Antenna Gain Enhancement* Presenting Author: Bharath reddy Gudibandi, VIT AP university
15:50 - 16:00	28	*Preparation and Characterization of $NiCo_2O_4$/RGO/Fe_3O_4 Hybrid Electrode Materials for High-Performance Supercapacitor Applications* Presenting Author: Kavinkumar Thangavel, Karpagam Academy of Higher Education, Coimbatore
Day 4: Parallel Session 2 Paper IDs (2, 36, 37, 38, 19, 69, 23)		
15:00 - 15:10	2	*Sm Doped Cu-Ni Spinel Ferrite Nanoparticles for Hyperthermia Application* Presenting Author: Mritunjoy Prasad Ghosh, Institute of Advanced Study in Science and Technology Guwahati
15:10 - 15:20	36	*Magnetic hyperthermia Studies of CoS/Fe3O4 and ZnS/ Fe3O4 Composites* Presenting Author: Savitha Pillai S, University of Kerala
15:20 - 15:30	37	*Magnetic Fluid Hyperthermia Properties of Polyethylene Glycol-Coated Cobalt Ferrite Nanoparticles* Presenting Author: Fouzia Khan, Indira Gandhi Centre for Atomic Research, Kalpakkam

15:30 - 15:40	38	*pH-Responsive Magnetic Hyperthermia in Chitosan-Coated $MnFe_2O_4$ Nanoparticles: Experimental and Finite Element Analyses* Presenting Author: Srujana Mahendravada, Homi Babha National Institute
15:40 - 15:50	19	*Fe3O4 Mesocrystals: A Multifunctional Platform for Magnetic Hyperthermia and pH-Responsive Drug Delivery in Cancer Treatment* Presenting Author: Akash M, SRM IST
15:50 - 16:00	69	*Structural, Magnetic, Electrical and Dielectric properties of Iron Oxide (Magnetite Phase) and Hyperthermia* Presenting Author: AMRUTHA K, VIT Vellore
16:00 - 16:10	23	*Characterization and Induction Heating Response of Co-Cu Nanoparticles* Presenting Author: Ramakrishna Rao Akurati, Vignan's Foundation for Science Technology and Research, Guntur, Andhra Pradesh
Day 4: Parallel Session 3 Paper IDs (94, 102, 80, 25, 83)		
15:00 - 15:10	94	*Color Center Induced Defects Impacting Magnetic, Optical, and Catalytic Activity of Zinc Ferrites* Presenting Author: Priyadharsini N, Dr.N.G.P Institute of Technology
15:10 - 15:20	102	*Investigating the Magnetic Properties of Magnetite Containing Stones Found at Palakkad Gap, India for Advanced Industrial Applications* Presenting Author: Nithyananda S, VIT-AP University, Amaravati, India
15:20 - 15:30	80	*Selenium-Doped Manganese Ferrite Nanoparticles: Structural Analysis And Applications In Environmental Remediation* Presenting Author: Aparna Unnikrishnan, PSGR Krishnammal College For Women
15:30 - 15:40	25	*Synthesis of Biomass-Derived Carbon Support Embedded With Magnetite For Waste Water Treatment* Presenting Author: Aswathy C T, PSGR Krishnammal College for Women
15:40 - 15:50	83	*Photocatalytic Activity of Green Synthesised Canted Ferromagnetic Hematite Iron Oxide Nanoparticles for Methyl Orange Removal in Wastewater Remediation* Presenting Author: Rahul Das, The University of Burdwan

Time (IST) hh:mm	**Paper ID**	**Day 5 (Saturday, 30 November 2024)**
Day 5: Parallel Session 1 Paper IDs (17, 43, 53, 70, 72)		
11:50 - 12:00	17	*Comprehensive Analysis of CoFeMnZ (Z=Sb, In) Quaternary Heusler Alloys: Structural, Thermoelectric and Magnetic Properties Using Experimental and Ab-Initio Method* Presenting Author: Shabeer Ali Pc, CSIR NIIST
12:00 - 12:10	43	*Effects of Superconductivity and Non-Linear Electron-Phonon Interaction on Impurity Bound States In BCS Superconductor* Presenting Author: Narasimha Raju Chebrolu, Central University of Karnataka
12:10 - 12:20	53	*Quantum Correlations in Nickel-Radical Molecular Complex (Et3NH)[Ni(hfac)2L]* Presenting Author: Muthuganesan R, SRM Institute of Science and Technology, Kattankkulathur, Tamil Nadu
12:20 - 12:30	70	*Tuning The Piezoelectric Polaron Properties Of Asymmetric Gaussian GaAs, CuCl And RbCl Quantum Wells: A Study Of Weak, Intermediate And Strong Coupling Strength Effects* Presenting Author: Swapna Vemula, National Institute of Technology Warangal

12:30 - 12:40	72	*Magnetocaloric Effect of 2D and 3D Ising Model for Honeycomb, Square, and Hexagonal Lattices: A Monte-Carlo Study* Presenting Author: Basit Iqbal, VIT-AP University Amravati
Day 5: Parallel Session 2 Paper IDs (93, 71, 74, 76, 84)		
11:50 - 12:00	93	*Theory of Spin Transport for Two Terminal Rashba-Zeeman Tunnel Junction* Presenting Author: Kingshuk Sarkar, VIT-AP University, India
12:00 - 12:10	71	*The Impact Of The External Magnetic Field On D_2^+ Ion Ground State Properties In A Gaussian GaAs Quantum Dot* Presenting Author: Siddartha Gone, National Institute of Technology Warangal
12:10 - 12:20	74	*Theory of Thermoelectric Transport in Magnetic Graphene* Presenting Author: PURNENDU RAY, VIT-AP University, India
12:20 - 12:30	76	*Structural, Electronic, and Magnetic Properties of Co2HfZ (Z = Al, Sn) Heusler Alloys for Spintronic Applications* Presenting Author: Karumuri Venkanna, National Institute of Technology, Andhra Pradesh-534101 and SGA Govt. Degree College, AP
12:30 - 12:40	84	*Characterization and Deconvolution of Soft and Hard Magnetic Phases in Pulsed Electrodeposited Cobalt-Nickel Films.* Presenting Author: Anand Raj M, Rajalakshmi Engineering College, Chennai

Synthesis, capping and applications of superparamagnetic magnetic nanoparticles

John Philip

Department of Physics.

Cochin University of Science and Technology, Kochi

E-mail: jphilip@cusat.ac.in

Magnetic nanoparticles (MNPs) have garnered significant attention from researchers due to their numerous technologically important applications in diverse fields, including biomedicine, diagnostics, agriculture, optics, mechanics, electronics, sensing technology, catalysis, and environmental remediation. The superparamagnetic nature of MNP is exploited for many applications and remains fascinating to study many fundamental phenomena. Nanoscale magnetic nanoparticle dispersions, which demonstrate remarkable physiochemical characteristics when subjected to a magnetic stimulus, have emerged as an important area of research due to their promising technological applications. These systems are being utilized across various fields, including biomedicine, mechanical engineering, and optics E.g. heat transfer, sensors such as temperature, pH, urea detection, cations, defect detection sensors, tunable optical filters, removal of dyes, dynamic seals, magnetic hyperthermia-based cancer therapy, creation of artificial and reconfigurable structures, biomedicine, etc. In my presentation, I will introduce nanoscale magnetic nanoparticles, their synthesis and capping methods, and preparation of magnetic fluids, and also present their potential applications.

[1] T. Muthukumaran & John Philip, Advances in Colloid and Interface Science (2024) https://doi.org/10.1016/j.cis.2024.103314

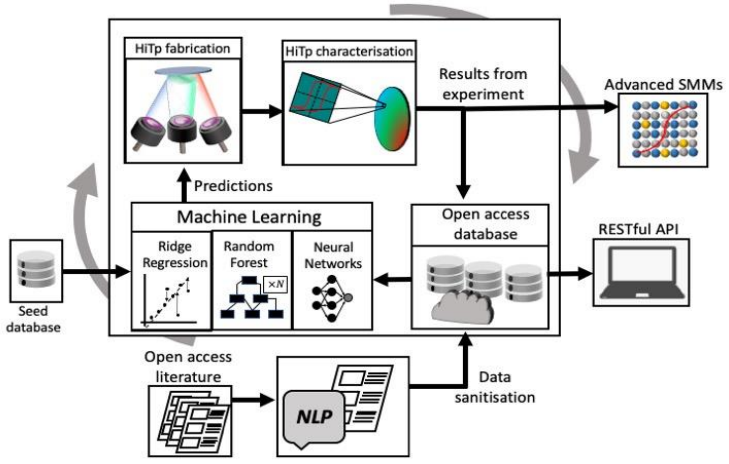
Materials Informatics for Magnetic Materials Discovery

Nicola Morley*, Emily Read, Richard Rowan-Robinson, Zhaoyuan Leong, Sophia Carpio, Coyun Oh, Tom Wilkinson

School of Chemical, Materials and Biological Engineering, University of Sheffield, Sheffield, S1 3JD
*Corresponding Author: n.a.morley@sheffield.ac.uk

Abstract

The climate emergency has established the need for sustainability within existing and new technologies, which is driving a demand for material innovation. New materials need to be economically sourced from abundant elements, whilst still obtaining the required functional characteristics. Functional Magnetic Materials (FMMs) are central to new green technologies. At the present, existing hard magnets, consist of critical elements, while soft magnets are limited due to processing costs and eddy losses. Thus by improving FMMs properties, industries can capitalise on engineering advances, saving money and the environment. Traditional material discovery methods are too slow and costly. Material informatics overcome these existing problems, by using data-driven solutions to reduce the use of natural resources and expensive experiments. Our research has focused on using Natural Language Processing (NPL), including large language models to data mine open access papers to create a FMM database. This has been achieved by combining the linear approach NPL, which searches for defined compositions and parameters, with semantic networks, to allow the compositions related parameters to be correctly linked together. Having created this database, machine learning algorithms are trained on it, which are then used to observe trends within the data, along with predicting compositions with specific magnetic parameters. These compositions are then fabricated and characterised using high-throughput techniques, including combinatorial sputtering, XRD, FMR and MOKE. This allows us to verify the results from the ML, quickly and cheaply, along with discovering new FMMs, plus the results are then feedback into the database, allowing for a full circle discovery methodology.



Keywords: functional magnetic materials; machine learning; natural language processing; high-throughput experiments

Thermally generated spin transport and spin Seebeck effect in thin film heterostructures

Hari Srikanth[*]

[*]*Department of Physics, University of South Florida, Tampa FL 33620, USA*

Abstract

Spin-heat coupling and thermo-spin transport are emerging areas of interest in the fields of spintronics and nanomagnetism. Central to this research are the longitudinal Spin Seebeck effect (LSSE) and its intricate relationships with magnetic anisotropy and magnon propagation across magnetic insulator/heavy metal interfaces. While the ferrimagnetic insulator $Y_3Fe_5O_{12}$ (YIG) serves as the benchmark system for LSSE studies, other insulating rare earth iron garnets like the compensated ferrimagnet $Gd_3Fe_5O_{12}$ (GdIG) and the ferrimagnetic insulator $Tm_3Fe_5O_{12}$ (TmIG) are also of significant interest but have been less explored in spin-caloritronics.

Our group has pioneered the use of RF transverse susceptibility to probe the effective magnetic anisotropy in magnetic materials and heterostructures. By integrating RF transverse susceptibility with LSSE measurements, we have demonstrated the correlation between bulk and surface anisotropy with the field and temperature dependence of LSSE in YIG/Pt heterostructures and other compensated ferrimagnets [1]. Additionally, we have identified a universal scaling of LSSE in GdIG/Pt bilayers with varying thicknesses and substrates, particularly around the compensation temperature [2]. Our recent studies on TmIG/Pt heterostructures with varying film thicknesses highlight the significant roles of anisotropy and Gilbert damping in LSSE [3]. Through a combination of RF susceptibility, LSSE, and broadband ferromagnetic resonance (FMR) experiments, we provide a quantitative analysis of magnon propagation length and its correlation with magnetic anisotropy and Gilbert damping.

Acknowledgements

Work supported by US Department of Energy, Office of Basic Energy Sciences, Division of Materials Science and Engineering under Award No. DE-FG02-07ER46438.

References

[1] V. Kalappattil, R. Geng, R. Das. M. Pham, H. Luong, T. Nguyen, A. Popescu, L.M. Woods, M. Klauei, H. Srikanth and M.H. Phan, *Mater. Horizons* **7** (2020) 1413.

[2] A. Chanda, C. Holzmann, N. Schulz, J. Seyd, M. Albrecht, M.H. Phan and H. Srikanth, *Adv. Func. Mater.* **32** (2022) 2109170.

[3] A. Chanda, C. Holzmann, N. Schulz, A. Ullrich, D. DeTellem, M. Albrecht, M. Gross, C.A. Ross, D. A. Arena, M.H. Phan and H. Srikanth, *ACS Nano.* **18** (2024) 7223.

Basic concepts of Nanomagnetism

Marcelo Knobel

Instituto de Física Gleb Wataghin, UNICAMP 13083-970, Campinas, SP, Brazil

Abstract

Although being studied for more than fifty years, the magnetism of ultra-fine particles is still a field to be better understood, not only from the technological point of view, but also owing to fundamental questions on the basic Physics of some observed phenomena. From an interdisciplinary viewpoint, the fine particle magnetism brings about interest on some areas that study systems which present natural dispersions of magnetic crystallites, such as some animals or geological elements. Also, one can artificially produce materials of potential application in chemistry and engineering (magnetic fluids, magnetic paints, catalysis, magneto-rheological fluids), facts that make the study of nanostructured magnetic materials being of broad utility.

The interest in these systems was renewed with the discovery of the giant magnetoresistance phenomenon in the beginning of the nineties, and, since then, several novel phenomena have been discovered, and subsequently calling the attention of the international scientific community. The inherent complexity of the granular systems, allied with the difficulty to study a single isolated magnetic particle, has become a challenge that has been continuously surpassed through novel theoretical models, computer simulations, and development of new experimental techniques.

In the talk, a general perspective of the magnetic investigations in granular magnetic systems constituted by ultra-fine particles embedded in a non-magnetic matrix. An emphasis will be given to the technological implications of such studies, and the main difficulties faced nowadays by the research teams that work in the field of magnetic recording, for example. To help with the understanding of the discussed topics, several basic principles related to the magnetism of nanocrystalline particle will be revised, such as the Stoner-Wohlfarth model and the concept of superparamagnetism. The phenomena of Giant magnetoresistance and giant Hall effect will be commented and discussed. Finally, recent results from the literature will be shown in order to illustrate the basic concepts and show some questions that are still unanswered in this fascinating area of magnetism and condensed matter Physics.

Searching For New Materials With Application Options

Marian Reiffers[1]

[1]*Faculty of Humanities and Natural Sciences, University of Presov, Ul. 17 novembra 1, 080 01 Presov, Slovakia*
*marian.reiffers@unipo.sk

Abstract

The exploration of intermetallic compounds, steeped in a rich historical legacy, is a testament to the significance of interdisciplinary collaboration in materials research. These compounds, comprising countless microscopic particles including electrons, neutrons, protons, and phonons, exhibit exciting and novel properties arising from their quantum arrangement. This has drawn scientific interest towards exploring condensed matter physics, the foremost field associated with strongly correlated electron systems. Additionally, the study of physical properties at low temperatures, which commenced in the early 20th century, is tied to the emergent behaviour of matter owing to the laws of quantum mechanics. These materials belong to a category of advanced materials and promising magnetic actuators. As the use of permanent magnets (PM) in technology for information storage and green energy generation becomes increasingly important, the development of new magnetic materials is a pressing need. This necessitates the creation of materials that are more cost-effective and contain fewer rare earth (RE) elements. While the task of finding new hard magnetic materials is challenging due to the vast range of crystal structures and chemical compositions, the use of structure-predicting techniques, such as evolutionary or adaptive genetic algorithms and ab initio calculations, offers a promising approach to material discovery. Experimental research on new materials not only opens the door to more environmentally friendly solutions but also unlocks technical practice, thereby recommending the studied material for possible future applications. This potential for future applications should inspire optimism and drive our continued efforts in materials research.

To push the boundaries of our knowledge in materials research, comprehending the behaviour of materials under specific physical conditions represents an initial vital step. We can innovate and develop progressive materials with this knowledge and the invaluable insights from modern physics and chemistry. By tailoring the properties of these materials, we can progressively unearth their potential applications, transforming this research into not just a theoretical effort but also an eminently practical one. Interdisciplinary collaboration will undoubtedly propel the advancement and enhancement of technologies, thereby making previously challenging efforts feasible and more straightforward.

Acknowledgements

The author wants to acknowledge colleagues A. Dzubinska, I. Curlik, F. Gastaldo, M. Giovannini, J. G. Sereni, S. Gabani, G. Pristas, P. Skyba, F. Vavrek, M. Fabian, A. Kumar, M. Clovecko, S. Arapan, P. Nieves, J. Sebesta and D. Legut that they were a member of the

research team. With them, this work could be performed. This research was supported by the VEGA 1/0407/24 and other European projects.

Keywords: intermetallics compounds, physical properties studies, experimental physics

Biomimetic Hybrid Magnetic Nanocarrier for MRI-Guided and Real-Time Monitoring of Cancer Thermal Therapy

Andris Bakuzis[1,2]

[1] *Institute of Physics, Federal University of Goiás, Goiânia, Brazil*
[2]*CNanoMed, Center for Integrative Nanomedicine Research, Federal University of Goiás, Goiânia, Brazil*

*Corresponding Author: bakuzis@ufg.br

Abstract

In this talk we report the development of distinct biomimetic magnetic nanocarriers containing magnetic nanoparticles encapsulated in vesicles and IR780 near-infrared dyes incorporated in the membranes [*10.1021/acsami.4c03434*]. The cell membranes investigated were red blood cell (RBC), melanoma (B16F10) and glioblastoma (GL261). Hybrid nanocarriers containing synthetic lipids and a cell membrane are designed. The nanoparticles were characterized by several techniques. Particular attention is given for MRI contrast agent and thermal therapy (magnetic hyperthermia - MNH and photothermal therapy - PTT) properties. Cell culture revealed lower wrapping times for biomimetic nanocarriers. In vivo murine experiments with distinct route of administration were investigated. We demonstrate the MRI-guided PTT application. Strategies of the group to monitor in real-time thermal therapy will also be discussed, namely luminescent thermometry [*10.1063/5.0211889*] and the implementation of the MRI proton resonance frequency shift thermometry using magnetic nanoparticles. The results support the theragnostic applications of the magnetic nanomaterials for cancer therapy.

Keywords: (thermal nanomedicine, cell membrane nanoparticles, spion, cancer, glioblastoma)

Magnetic Thin-Films and Multilayers: The Role of Interfaces and Bulk Film Variations on Magnetic and Spintronic Behaviour

Del Atkinson[1]

[1]*Department of Physics, Durham University, DH1 3LE, U.K.*
*Corresponding Author:del.atkinson@durham.ac.uk

Abstract

Interfacial interactions mediate phenomena that are significant for spintronics applications, such as interfacial anisotropy, Dzyaloshinskii-Moriya interactions (iDMI) and the proximity-induced-magnetization (PIM) of heavy metals. The materials and structure at the interface are critical to these effects and to spin transport through the interface. This is critical in FM/NM systems for magnetic damping, via the pumping of spin current into NM layers, and spin-orbit torque (SOT) switching from the propagation of spin-current from a HM into a FM layer. The first part of this talk focuses on the relationships between interfacial phenomena, microstructure and functional behaviour. Examples discussed include iDMI and PIM [1] and interfacial enhanced damping and spin-transport [2, 3].

Whilst changes in composition and film structure across interfaces have been widely studied the composition and microstructure within the bulk of a thin-film is often assumed to be uniform. However, results from two studies are presented showing that uniform composition and magnetic behaviour through the 'bulk' of a thin-film should not be assumed without investigation. The first results demonstrate that controlled localised doping within a ferromagnetic layer can effectively reduce the fundamental precessional damping. While a second study, combining compositional and magnetic profiling analysis of rare-earth:transition-metal (RE:TM) ferrimagnetic alloys thin-films, demonstrates that the RE:TM composition ratio varies significantly through the thickness of nominally uniform thin-films [4]. This has implications for RE:TM ferrimagnetic alloys in spintronics affecting the magnetization, compensation temperatures, PMA and potentially the spin transport.

A final study demonstrates that deliberate, controlled localised compositional doping within a ferromagnetic layer can effectively reduce the fundamental precessional damping of the layer by localised electronic engineering with a NM species in the upper and lower few monolayers of a Co layer [5]. The experimental reduction of damping and the tight binding theory, agree up to 30% doping, above which structural changes can occur.

Funding is acknowledged for parts of this work from the UK EPSRC and the Royal Society.

References

[1] Rowan-Robinson … & Atkinson D. ***nature.com/scientific reports*** 7: 16835 (2017)
[2] Swindells C. Hindmarch A.T. Gallant A.J. & Atkinson D. ***Phys Rev B*** 99, 064406 (2019)
[3] Swindells C… & Atkinson D. ***Appl. Phys. Letts***. (2021)
[4] O. Inyang et al. ***APL*** (2023)
[5] S. Azzawi et al. ***APL-Materials*** (2023)

Computationally Driven Synthesis and Optimization of Magnetocaloric Materials

Carlos, Romero-Muñiz[1], Zhe, Cui[1], Jia Yan, Law[1], Luis M, Moreno Ramírez[1], Victorino, Franco[1]

[1]*Departamento de Física de la Materia Condensada, ICMS-CSIC, Universidad de Sevilla, PO Box 1065, 41080 Sevilla, Spain*

*Corresponding Author: crmuniz@us.es

Abstract

Magnetic refrigeration has established itself as a viable alternative to conventional refrigeration technologies based on gas compression cycles. For this purpose, hundreds of magnetic materials have been characterized to achieve competitive performance of upcoming devices.[1] In this regard, computational screening procedures based on density functional theory calculations have proved to be very useful in detecting promising working materials.[2] They do not require large databases of known compounds and can be carried out quickly, cost-effectively, and with a high reliability, as a previous step before the experimental synthesis of target compounds. Recently, we have applied this type of procedure (see flow diagram in Figure 1) in optimizing the magnetocaloric properties of MnB,[3] a metal monoboride that belongs to a family of inorganic compounds with a very rich chemistry. Although previous studies aimed to perform substitutional doping of the magnetic atomic site of monoborides, we demonstrate that magnetic substitutions at the Mn site significantly decrease the once promising magnetocaloric and magnetic properties. Conversely, partial substitutions of boron atoms by nonmagnetic elements, (i.e., Ge or Si) lead to new compounds with a magnetocaloric effect greater than that of pure MnB. Presently, we are using this methodology in other systems of interest like MM'X alloys. They display a martensitic transformation and can incorporate a great variety of chemical elements in its structure.[4]

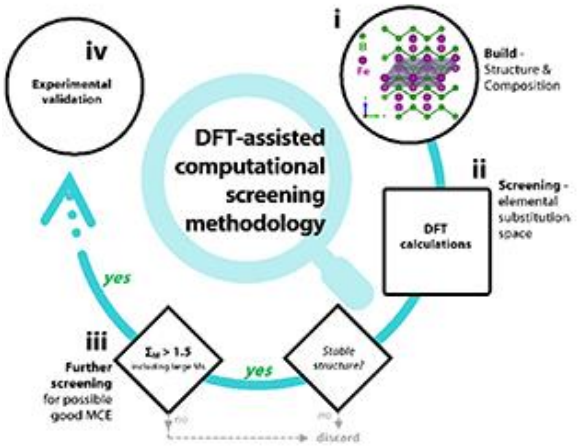


Figure 1: A flowchart that summarizes our computational approach to the synthesis of new borides using the composition and crystal structure as inputs for the screening procedure.

[1]V. Franco et al., Prog. Mater. Sci., **93**, 112 (2018)
[2]J. D. Bocarsly et al., Chem. Mater., **29**, 1613 (2017)
[3]C. Romero-Muñiz et al., J. Phys.: Energy, **5**, 024021 (2023)
[4]Z. Cui, et al., (In preparation)

Keywords: Magnetocaloric effect; Density functional theory; Computational screening,

The Effect of Epitaxial and Non-Epitaxial Substrates on the Magnetic Properties of $GdMnO_3$ films and the Influence of Mn in ferroelectric $Bi_{0.5}Na_{0.5}TiO_3$

Prof. Venkateswaran C
Department of Nuclear Physics, University of Madras, Chennai, India

Abstract

The role of substrates on the structural, topographical and magnetic properties of orthorhombic $GdMnO_3$ (GMO) thin films deposited by RF Magnetron Sputtering on (100) oriented $SrTiO_3$ (STO) and Quartz substrates are studied. Orthorhombic GMO show uniform plane growth in the (100) direction of STO, whereas a polycrystalline feature with an island growth is observed on the Quartz substrate. GMO deposited on both the substrates show canted antiferromagnetism at ~ 25 K and a paramagnetic-antiferromagnetic transition at T_N ~ 47 K. But a cusp representing spin glass transition is observed in GMO coated on Quartz substrate at low temperature ZFC measurements. In another study, the effect of manganese (Mn) on the B site of ferroelectric bismuth sodium titanate is investigated. Samples with increasing Mn concentration induce particle growth due to the agglomeration of particles along with the oxygen reduction, also exhibiting ferromagnetic behaviour. Ferroelectric nature is exhibited by all the Mn doped samples, but the 1 % Mn sample shows high retentivity in the magnetisation studies and a high switched charge density of 2.646 $\mu C/cm^2$, determined from the ferroelectric Positive Up Negative Down (PUND) measurements.

Tunable entropy systems: Ambient synthesis and role of chemical disorder for harvesting energy and future magnetoelectronics

Sahu, Alok Kumar[1], Nidhi, Rawat[1], Tandirma, Mitra[1], Perumal, Alagarsamy[1]
[1]*Department of Physics, Indian Institute of Technology Guwahati, Guwahati – 781 039, India*
*Corresponding Author: perumal@iitg.ac.in

Abstract

The ever-demanding techie world in today's life brings uncontrolled growth of the Internet of Things, wearable electronics, consumer electronic devices, etc., requiring substantial research interest in materials science to quest for novel/advanced materials [1]. The most common approach to tuning materials' properties is the substitution of preferred choices of elements in the parent materials. However, such approaches have limitations due to precipitations/phase changes. The other approach that has gained significant interest recently is based on mixing together multiple principal elements in relatively high concentrations. In this disordered and multi-component system (see Fig. 1), high entropy produces appealing qualities. Materials synthesized from this strategy not only allow for the tailoring properties but also provide an opportunity to explore multi-component phase diagrams [2,3]. In this presentation, we report the viability of ambient synthesis of tunable entropy systems using the simplest and most cost-effective techniques without high-temperature treatment and exploring chemical disorders for harvesting energy and future magnetoelectronics.

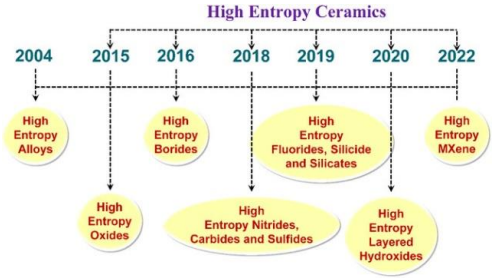


Fig.1. Era of high entropy materials [4].

Single-phase tunable entropy systems based on oxides and silicides were prepared using the planetary ball mill at ambient conditions. The structural studies revealed that the as-prepared oxides and silicides exhibited single-phase spinel structure having M_3O_4 structure (M-NiMnZnFeAl) (space group $Fd\bar{3}m$, 227) and MSi structure (M-MnNi) (space group $P2_13$, 198). The systematic investigation of structural and microstructural properties, electronic, electrical, and magnetic properties in both these systems will be presented in detail.

Keywords: Tunable entropy, High entropy oxides, Energy harvesting, Magnetoelectronic, Ball milling

ACKNOWLEDGEMENT

The authors acknowledge the SERB, New Delhi [CRG/2022/002284], DST, New Delhi [SR/ S2/ CMP-19/ 2006; SR/ FST/ PII-020/ 2009; SR/ FST/ PSII-037/ 2016] for support.

REFERENCES

[1]. V.B. Pawade, P.H. Salame and B.A. Bhanvase, Multifunctional nanostructured metal-oxides for energy harvesting and storage devices, Taylor & Francis Group, CRC Press (2020).

[2]. Sarkar et al., Scripta Materialia 187, 43 (2020).
[3]. Kotsonis et al., J. Amer. Ceramic Soc. 106, 5587 (2023).
[4]. Yao *et al.*, Science, 376 (2022) 151

Spin Reorientation, Exchange-bias Effect and Magnetic Switching Studies in Modified Rare-earth Chromite System

P. Murugavel* and Manu Mohan

Perovskite Materials Laboratory, Functional Oxides Research Group (FORG),

Department of Physics, IIT-M, Chennai

**Corresponding Author's email: muruga@iitm.ac.in*

Abstract

Research on rare earth chromite and orthoferrites systems is attractive due to their coexisting functionalities comprising multiferroicity, spin-reorientation phase transition, and sign reversal of magnetization. Among rare earth chromites, $SmCrO_3$ is a well-studied system exhibiting complex magnetic properties. On the other hand, the orthoferrites $SmFeO_3$ is a prominent compound exhibiting the highest Néel temperature and spin reorientation temperature. The spin reorientation phenomenon in magnetic systems generates interest due to its application potential in fields like spintronic devices. However, both $SmCrO_3$ and $SmFeO_3$ exhibit the spin-reorientation transition (T_{SR}) either at low or well above room temperature. In this work, a systematic tuning of the T_{SR} towards room temperature is demonstrated in $SmFe_{1-x}Cr_xO_3$ (x = 0.0,0.1,0.3, 0.4, 0.8, 1.0) system[1], where the composition x = 0.4 revealed near-room temperature magnetic ordering along with the signature of spin-phonon coupling. Additionally, the compound $SmCr_{0.8}Fe_{0.2}O_3$ exhibits interesting magnetic properties like negative magnetization and magnetic compensation in field-cooled conditions. Notably, the temperature- and field-dependent magnetic switching are demonstrated in the $SmCr_{0.8}Fe_{0.2}O_3$ sample.[2] This sample also displays the exchange bias phenomenon at 10 K with a remarkable value of -1.39 T as an exchange bias shift. The detailed results will be presented in this talk.

References:

[1]M. Mohan and P. Murugavel, Tuning the spin-reorientation towards room temperature and the evidence for spin-phonon coupling in modified $SmFeO_3$, *J. Alloys Compd.,* 955, 170140 (2023).

[2]M. Mohan, S. Nayak, A. Pal, and P. Murugavel, Bipolar magnetic switching and large exchange-bias in Fe-substituted $SmCrO_3$, *J. Phys.: Condens. Matter*, 47, 475801 (2023).

Advances of polar and multiferroic topology

Sujit Das

Materials Research Centre, Indian Institute of Science, Bangalore, Karnataka, India

Complex topological configurations in condensed matter physics provide a fertile ground for the exploration of novel emergent phenomena and exotic phases. Recent discoveries of polarization vortices, flux closures, and phase coexistence in ferroelectric oxide superlattices under applied fields have revealed new opportunities for studying topological behavior and manipulating these features with electric fields. [1,2] In this talk, we demonstrate the transition from room-temperature ferroelectric flux closures to polar vortices and skyrmions in lead titanate layers confined by strontium titanate layers through epitaxial engineering.[3] Phase-field modeling and second-principles calculations confirm that polar vortices carry a topological charge of zero, while polar skyrmions have a charge of +1.[4] Additionally, these nanometer-scale polar structures can be controlled via electric fields and temperature modulation. We also observe self-assembled topological nanostructures in multiferroic $BiFeO_3$, which can be further manipulated by electric fields. Importantly, applying a small voltage generates high domain wall currents suitable for resistive memory applications, and a notable magnetic moment is detected from these self-assembled structures, offering promise for high-frequency electronics and memory technologies.

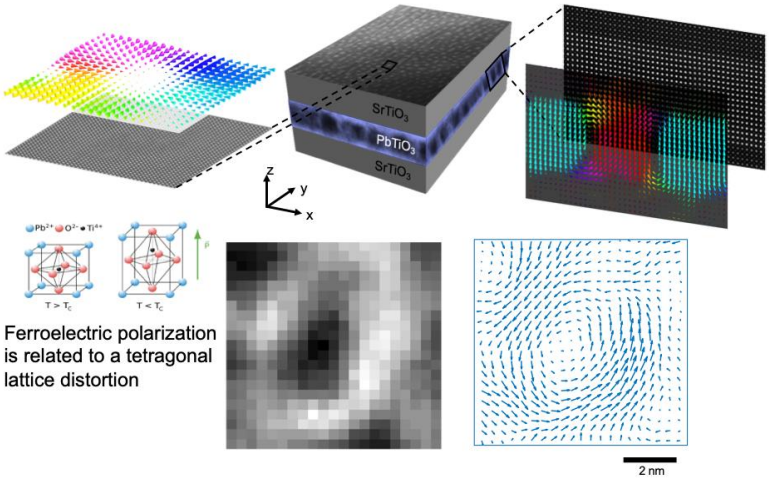


Fig.1. Polar-skyrmion structure. The HAADF-STEM image (top left) shows a hedgehog-like skyrmion structure with reversed Ti-displacement vectors. The dark-field TEM image (top middle) provides a top view of the superlattice, while the cross-sectional HAADF-STEM image (top right) reveals a cylindrical domain with anti-parallel polarization. The 4D-STEM image (bottom) indicates Bloch-like polarization in the superlattice.

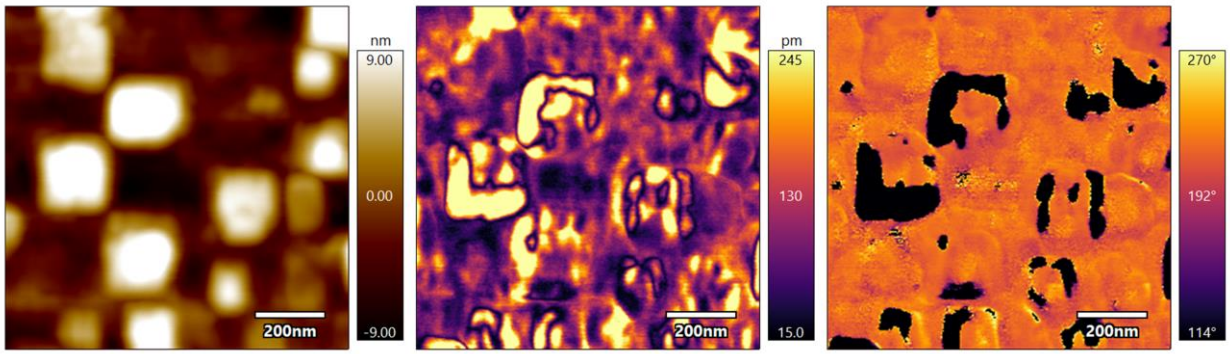


Fig.2 Vertical PFM images for the BFO/LSMO films, topography (left), amplitude (center) and phase (right).

References

[1]Yadav, A.K., Nelson, C.T. *et al*., Observation of polar vortices in oxide superlattices. Nature **530**, 198-201 (2016).
[2]Damodaran, A., Clarkson, J., Hong, Z., Liu, H. et al., Phase coexistence and electric-field control of toroidal order in oxide superlattices. Nat. Mater. **16**, 1003 (2017).
[3] Das, S *et al*, Observation of room temperature polar skyrmions. Nature **568**, 368-372 (2019).
[4]Li, Q.,Das, S. *et al*, Collective excitations of polar vortices. Nature **592**, 376-380 (2021)

Absorption of Positive Magnetostriction in CFO-LCO Composites and ME Coefficient in Self-composite CFO-NBT Particulates

Sundarakannan, Balasubramanian

[1]*Department of Physics, Manonmaniam Sundaranar University, Tirunelveli - 627012*

*Corresponding Author: sundarakannan@msuniv.ac.in

Abstract

Polycrystalline cobalt ferrite exhibit bipolar magnetostriction as a function of applied magnetic field and formation of composites with suitable materials enhances this response at low range of magnetic field. A novel CoFe2O4 -LaCoO3 composite was prepared to enhance the strain sensitivity of the CoFe2O4 for magnetic sensor applications. Minimal interdiffusion at the interface between grains of the two constituents inferred from the Backscattered electron micrographs and the elemental mapping which confirms the formation of composites. The shape of λ-curves and the magnitudes of magnetostriction coefficients are changed significantly with an increase in LCO content. Quadratic behavior of the magnetostriction is found to deviate drastically. A model consisting of two interfaces between CFO-LCO-CFO grains is proposed to explain the conversion of bipolar to uni-polar behavior of magnetostriction of CFO [1]. Magnetoelectric particulate composite (100-*x*) NBT- *x*CFO(sc) (*x* = 5,15,25,35) were prepared from pre-sintered NBT and self-composite CFO(sc) by solid-state reaction route. Unsaturated ferroelectric loops and enhanced ferromagnetic properties are evidenced. The enhancement ME coefficient is due to the effective strain transfer at the interfaces of the composites. This is explained by a simple dimensionless quantity, degree of interface. This quantity is defined using the interface length of ferroelectric-ferromagnetic phases and the weighted average grain size which corroborates the enhancement of the ME coefficient [2].

Keywords: Magnetostriction; ME coefficient; Composites; Self-composites; Interface

Reference:

1. Ferromagnetic-ferroelastic novel particulate composites: Absorption of positive magnetostriction of CoFe2O4 by LaCoO3 and enhanced strain sensitivity at low field, P.M.Priya Dharsini, G.C. Ancy, Amritesh Kumarb, A. Arockiarajan, B. Sundarakannan, J. Alloy & Compds, 968 (2023) 171984

2. Leveraging the strain transfer at the interface between self-composite $CoFe_2O_4$ embedded in pre-sintered $Na_{0.5}Bi_{0.5}TiO_3$ ceramics matrix for the enhancement of magnetoelectric voltage coefficient, P M Priya Dharsini, Bhadra Priya, K Nandakumar and B Sundarakannan, Physica Scripta, 99(2024) 055909

Frustration Dirven Magneto-Structural Quantum Phases in Spinels

Subhash Thota

Department of Physics, Indian Institute of Technology Guwahati, 781039, Assam, India
*Email: subhasht@iitg.ac.in

Abstract

Spinel oxides (general formula AB_2O_4) have provided many delightful fundamental physical phenomena to the strongly correlated matter community which are still considered as great examples in frustrated magnetism [1]. Spinels are also considered as archetypal examples for spin-liquids, spin-ice and re-entrant spin-glass systems all of which are essentially originating from magnetic frustration [2-3]. In the current talk we focus on the magneto-structural quantum phases exhibited by several spinels due to which a prodigious research activity has been carried out in the recent past [1-4]. Along with these properties many exciting experimental observations are reported with theoretical explanations to understand such unique electronic and magnetic properties of few strongly correlated spinel oxides at both bulk- and nano-scales [1-3]. In this talk we mainly focus on the magneto-structural quantum phases, electronic structure and magnetic behaviour of few diluted cobalt-spinels such as Co_2TiO_4 and Co_2RuO_4. Generally, the cations at the B-site of cubic spinel lattice forms the three dimensional network of corner sharing tetrahedra leading to an arrangement commonly noticed in Pyrochlore lattice which causes the phenomena of geometrical-frustration. These aspects result in a degenerate manifold of ground states. Competing exchange interactions between the cations causes unravelling mixed phase magnetic structure such as Gabay-Toulouse type mixed phases, bipolar-exchange bias, negative magnetization and compensation etc. Such intriguing properties of above inverse-spinel oxides along with their unusual electronic structure will be the main focus of the present talk.

Acknowledgements

Author thank the FIST program of Department of Science and Technology, India, for partial support of this work (Grants No. SR/FST/PSII-020/2009 and No. SR/FST/PSII-037/2016)..

Keywords: Spinels, Ferrimagnetism, Spin-glass and Geometrical Frustration

References

[1] F. Guillou, S. Thota, W. Preellier, J. Kumar and V. Hardy, *Phys. Rev. B*. **83,** 094423, (2011)

[2] A. W. Kinross, M. Fu, T. J. Munsie, H. A. Dabkowska, G. M. Luke, Subir Sachdev, and T. Imai, *Phys. Rev. X*. **4**, 031008 (2014)

[3] J. A. Hertz, *Phys. Rev. B*. **14**, 1165 (1976)

[4] S. Chakravarty, B. I. Halperin, and D. R. Nelson, *Phys. Rev. B*. **39**, 2344 (1989)

Unconventional Magnetism in Highly Frustrated Spin Chains

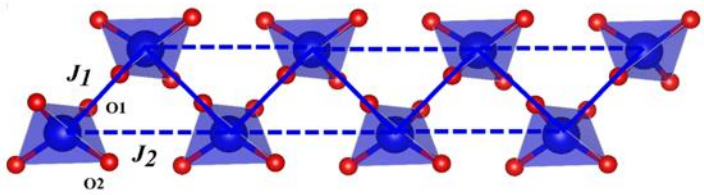
B. Koteswararao

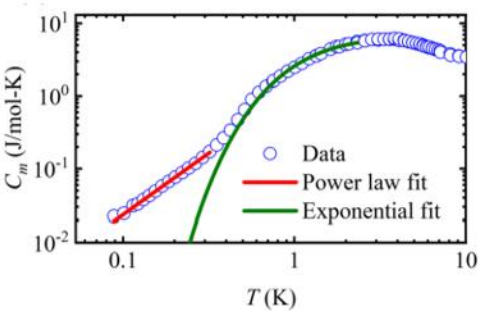
Department of Physics, Indian Institute of Technology Tirupati, Tirupati 517 619, India.

Abstract

Highly frustrated magnets (HFMs) exhibit novel ground states ranging from exotic spin-disorder to unconventional spin-order states. Quantum Spin Liquid (QSL) is a spin-entangled quantum state in which the strongly interacted spins do not order even at $T = 0$ K. Generally, the QSL state is observed in a few $S = ½$ model HFMs. The QSL is rarely noticed in the large spin $S = 5/2$ systems, as the large spin systems show a small amplitude of quantum fluctuations. In my talk, I will present our recent investigation of a few potential $S = 5/2$ HFMs, $Bi_3FeMo_2O_{12}$ (BFMO) and $K_3FeMo_4O_{15}$ (KFMO).

The structure of BFMO and KFMO consists of very well-separated, infinite $S = 5/2$ frustrated spin chains (FSC), like the Majumdar-Ghosh (MG) chains [1]. While tuning the ratio of the next-nearest-neighbour (NNN) and nearest-neighbour (NN) coupling ($\alpha = J_2/J_1$), the $S = ½$ FSC system exhibits a fully gapped phase [1]. The $S = 5/2$ FSC system shows a large "quantum floating phase" region, a gapless disorder state maintaining incommensurate correlations [2]. However, there is no experimental realization so far. With this motivation, we have investigated two compounds: BFMO and KFMO [3, 4]. The electronic structure calculations show that the α values for BFMO and KFMO are close to 1. Despite relatively large antiferromagnetic interactions, no magnetic long-range order (LRO) is noticed down to 100 mK. The temperature-dependent magnetic heat capacity follows the power-law behavior, indicating that the compounds exhibit gapless excitations. According to the quantum phase diagram of the S = 5/2 FSC theoretical model, the BFMO and KFMO systems should be placed in the "*Quantum floating phase"* region.





References:

[1] C. K. Majumdar and D. Ghosh, J. Math. Phys. **10**, 1388 (1969).
[2] N. Chepiga, I. Affleck, & F. Mila, Phys. Rev. B **105**, 174402 (2022).
[3] K. Boya *et al.*, Phys. Rev. B **104**, 184402 (2021).
[4] K. Boya *et al.*, Phys. Rev. B 109, 155130 (2024).

Studies on magnetocaloric materials: Effect of synthesis conditions on microstructure and magnetism

R. Nirmala*

Department of Physics, Indian Institute of Technology Madras, Chennai 600 036, India

*E-mail: nirmala@physics.iitm.ac.in

Abstract

Rare-earth intermetallic compounds and transition metal alloys are considered as potential materials for magnetic refrigeration [1]. Conventionally, these are synthesized by electric arc-melting under inert atmosphere. In the present work, in addition to the standard arc-melting process, melt-spinning and undercooling techniques have been used to prepare the intermetallic compounds. The effect of synthesis conditions on microstructure and magnetism is investigated. Results obtained on ferromagnetic, antiferromagnetic and ferrimagnetic materials such as RAl_2, RNi, $AlFe_2B_2$, RCu_2 and RCo_2 will be discussed [2-4]. Rapid solidification of these samples has resulted in crystalline samples with textured, micrometer-sized grains with competitive magnetocaloric properties when compared to arc-melted specimens. Undercooling also yields phase-pure rare earth intermetallic compounds and it could be one alternative method of synthesis of magnetocaloric materials.

Keywords: Rare earth intermetallic compounds, magnetic properties, magnetocaloric effect.

References:

1. Franco et al, Prog. Mater. Sci. **93** (2018) 112
2. Rajivgandhi et al, J. Alloys. Compd. **815** (2020) 152659
3. Jinu Kurian et al, J. Magn. Magn. Mater. **499** (2020) 166302
4. Prusty et al, AIP advances **12** (2022) 035145

Enhanced Microwave Absorption Using Magnetic Nanostructures and Functional Carbon Nanoarchitectures

S. Balakumar* and G. Theertharaman

National Centre for Nanoscience and Nanotechnology, University of Madras, Chennai 24

***balasuga@yahoo.com**

The rapid advancement of technology has led to a rise in electromagnetic radiation, contributing to a new form of pollution that negatively impacts human health, living organisms, and sensitive electronic equipment. Recent breakthroughs in nanotechnology have enabled the development of composite materials with outstanding microwave absorption capabilities. This research focuses on the creation of advanced nanostructured materials designed to enhance microwave electromagnetic interference (EMI) shielding. By integrating magnetic nanotextures with functionalized conducting carbon nanoarchitectures, the study aims to improve the effectiveness of microwave absorption.The research combines magnetic nanomaterials such as Fe0, Fe_3N, Fe_3S_4, and Fe_3O_4 with various carbon-based materials like reduced graphene oxide (rGO), nitrogen-doped rGO (N-rGO), nitrogen-doped sugarcane bagasse (N-SCB), carbon black (CB), 3D reduced porous carbon (3D rPC), and amine-functionalized multi-walled carbon nanotubes (MWCNT). These high-performance composites offer significant improvements in microwave absorption, making them ideal for EMI shielding applications. Key advantages include their lightweight nature, flexibility, chemical stability, high surface area, and excellent electrical conductivity. The presentation explores the optimization of these materials, highlighting how the composition and structural design of the composites impact their microwave absorption efficiency. The findings demonstrate the enhanced performance and practical applications of these nanostructured materials for EMI shielding and microwave absorption.

Keywords: EMI shielding; Ferrites; Carbon nanocomposites; Microwave absorption

Structure and Magnetic Properties of Fe-based Alloys Obtained Through Instant Chemical Reduction

R. Justin Joseyphus

Department of Physics, National Institute of Technology, Tiruchirappalli 620015, Tamil Nadu, India

*rjustinj@nitt.edu

Abstract

Fe and its alloys, such as FeCo and FeNi, are soft magnetic materials useful in more electric aircraft applications due to their large magnetic force-to-weight ratio. Bulk FeCo with the bcc structure has the largest saturation magnetization and Curie temperature among all the known alloys. Fabrication of miniature, lightweight components through additive manufacturing and soft magnetic composites requires Fe alloy particles. Compared to magnetite nanoparticles, rigorous research on Fe and its alloy nanoparticles is sparse despite the high saturation magnetization, almost three times higher than magnetite. This has been attributed to the limited options for synthesizing Fe and its alloy particles, their oxidizing tendency, and difficulty elucidating the magnetic properties contrasting the bulk.

An instant chemical reduction process was developed to synthesize Fe [1] extended to obtain binary alloys such as FeCo, FeNi, and, more recently, Fe-based high entropy alloys by our group. The reaction mechanism to obtain Fe through instant chemical reduction has been elucidated, and recent X-ray absorption studies have shown that a ferric octahedral complex is reduced to Fe in vicinal polyols [2]. The Fe and FeCo particles obtained through the instant chemical reduction process exhibit particle size-dependent coercivity, exchange bias and disorder. The bcc structure of the FeNi alloys with a large Curie temperature starkly contrasts the fcc structure of the equilibrium bulk alloys. The intricacies involved in obtaining Fe-based alloys through instant chemical reduction, as well as their structure and magnetic properties, shall be discussed.

Keywords: Soft magnetic materials; polyol process; magnetic properties; FeCo alloys

References

1. R. Justin Joseyphus et al., J. Magn. Magn. Mater. 310 (2007) 2393.
2. Sivaranjani K.S., Phys. Chem. Chem. Phys. 25 (2023) 21970.

Nanomagnetism: spin polarized electron transport, memories, rare earth free hard magnets, and nanomedicines

Pankaj Poddar

National Chemical Laboratory, Pune 411 008, India

Email: p.poddar@ncl.res.in

Abstract

Since the early work on Nèel, Stoner, Wohlfarth, Aharoni etc., the interest in the physics of the nanomagnetism was fuelled by the advent of computers and ever increasing demand of denser and faster magnetic memories, read-heads etc. It is interesting to investigate how the spin transport takes place across few superparamagnetic particles. Additionally, the dipolar interactions and induced anisotropy in 2D and 3D superlattices of these particles is of interest. Our recent work on the finite size effects on rare earth free hard magnets and multiferroics will be presented. At the end, we will discuss how the direct observation of surface spin structure, the freezing and melting of spins in the arrays of superparamagnetic particles as a function of temperature and magnetic field still remain challenging problem for the physics community.

Keywords: Nanomagnetism; Superparamagnetism; Hard magnets; Multiferroics

Phase Analysis And Crystallization Kinetics of Rare Earth Magnetic Garnets ($RE_3Fe_5O_{12}$) For High Frequency Applications

S. Gokul Raj[1, *], G. Ramesh Kumar[2]

[1]*Department of Physics, Pondicherry University, Kalapet, Puducherry 605014, India*
[2] *Department of Science and Humanities, University College of Engineering Arni-Thatchur- (Anna University, Chennai), 632 326, India*

*Corresponding Author: gokulraj@pondiuni.ac.in

Abstract

Rare earth iron garnets ($RE_3Fe_5O_{12}$) have been extensively studied as they are an important class of ferrimagnetic materials due to their scientific and technological advancements in the area of magnetism. Their environmental stability and structural defects have paved the way for the synthesis of garnets as thin films and polycrystalline materials by several methods. In particular, Iron-containing oxide phases crystallize in garnet structure shows significant interest in the field of microwave devices and in magnetic material applications. The metal cation's occupy octahedral (a) and the tetrahedral (d) sites in the garnet system with Fe^{3+} known to occupy the simple end-member garnets is shown in below figure. The garnet structure of rare earth iron garnets makes them a prominent class of ferrimagnetic materials that have applications in microwave devices [1-3]. Only Fe^{3+} is known to produce the straightforward end-member rare earth iron garnets, which have the formula $R_3Fe_5O_{12}$, out of the several metal cations that can be incorporated into the octahedral [a] and tetrahedral (d) sites of the garnet system [4,5].

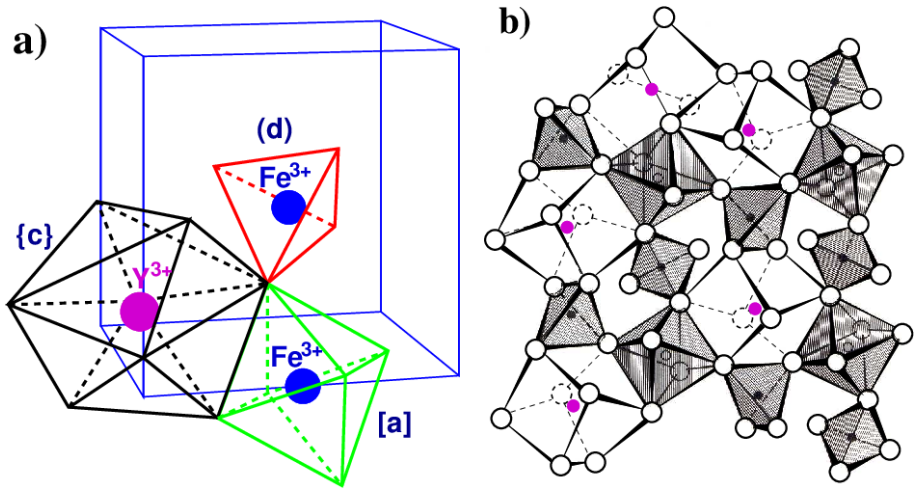


Figure The garnet structure is the positioning of the [a], [c], and (d)-sites at the corresponding centers of octahedra, dodecahedra, and tetrahedra.

In the present work, the investigations on the phase formation of Yttrium Iron Garnet (YIG - $Y_3Fe_5O_{12}$) and Gadolium Iron Garnet (GdIG- $Gd_3Fe_5O_{12}$) by various synthesis routes were discussed in detail. The information on crystallization behavior through crystallization kinetics was determined from the thermal analysis through Johnson–Mehl–Avrami (JMA) method of equation from simultaneous thermo gravimetric differential thermal analysis (TG-DTA) through various heating rate of the samples. The phase formation of GdIG was investigated by powder X-ray diffraction technique. The magnetic properties of the samples were measured with an attempt to emphasis its magnetic properties as a function of temperature and its effect on crystallite size. The microstructural and particle size were further confirmed through TEM analysis.

Keywords: Garnets; High Frequency Applicaions; X-ay Analysis; thermal analysis; Magnetic Properties

References:

[1] G. Winkler, in: Inter-university electronic series, Vol. 13, Magnetic properties of materials, ed. J. Smith McGraw- Hill, New York, 1976.
[2] S. Geller, H. J. Williams, and R. C. Sherwood, (1961), 'Magnetic and Crystallographic Study of Neodymium-Substituted Yttrium and Gadolinium Iron Garnets', Phys. Rev., Vol.23, pp.1692.
[3] C.P. Khattak, F.F.Y. Wang, in: K.A. Gschneidner Jr., L. Eyring (Eds.), Handbook of the Physics and Chemistry of Rare Earths, North-Holland, Amsterdam, 1979.
[4] V. Buscaglia, M.T. Buscaglia, L. Giordano, A. Martinelli, M. Viviani, C. Bottino, (2002), 'Growth of Ternary Oxides in the Gd2O3–Fe2O3 System - a Diffusion Couple Study', Solid State Ionics, Vol.146[3-4], pp.257-271.
[5] Hans J. Schmitt, (2007), 'Magnetic components for microwaves and optics', Festkörperprobleme, Vol.21, pp 383–402.

Metamagnetism from Correlation

A.Taraphder

Department of Physics, Indian Institute of Technology Kharagpur 721302 India

Email: arghya@phy.iitkgp.ac.in

Abstract

Correlated electron metamagnetism is revisited with new insights. Inspired by an earlier experiment [1] on liquid He^3 and an analysis by Vollhardt [2], the feasibility of metamagnetism and its critical response, due to correlation only, are addressed from a model Hamiltonian. Although there are several reports of metamagnetism recently, the underlying cause is unknown due to competing effects, viz. structural transition, spin exchange and Coulomb correlation. A systematic study using Hubbard model has been carried out [3] at half-filling within dynamical mean field theory. In agreement with previous studies, a zero-temperature itinerant metamagnetic transition, reflected in the discontinuous magnetization jump from a paramagnetic metallic state to a polarized quasi-ferromagnetic state, is obtained. The attendant hysteresis is also delineated. The jump in magnetization vanishes smoothly with decreasing interaction strength; at a critical correlation, the transition is continuous. We conjecture that the first order metamagnetic transition is a result of the competition between Kondo screening, trying to quench the local moments, and Zeeman coupling that freezes the local moments. We also work on $t-U-J$ and $t-t^{'}-U-J$ model in the presence of external Zeeman field, using slave-rotor theory and its cluster incarnations [4] and show that the proximity to a Mott transition allows realization of metamagnetism in a range of magnetic field well within the experimentally attainable values. We propose a possible phase diagram in the T-U-filling plane.

[1] S. Weigers, P. E. Wolf, and L. Puech, Phys. Rev. Lett. **66,** 2895 (1991)
[2] D. Vollhardt, Rev. Mod. Phys. **56**, 99 (1984)
[3] D. Parihari, N. S. Vidhyadhiraja and A. Taraphder, J. Phys. Condens. Matter **23,** 055602 (2011)
[4] Swagata Acharya, Amal Medhi, N S Vidhyadhiraja and A Taraphder, J. Phys. Condens. Matter **28**, 116001 (2016)

Keywords: Correlated electrons; Metamagnetism

Anisotropy Engineered Magnetic Thin Film for Possible Application

Jyoti Ranjan Mohanty

Department of Physics, IIT Hyderabad

Email: jmohanty@phy.iith.ac.in

Abstract

Modern magnetic devices (magnetic sensors, hard disks and spintronics devices) relies on storing or manipulating magnetic information in smaller length scales at faster time scales. In order to increase the data storage density many class of magnetic materials have been explored. Thin films of rare-earth and transition metal combination have shown tremendous potential for high density data storage due to their intrinsic and extrinsic tuneable properties. We will present different methods of anisotropy tuning (both intrinsic and extrinsic) in materials with higher perpendicular magnetic anisotropy (PMA) for possible applications. We are exploring a material system consisting of rare-earth and transition metal (RE-TM) alloy thin films where both the TM and RE sub-lattices couple antiferromagnetically, and hence the material shows ferrimagnetic behaviour. This material is interesting because it is a soft magnetic material along with a controllable PMA with film thickness, composition, deposition methods and associated stress as well as external perturbations (ion and electron beam). Ferrimagnetic thin films consisting of RE-TM with PMA are the appropriate choice for magneto-optical data storage devices. This system offers PMA at higher thickness, avoid defect pinning, and reduced skyrmion Hall effect which aims at energy efficient devices with higher switching field compared to ferromagnet and has the advantage of magnetic contrast over antiferromagnetic counterpart. We will present potential of this system for creating controlled magnetic domain and possibility of skyrmion without the use of heavy metal. We will also discuss the ultrafast laser induced creation and switching of magnetic skyrmions in these ferrimagnetic systems.

Keywords: (Perpendicular magnetic anisotropy, Ferrimagnetic, Skyrmion)

Erbium-Doped CuS Nanostructures: Effects on Structural, Optical and Magnetic Behaviour

B Sree Sesha Sudha Gayatri[1], Madhusudhana Rao N[1]*

[1]Department of Physics, School of Advanced Sciences, VIT-AP University,

Inavolu, Beside AP Secretariat, Amaravati, AP - 522237, India

**Corresponding Author: drnmrao@gmail.com*

Abstract:

To investigate the impact of rare earth ions on CuS nanostructures, a series of Erbium (Er) - doped copper sulphide ($Cu_{1-x}Er_xS$) nanostructures were synthesized using the hydrothermal method with concentrations of Er as x = 0, 1, 3, 5, and 7 at. %. The prepared samples' structural, optical, and magnetic characteristics were investigated. Structural analysis was performed using Powder X-ray diffraction and Raman spectroscopy, confirming the existence of a covellite phase hexagonal structure. Observations of the surface morphology study from FESEM reveal the formation of flower-shaped structures resembling nanospheres, while at lower magnification nanoflakes were observed. Optical reflectance spectra were recorded using UV-Vis spectroscopy, which showed the variation in bandgap as the concentration of Gd rises. Room temperature photoluminescence was analyzed using the fluorescence spectrophotometer with notable emission peaks around 435 nm. Fluorescence lifetime studies were carried out to confirm the fluorescence decay of CuS nanostructures doped with Gd. Magnetic measurements revealed that CuS nanostructures doped with 1% Er exhibited low field ferromagnetism while those doped with 3%, 5% and 7% Er exhibited paramagnetic behaviour at room temperature.

Keywords: Er-doped CuS nanostructures; Diluted Magnetic Semiconductor; Hydrothermal method; Room temperature ferromagnetism; spintronic devices.

References:

[1] N. Sreelekha, K. Subramanyam, D. Amaranatha Reddy, G. Murali, S. Ramu, K. Rahul Varma, R.P. Vijayalakshmi, Structural, optical, magnetic and photocatalytic properties of Co doped CuS diluted magnetic semiconductor nanoparticles, Appl. Surf. Sci. 378 (2016) 330-340.

[2] Almohammedi A., Structural, optical and magnetic properties of nickel-doped copper sulphide diluted magnetic semiconductor nanoparticles for spintronic devices, Appl. Phys. A. 129 (2023) 221.

[3] AL-Jawad S.M.H., Taha A.A. & Redha A.M., Studying the structural, morphological, and optical properties of CuS:Ni nanostructure prepared by a hydrothermal method for biological activity, J Sol-Gel Sci Technol. 91 (2019) 310–323.

Topic Code: D

Structural and Magnetic Properties of Europium Substituted Zinc Ferrite Nanoparticles Prepared Via Coprecipitation Method

B. Uday Kumar[1], S. Katlakunta[2], K. Praveena[1*],

[1]Department of Physics, Post Graduate College, Palamuru University, Mahabubanagr – 509001, Telangana, India.

[2]Department of Physics, University College of Science, Saifabad, Osmania University, Hyderabad – 500004, Telangana, India.

*Corresponding Author: praveenaou@gmail.com

Abstract

The europium substituted $ZnEu_yFe_{2-y}O_4$ (y = 0.0 - 0.10) nanoparticles synthesized by co-precipitation method. The nano powders have been characterized using X-ray diffraction (XRD), field emission scanning electron microscopy (FE-SEM) and energy dispersive spectroscopy (EDS) . XRD investigation confirms the cubic spinel structure with Fd-3m space group. The position and relative intensity of the diffraction peaks matches well with the standard patterns of $ZnFe_2O_4$ (JCPDS file no. 22-1012), which indicated that the samples owned spinel structure. The average crystallite size from Scherrer formula varies in between 16 to17 nm and the grain size is in between 16 to 17 nm. The detailed magnetic investigation revealed that the nanoparticles coercivity increase upto y = 0.04 then decreases with increasing europium whereas anisotropy constant increases. The corresponding magnetic mechanism and structural studies had been discussed in detail.

Keywords: Co-precipitation method; Structural studies: Ferrites; Spinel; Magnetic properties

References:

[1]. J Lili Yang, Zhe Wang, Bowen Zhai, Yexu Shao , Zhiqiang Zhang, Yunfei Sun, Jinghai Yang, Magnetic properties of Eu^{3+} lightly doped ZnFe2O4 nanoparticles, Ceram. Inter. 39 (2013) 8261 – 8266.

Nickel Ferrite: Advances in the Synthesis Methods and Their Impact on Structural and Magnetic Properties

Jayashree Patra[1] and V.K. Verma[1, *]

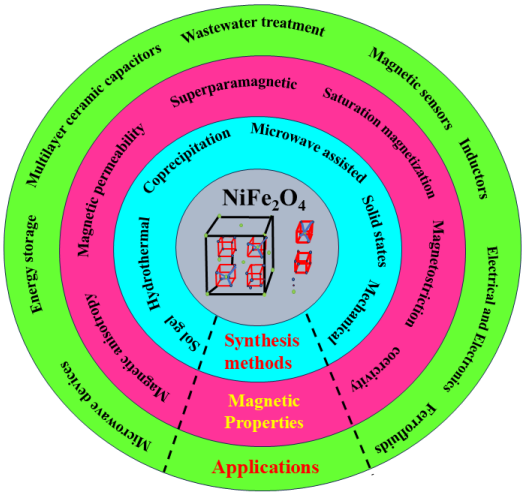
[1]*Department of Physics, School of Advanced Sciences, VIT-AP University, Amaravati, Andhra Pradesh – 522237, India*

*Corresponding Author: virendra.verma@vitap.ac.in

Abstract

Spinel ferrite (MFe_2O_4) has recently received a lot of attention because it has excellent magnetic properties such as high magnetic permeability and low magnetic losses, making it useful in a variety of applications such as electronic devices, telecommunications, magnetic sensors, transformers, and so on. Nickel ferrites have an inverse spinel structure, with the divalent nickel ions (Ni^{2+}) placed at the octahedral positions (B sites) and the trivalent ion Fe^{3+} can readily be dispersed between the tetrahedral positions (A sites) and the octahedral positions (B sites). Nickel ferrites can be made by various synthesis processes. Each method has benefits and drawbacks in terms of scalability, cost-effectiveness, and property control. Nickel ferrites' qualities and characteristics are greatly influenced by their synthesis method. In this article, we have discussed various synthesis methods, applications, and magnetic properties of nickel ferrite. Nickel ferrites have been produced utilizing various techniques, including sol-gel, co-precipitation, solvothermal, microwave-assisted route, and hydrothermal synthesis. Effect of doping with various elements (such as Zn, Mg, Co, or rare earth metals) is being investigated to improve magnetic and catalytic capabilities. Nickel ferrite and its doped variants perform well as catalysts in wastewater processes such as dye degradation, heavy metal removal, and photocatalysis. Magnetic characteristics tuned through doping for specific purposes, increasing their potential in biomedical and technical domains [1,2].

Keywords: Nickel ferrite; Inverse spinel structure; Magnetic materials; Wastewater treatment



References:

[1]. M. Amiri, M. Salavati-Niasari, A. Akbari, Magnetic nanocarriers: evolution of spinel ferrites for medical applications, Adv Colloid Interface Sci 265 (2019) 29–44.

[2]. H. Du, O.U. Akakuru, C. Yao, F. Yang, A. Wu, Transition metal ion-doped ferrites nanoparticles for bioimaging and cancer therapy, Transl Oncol 15 (2022) 101264.

Topic Code: D

Investigation Of Structural, Morphology, Thermal, And Magnetic Properties Of $Ni_{0.90}Cu_{0.10}Te_2$ Single Crystal

Rajkumar, Sokkalingam[1], Arumugam, Sonachalam*[1,2]

[1]*Centre for High Pressure Research, Department of Physics, Bharathidasan University, Tiruchirappalli - 620 024, Tamil Nadu, India,*
[2]*Tamil Nadu Open University, Anna Salai, Saidapet, Chennai - 600 015, Tamil Nadu, India*

*Corresponding Author: sarumugam1963@yahoo.com

Abstract

Layered Transition Metal Dichalcogenides (LTMDCs) are quasi-two-dimensional materials with notable structural and magnetic properties. Recent research has highlighted intriguing features in the $NiTe_2$ system, especially in LTMDCs. In this study synthesized $Ni_{0.90}Cu_{0.10}Te_2$ using the self-flex technique to explore the effects of Cu doping on $NiTe_2$'s structural, morphology, thermal, and magnetic properties. X-ray powder diffraction (XRPD) confirmed a trigonal structure with CdI2-type configuration and an *l*3*m*1 space group, validating the crystalline organization. Field emission scanning electron microscope (FESEM) imaging illustrated the layered structure due to Cu doping. Thermal analysis via thermogravimetry differential thermal analysis (Tg/DTA) demonstrated stability up to 800 °C, with only a 2% weight loss between 800 and 1000 °C. Magnetization studies in a 1 T field showed paramagnetic behavior across 2 to 200 K temperatures. These findings indicate that Cu doping significantly enhances the magnetic properties of $NiTe_2$, making it suitable for magnetic device applications.

Keywords: $NiTe_2$ single crystal; Rietveld refinement; Morphology; Thermal properties; Paramagnetic.

References:

[1]. Je, Yeonjin, Eunjeong Kim, *et al*., *Electronic Materials Letters* 19, no. 5 (2023): 452-461.

[2]. Tomojit Chowdhury, Erick C. Sadler, and Thomas J. Kempa, c*hem. Rev.* 120, 22, 12563–12591 (2020)

[3]. Chunqiang Xu, Bin Li, Wenhe Jiao, *et al*, *Chem. Mater.* 30, 4823-4830 (2018).

[4]. Feipeng Zheng , Xi-Bo Li, *et al*., *Physical Review B*101, 100505 (R) (2020).

[5]. Zhang, Liguo, Dapeng Zhao, *et al*., *Applied Physics Letters* 125, no. 5 (2024)..

[6]. Zheng, Feipeng, Xi-Bo Li, *et al*., *Physical Review B* 101, no. 10 (2020): 100505.

Topic Code: D2

Structural and Magnetic Properties of $La_{0.7}Ce_{0.3-x}Ca_xMnO_3$ (x = 0.0 and 0.15)

M.P. Sharma

Department of Pure and Applied Physics, Guru Ghasidas Vishwavidyalaya, Bilaspur (C.G.) – 495009

*Corresponding Author: mps.phy@gmail.com

Abstract

The intrinsic objective of this work is to investigate the structural and magnetic properties of $La_{0.7}Ce_{0.3-x}Ca_xMnO3$ (x = 0.0 and 0.15) prepared through the sol–gel method. All these systems crystallize in the rhombohedral structure, with the presence of a secondary phase for x = 0.0. We recorded the increase of a unit cell volume when the La deficiency amount increases, which refers to the fact that the vacancy is characterized by a radius other than zero. Another point that can be quoted is the increase of Mn–O–Mn bond angle and the decrease of Mn–O length with lanthanum deficiency (x), confirming the increase of the unit cell volume. The thermal variation of the magnetization indicates the existence of a paramagnetic – ferromagnetic transition at Curie temperature with the increase of lanthanum deficiency. Saturation magnetization and Curie temperature increased with x (0.0 and 0.15). Hysteresis cycles confirm the ferromagnetic character at low temperatures and paramagnetic state with temperature increase. The increase of saturation magnetization can be accounted for in terms of the change of high spin Mn3+ to low spin Mn4+.

Keywords: structural; magnetic; transition.

References:

[1]. Schiffer P, Ramire A P, Bao W and Cheong S W, *Phys. Rev. Lett*. **75**, 3336 (1995)
[2]. Gayathri N, Raychaudhuri A K, Tiwari S K, Gundakaram R, Arulraj A and Rao C N R, *Phys. Rev. B* **56**, 1345 (1997)
[3]. Zener C, *Phys. Rev.* **83,** 440 (1951)
[4]. Itoh M, Shimura T, Yu J–D, Hayashi T and Inaguma Y, *Phys. Rev. B* **52**, 12522 (1995)
[5]. Skumryev V, Ott F, Coey J M D, Anane A, Renard J –P, Pinsard-Gaudart L and Revcolevschi A, *Eur. Phys. B* **11**, 401 (1999)

Ferrimagnetic Behavior and Low-temperature Anomalies in Nickel Chromate spinel

Arijit Datta, Mouli Roy-Chowdhury and Subhash Thota

Department of Physics, Indian Institute of Technology Guwahati, 781039, Assam, India
*Corresponding Author: (subhasht@iitg.ac.in)

Abstract

Among the family of spinels oxides (AB_2O_4) that stabilizes in cubic *Fd-3m* symmetry, Nickel Chromate, $NiCr_2O_4$ (NCO) occupied unique place due to its impressive industrial applications [1]. Switching of its crystal symmetry from *Fd-3m* to tetragonal $I4_1/amd$ has been realized in this NCO based systems depending upon the type of substituents used and synthesis conditions [1,2]. In NCO the divalent Ni ions occupancy the tetrahedral (A) sites and the trivalent Cr ions resides in the octahedral (B) cage of spinel lattice [1]. Substitution of Mn into the octahedral sites usually leads to a significant tetragonal distortion due to Jahn-Teller (JT) effect which is the topic of current research work. Here, two different compositions (NCO, and $NiCrMnO_4$) have been investigated including the pristine system all of which were stabilized with cubic-structure of *Fd-3m* space group having the lattice parameters *a* = 8.32-8.37 Å. The NCO magnetic sublattices contains unequal magnetic moments and different temperature dependence due to which ferrimagnetic (FiM) ordering arises in these systems. For the pristine case the FiM Néel temperature T_{FN} occurs at 73.5 K (Fig.1a). But with the incorporation of JT active Mn^{3+} ions the T_{FN} was found to be increased to 74.11 K above which the two-sublattice magnetizations balances with each other leading to a magnetic compensated states across 92 K (T_{CMP1}) and 112 K (T_{CMP2}) (Fig.1b). Also, the effective magnetic moment (μ_{eff}) increases from μ_{eff} = 6.8 μ_B (for $NiCr_2O_4$) to 6.85 μ_B (for $NiCrMnO_4$). Along with the major transition T_{FN}, we also noticed low-temperature anomalies (T^*) in the differential susceptibility ($d(\chi T)/dT$) in both the systems due to the short-range correlations below T_{FN}.

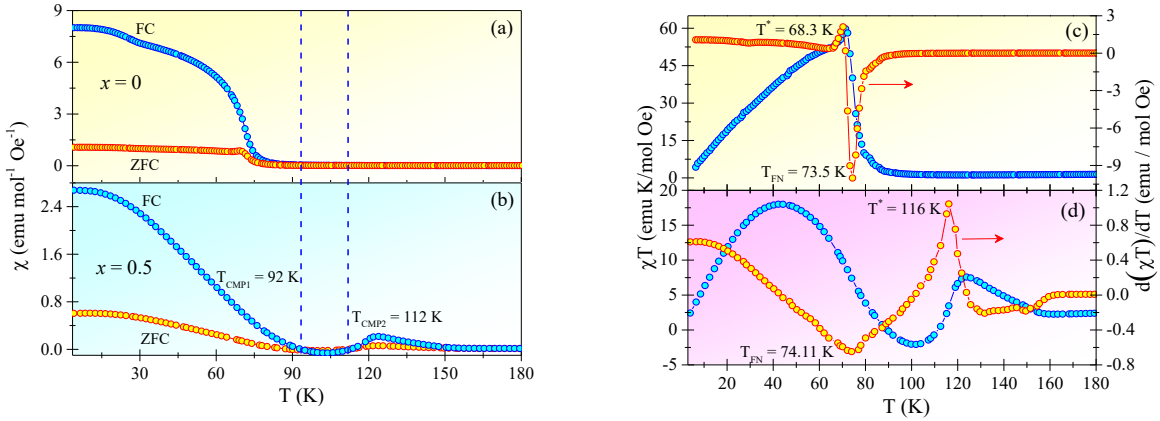


Figure 1: (a,b) Temperature dependence of magnetic susceptibility χ(T) measured under both ZFC and FC modes for $NiCr_2O_4$ (x = 0) and $NiCrMnO_4$ (x = 0.5), and (c,d) Differential susceptibility d(χT)/dT Vs. T and the product χT Vs. T for x = 0 ($NiCr_2O_4$) and x = 0.5 ($NiCrMnO_4$) depicting the inflection points across T^*, T_{CMP1} , T_{CMP2} , and T_{FN}.

Keywords: Jahn-Teller distortion; Kubelka-Munk analysis; Ferrimagnetic; Néel temperature.

References:

[1]. Shang-Di Mo, W. Y. Ching, *Phys. Rev. B*, **54**, 16555 (1996).
[2]. P. Pramanik, *J. Phys.: Condens. Matter*, **29**, 425803, (2017).

Topic Code: D

Unravelling the Nature of Magnetism in $Ni_{5 \pm x}Al_{3 \mp x}$ / NiO Core / Shell Nanoparticle System

P V Prakash Madduri[1], S N Kaul[2]

[1]*Department of Sciences,*
Indian Institute of Information Technology Design and Manufacturing Kurnool,
Kurnool-518008, Andhra Pradesh, India
[2]*School of Physics, University of Hyderabad, Central University P.O,*
Hyderabad 500 046, Telengana, India
*Corresponding Author: prakash.madduri@iiitk.ac.in

Abstract

The present work unravels the *complex nature of magnetism in nanocrystalline* core-shell Ni_5Al_3 / NiO nanoparticle system with an average crystallite size 6 (2) nm, synthesized by the Inert Gas Condensation technique. A *H-T* phase diagram reported on the system at low fields ($0 \leq H \leq 30$ Oe) is extended to fields as high as 1 kOe using the weak and strong magnetic irreversibility temperatures, $T_{WI}(H)$ and $T_{SI}(H)$, inferred from zero-field-cooled and field-cooled magnetization (M) measurements. While both $T_{WI}(H)$ and $T_{SI}(H)$ follow the $H^{2/3}$ field variation characteristic of the Almeida-Thouless (AT) transition for $H \leq 30$ Oe, strong departures are observed from the AT-type field variation in both $T_{WI}(H)$ and $T_{SI}(H)$ for $H >$ 30 Oe. Thermal demagnetization curves $M_H(T)$ at fixed fields in the range 2 kOe $\leq H \leq$ 70 kOe, exhibit an anomalous upturn at $T < T^* \approx 30$ K. This upturn, associated with the anomalous softening of spin wave modes, is shown to be a manifestation of the *Bose-Einstein condensation of magnons.* Stoner-Wohlfarth (SW) model describes well the observed temperature variations of the remanent magnetization and coercive field.

Keywords: Low-lying magnetic excitations; Magnon Bose-Einstein Condensation; Irreversibility in magnetization; magnetic nanoparticles;

References:

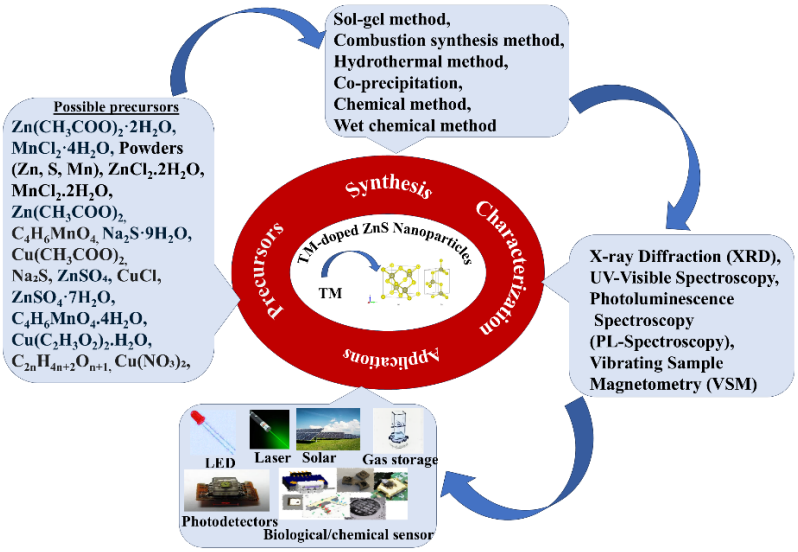
[1]. P V Prakash Madduri, S N Kaul, Magnetic irreversibility and magnetization processes in Ni_5Al_3/NiO core/shell nanoparticle system, J. Phys.: Condens. Matter **36** (2024) 455806.
[2]. P V Prakash Madduri, S N Kaul, In-field critical behavior and magnetocaloric effect in Ni_5Al_3/NiO nanoparticle compacts, J. Alloy Compd. **870** (2021) 159388.
[3]. P V Prakash Madduri, S N Kaul, Intrinsic chiral-spin glass and spin glass transitions in compacted Ni_5Al_3/NiO nanoparticles, Phys. Rev. Materials **3** (2019) 126003.

Structural, Optical, and Magnetic Properties of Mn-doped, Cu-doped, and (Mn, Cu)-codoped ZnS Nanoparticles and its Applications

Pujarani Parida[1] and V.K. Verma[1, *]

[1]*Department of Physics, School of Advanced Sciences, VIT-AP University, Amaravati, Andhra Pradesh – 522237, India*
*Corresponding Author: virendra.verma@vitap.ac.in

Abstract
Nanoparticles have improved their properties over the last century and are now employed in many fields. As a result, scientists are now more inclined to produce nanoparticles. Zinc Sulphide (ZnS) nanoparticles (NPs) are highly researched II-VI semiconductors with numerous potential applications. Among the inorganic semiconductors, ZnS often exhibits one of the most interesting morphologies, resulting in a variety of unique characteristics and uses. ZnS nanoparticles have possible applications in sensors [1], field-emitting transistors, and diodes [2]. Numerous research has been conducted on both pure and doped ZnO, CdTe, and CdS nanostructures. This work focused on examining several synthesis methods of Mn-, Cu-doped, and (Mn, Cu)-codoped ZnS nanoparticles. The double doping (Mn, Cu)-codoped nanoparticles enhance the structural, magnetic, and optical properties of ZnS semiconducting compounds. In this article, we have discussed various chemical synthesis methods like sol-gel, coprecipitation, hydrothermal processing, combustion synthesis methods, chemical methods, and wet chemical methods to prepare Mn, Cu, and both (Mn, Cu)-codoped ZnS nanoparticles. The physical and chemical properties were studied by variety of spectroscopic analytical techniques, including XRD, VSM, and UV-visible spectroscopy. It has been reported that ZnS nanoparticles are employed in several industries, including engineering, optics, and medicine. Hence, we believe that our research will serve as a resource for individuals, manufacturers, and researchers to investigate significant, cost-effective ways to these types of Nanoparticles.
Keywords: Diluted magnetic semiconductor; Zinc sulfide; Sensor; Photocatalytic activity



References:

[1]. J. Patel, B. Jain, A.K. Singh, M.A.B.H. Susan, L. Jean-Paul, Mn-doped ZnS quantum dots–an effective nanoscale sensor, Microchemical Journal 155 (2020) 104755.
[2]. C. Ippen, T. Greco, Y. Kim, J. Kim, M.S. Oh, C.J. Han, A. Wedel, ZnSe/ZnS quantum dots as emitting material in blue QD-LEDs with narrow emission peak and wavelength tunability, Org Electron 15 (2014) 126–131.

Topic Code : Design and synthesis of magnetic materials

Coercivity Enhancement in Al^{3+} Substituted Barium Hexaferrite Nanoparticles

Shalini Govindaraj M [1,2] , Subha A [2] , Subasa C. Sahoo [2 *]

[1]*Vellore Institute of Technology, Kelambakkam - Vandalur Rd, Rajan Nagar, Chennai, Tamil Nadu 600127, India*

[2]*Department of Physics, Central University of Kerala, Tejaswini Hills, Periya Kasargod - 671320, Kerala, India*

*Corresponding author: subasa.cs@gmail.com

Abstract : $BaAl_xFe_{12-x}O_{19}$ (x=0.5,1,1.5) nanoparticles were synthesised via the sol-gel autocombustion method and subsequently annealed at temperatures ranging from 900°C to 1200°C for 4 hours. The aim of this study was to investigate the structural and magnetic properties of the samples. A molar ratio of 1.2:12 for barium nitrate to ferric nitrate was employed to achieve the desired composition. The annealed samples were characterized using X-ray diffraction (XRD),Raman Spectroscopy, and vibrating sample magnetometry (VSM). XRD analysis revealed the crystal structure and phase composition, while Raman modes of vibration were utilized to determine the presence of Fe^{3+} ions and understand the extent of their replacement by Al^{3+} ions in the site occupancy of the material. VSM measurements were conducted to assess the magnetic properties, including magnetization, coercivity, and magnetic susceptibility.The magnetic properties were further elucidated by calculating the magnetocrystalline anisotropy constant (K_1) and anisotropy field (H_a), showing the highest K_1 and H_a values where 2.8 x10^6 erg/cm^3 and 16.5 kOe respectively, at 300K for x=1 and x=1.5 respectively.The results obtained from this comprehensive characterization will contribute to a deeper understanding of the structural and magnetic behaviours of nanocrystalline $BaAl_xFe_{12-x}O_{19}$ nanoparticles, paving the way for their potential applications in diverse fields.

Keywords: (Hard ferrite, Barium Hexagonal Ferrite, Magnetization, Anisotropy Constant,Magnetic nanoparticles)

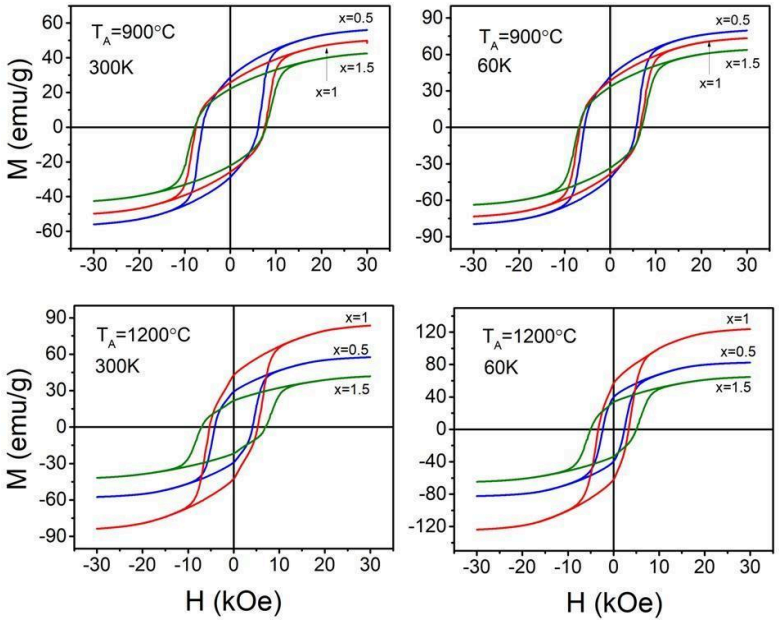


Fig.1 M-H loops of T_A=900°C and T_A=1200°C annealed $BaAl_xFe_{12-x}O_{19}$ nanoparticle samples.

Erbium-Doped β-Ga_2O_3: Synthesis, Structural Characterization, and the Role of Doping in Magnetic and Optical Properties

Anju, Babu[1], Nasina Madhusudhana, Rao[1]

[1]*Department of Physics, School of Advanced Sciences, VIT-AP University, Amaravati, Andhra Pradesh – 522237, India*

*Corresponding Author: drnmrao@gmail.com

Abstract

Erbium-doped β-Ga_2O_3 has attracted attention for its potential in magneto-optical and spintronic applications, owing to the distinctive magnetic and optical properties erbium ions impart to host materials. In this study, we explore the structural, optical, and magnetic behavior of β-gallium oxide doped with erbium ions at 0, 1, 3 and 5 M%, synthesized via a hydrothermal method followed by calcination. X-ray diffraction analysis confirmed the formation of a single-phase monoclinic β-Ga_2O_3 across all doped samples, with additional peaks of $Er_3Ga_5O_{12}$ appearing in samples doped with erbium at 5 M%. Scanning electron microscopy revealed an irregular and agglomerated morphology with increasing dopant concentration. EDX analysis confirmed the presence of Ga, O, and Er in the samples. UV-Vis absorbance studies and Tauc plot analysis indicated a reduction in both absorbance and bandgap in all doped samples. Photoluminescence studies in the UV-Vis region revealed characteristic emission peaks of erbium ions. Room-temperature magnetic studies using a vibrating sample magnetometer demonstrated a transition of pure β-Ga_2O_3 from a diamagnetic to a paramagnetic state upon erbium doping. The observed paramagnetism offers valuable insights into the effects of rare-earth doping in Ga_2O_3, opening avenues for further research into its multifunctional properties.

Keywords: wide bandgap semiconductors; β-Ga_2O_3; erbium ions; photoluminescence; magnetism

References:

[1]. J. Vincent; O. Guillot-Noël; L. Binet; P. Aschehoug; Y. Le Du; F. Beaudoux; P. Goldner, Electron paramagnetic resonance and optical spectroscopy of Er-doped β-Ga_2O_3, J. Appl. Phys. (2008)104(3).

[2]. Chen Li, Bao-Lin Lu, Chen-Long Huang, Hao-Bo Lin, Zheng-Nan Li, Yuan-Hang Ren, N.Z. Khan, Ren-Kui Zheng, Tremendous enhancement of green emission from Er3+/In3+co-doped β-Ga2O3 ultrawide bandgap semiconductors,Ceramics International,50 (2024) 1683-1692.

Topic Code: D

C-TAB and magnetic field assisted hydrothermal synthesis of cobalt ferrite for the mid-range 5G frequency band applications

V. Seetha Rama Raju[1], and G. Bhishamaiah[1], A. K. Singh[1]

[1]*Center for Nanotechnology Materials Research Lab, CVR College of Engineering, Hyderabad 501510, Telangana, India*

Abstract

In this research, formation of cobalt ferrite was investigated using the hydrothermal method in two approaches. In first method, cetyltrimethyl ammonium bromide (CTAB) was used as surfactant to the cobalt ferrite while in second magnetic field was applied to the cobalt ferrite without surfactant. XRD patterns of all synthesized $CoFe_2O_4$ samples reflect typical spinel phase peaks with noticeable absence of impurities/residue peaks. Improved crystallinity was observed in the case of magnetic field assisted cobalt ferrite than the CTAB assisted cobalt ferrite. Fourier transforms infrared (FT-IR) spectra of the samples show absorption bands at 400-500 cm^{-1}, 300-375 cm^{-1} and 1000-1200 cm^{-1} corresponding to stretching vibrations of tetrahedral, octahedral and O-H bonds respectively. Field emission scanning electron microscope images indicates that the application of both the magnetic field and addition of CTAB have modified the morphology of ferrites as nanofibers. The magnetization studies show that the saturation magnetization of the cobalt ferrites is in the range of 50 to 55 emu/g. The complex permittivity, permeability and reflection loss of the cobalt ferrites have been investigated in present experimental materials in the frequency range of 1MHz to 3.6 GHz. The ferromagnetic resonance of the cobalt ferrite nanofibers is found in the frequency range of 1 – 2.5 GHz which is significantly higher than the cobalt ferrites having isotropic power particles. Incidentally, present synthesized cobalt ferrites also show a reflection loss of around 44 to 56 dB.

Keywords: Spinel ferrites; Magnetic materials, Hydrothermal synthesis; Complex permittivity; Complex permeability; Reflection loss.

D1

Magnetic Study of Co_3O_4-Go And Co_3O_4 Nanoparticles Synthesized By Polymer Combustion Method

Surekha, Jogdand, Satyawati Joshi

[1]*Department of Chemistry, Pratibha College of Commerce and Computer Studies, Chinchwad, Pune-411019, India*

[2]*Department of Chemistry, University of Pune, Ganeshkhind – 411007*

*Corresponding Author: surekhajogdand72@gmail.com

Abstract

Co_3O_4-graphene oxide (GO) nanocomposite and Co_3O_4 nanoparticles have been synthesized by polymer combustion method. Polyvinylpyrrolidone of molecular weight 40,000 was used for the synthesis. The effect of annealing temperature on phase, composition and magnetic properties were investigated. The Co_3O_4-GO nanocomposite formation was observed in pristine and 300°C annealed sample synthesized by using PVP40000. Further annealing at higher temperatures viz. 500 and 800°C Co_3O_4 nanoparticles were obtained. Synthesized Co_3O_4–GO nanocomposite and Co_3O_4 nanoparticles were characterized by X-ray diffraction, Fourier transform infrared, Raman, electron paramagnetic resonance, transmission electron microscopy, and vibrating sample magnetometry. Magnetic study showed room temperature ferromgnetism in all samples. Enhanced coercivity of 304 G was observed in pristine samples as compared to other samples.

Keywords: Co_3O_4 nanoparticles; magnetic properties; polymer combustion

References:

[1].S. S.Jogdand, A. Das, A. Dhayagude, S.Kapoor, S.S. Joshi, Polymers for Advanced Technologies, 2015,26, 1114.

[2].Niasari, S. M.; Davar,. F.; Mazaheri, M.; Shaterian, M.. J. Magn. Magn. Mater 2008, 320 ,575.

[3].Partha Hajra, Sourav Dutta, Pradip Bramha, Dipankar Chakravorty, Journal of Magn. Magn. Mater., 2011, 323,6, 864-867

[4].Jiachun Deng, Litao Kang, Gailing Baid, Ying Li, Peiyang Li, Xuguang Liu,Yongzhen Yang ,Feng Gao, Wei Liang,Electrochimica Acta 2014, 132, 127-132

Topic Code: D

Structural, Optical, and Magnetic Characterizations of Ni Doped ZnSe Nanoparticles

P. Kannappan[1,2*] K.R. Naveen Kumar[3], K. Asokan[3], R. Dhanasekaran[2]

[1]*Department of Physics, Sacred Heart College (Autonomous), Tirupattur - 635 601, India*
[2]*Crystal Growth Centre, Anna University, Chennai - 600 025, India*
[3]*Department of Physics and Centre for Interdisciplinary Research, University of Petroleum and Energy Studies, (UPES), Dehradun - 248 007, India*

*Corresponding Author: kanna.phy6gmail.com

Abstract

Recently there has been a great deal of interest in wide band gap dilute magnetic semiconductors (DMS) for spintronics applications [1]. DMS have applications in spintronics devices by doping of transition metals in these wide band gap semiconductors [2,3]. In this study, we report the structural, optical, and magnetic properties of pure and Ni doped ZnSe nanoparticles prepared by the hydrothermal method. The crystal structure of ZnSe confirms the cubic phase with the morphology of the spherical shape. The optical absorption cut-off wavelength is ~445 nm (E~2.75 eV) from its UV-visible absorption spectrum. The optical absorption increases with the increase of Ni concentrations. The photoluminance (PL) spectroscopy reveals the characteristic near-band edge emission at 468 nm. The PL emission decreases with increasing Ni concentration due to the non-radiative process. The magnetic studies using VSM show that both ZnSe and Ni-doped ZnSe exhibit room-temperature ferromagnetism. The coercivity decreases and saturation magnetization increases with increasing Ni concentration. The pure and Ni-doped ZnSe nanoparticles with tuned magnetic properties are promising materials for spintronics applications.

Keywords: ZnSe; Hydrothermal; X-ray diffraction; Photoluminance, Ferromagnetism; Coercivity

References:

[1]. Guozhong Xing, Dandan Wang, Jiabao Yi, Lili Yang, Ming Gao, Mi He, Jinghai yang, Jun Tze Chien Sum, and Tom Wu, Appl. Phys. Lett. 96 (2010) 112511

[2]. Ding, Tze Chien Sum, and Tom Wu, Appl. Phys. Lett. 96 (2010) 112511

[3]. Vinayak B. Kamble, S.V.Bhat, A.M. Umarji, J. Appl. Phys.113 (2013) 244307

Topic Code: D

Coercivity Enhancement On Sm-Fe-N Using Novel Low Melting Zn Based Eutectic Alloy

G. Vijayaragavan[1,2], D. Prabhu[1], M. Sadhasivam[2], Wang Xinan[3] ,R. Gopalan[1], K. G. Pradeep[2]

[1]*International Advanced Research Centre for Powder Metallurgy and New materials (ARCI), Chennai, 600 113, India,*
[2]*Department of Metallurgical and Materials Engineering, Indian Institute of Technology Madras, Chennai, 600 036, India,*
[3]*Ningxia Magvalley Novel Materials Technology Co., Ltd., Ningxia, 750411, China.*
Email: vragav88@gmail.com

Abstract:

$Sm_2Fe_{17}N_x$ is a promising hard magnetic intermetallic compound for high temperature applications in automotive sectors owing to its excellent intrinsic magnetic properties. However, consolidation of these powders into magnet remains as a major challenge through conventional sintering due to the decomposition of $Sm_2Fe_{17}N_x$. The present work reports the coercivity enhancement and the reason thereof achieved in Sm-Fe-N powders by annealing with Zn-Al eutectic powder mixture. Anisotropic $Sm_2Fe_{17}N_x$ powder (Magvalley China, $H_c \approx$ 9koe, particle size = 0.5-3µ) was mixed with Zn-5Al (wt. %) alloy prepared through melt spinning in different proportion (10,20 and 30 wt. %) by ball milling. Optimal annealing of the mixture in a temperature range between 400- 460 ^oC yielded a coercivity enhancement of 66% compared to original as received powder. Detailed microstructural characterization has been carried out using SEM, TEM and 3D-APT techniques. The observed enhancement in coercivity could be attributed to effective reduction in the free-Fe by the formation of non-magnetic ɾ-FeZn (Fe_3Zn_7 phase) and the formation of smooth coating of Sm-Fe-Zn-N phase observed from 3D-APT studies.

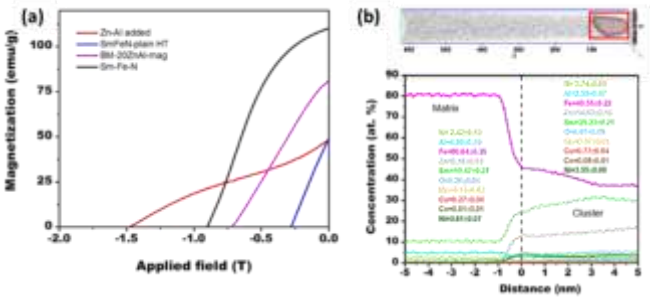


Fig. 1. a) Demagnetization curve of Sm-Fe-N, plain Sm-Fe-N annealed and Zn-Al added sample b) Zinc rich regions in the elemental map (top) delineated with 8 at.% isoconcentration surface and the representative proximity histogram obtained from the rectangular (red color) region with 0.1 nm bin width.

Keyword: Sm-Fe-N magnet, Atom probe tomography.

Reference:

1. C. Kuhrt, K. O'Donnell, M. Katter, J. Wecker, K. Schnitzke, L. Schultz, Pressure-assisted zinc bonding of microcrystalline $Sm_2Fe_{17}N_x$ powders, Appl. Phys. Lett. 60 (1992) 3316–3318. https://doi.org/10.1063/1.106678.

Optimization of Spin-coated Manganese Doped Cobalt Ferrite Coatings.

Ketankumar, Gayakvad[1,2], Ketaki, Patankar[2]

[1]*Department of Physics, K.J.Somaiya College of Science and Commerce(Autonomous), Vidyavihar. Mumbai, Maharashtra-400077, India.*
[2]*Composite Material Laboratory, Department of Physics, Rajaram College, Vidyanagar, Kolhapur, Maharashtra-416004, India.*

*Corresponding Author: ketakiketan@gmail.com

Abstract

The optimization of spin-coated manganese (Mn)-doped cobalt ferrite ($Co_{0.7}Mn_{0.3}Fe_2O_4$) on a fluorine-doped tin oxide (FTO) substrate is studied. A precursor solution with a 0.1 M metal ion concentration and Co: Fe ratio of 1:2 was prepared, and the coatings were deposited by dropping the solution onto the substrate, followed by spinning of the substrate at 3000 rpm for 30 seconds. Single- to six-layer coatings were achieved, with each layer undergoing thermal heating at 200 °C for 5 minutes in a microwave oven, followed by annealing at 500 °C for 7 hours in ambient air to increase crystallinity. Structural characterization by X-ray diffraction (XRD) confirmed the formation of the expected spinel phase, while Energy Dispersive X-ray spectroscopy (EDX) and Field Emission Scanning Electron Microscopy (FESEM) provided detailed elemental and morphological analysis. Mn-doped cobalt ferrite coatings demonstrate potential applications in memory devices and energy storage devices namely resistive random-access memory (RRAM), Spintronics devices, and supercapacitors. The optimized synthesis parameters and comprehensive structural characterizations suggest that these materials are promising candidates for multifunctional electronic and magnetic applications.

Keywords: Synthesis, Material characterization, Structural properties and Magnetic materials

References:

[1] S. K. Tong, J. H. Chang, Y. H. Hao, M. R. Wu, D. H. Wei, and Y. L. Chueh, "Optimum resistive switching characteristics of NiFe2O4 by controlling film thickness," *Appl Surf Sci*, vol. 564, Oct. 2021, doi: 10.1016/j.apsusc.2021.150091.

[2] A. Hao, D. Jia, M. Ismail, R. Chen, and D. Bao, "Controlling of resistive switching and magnetism through Cu2+ ions substitution in nickel ferrite based nonvolatile memory," *J Alloys Compd*, vol. 790, no. March, pp. 70–77, Jun. 2019, doi: 10.1016/j.jallcom.2019.03.193.

[3] T. D. Dongale *et al.*, "Bipolar resistive switching with coexistence of mem-elements in the spray deposited CoFe2O4 thin film," *Journal of Materials Science: Materials in Electronics*, vol. 29, no. 4, pp. 3231–3238, Feb. 2018, doi: 10.1007/s10854-017-8258-7.

[4] K. Gayakvad, K. Somdatta, V. L. Mathe, T. D. Dongale, M. W, and K. K. Patankar, "Spinel ferrites for resistive random access memory applications," *Emergent Mater*, vol. 7, no. 1, 2024, doi: 10.1007/s42247-023-00576-y.

[5] M. Kamran and M. Anis-ur-Rehman, "Enhanced transport properties in Ce doped cobalt ferrites nanoparticles for resistive RAM applications," *J Alloys Compd*, vol. 822, p. 153583, May 2020, doi: 10.1016/j.jallcom.2019.153583.

Topic Code: D

Structural and Magnetic Properties of $Fe_{100-X}Ti_x$ AlloysPrepared By Planetary Ball Milling Process

Harekrushna, Behera[1], Sourav, Mandal[1], Manivel Raja[2], Perumal Alagarsamy[*1]

[1]*Indian Institute of Technology Guwahati, Guwahati – 781 039*
[2]*Defence Metallurgical Research Laboratory-DRDO, Hyderabad - 500058*
*Corresponding Author: hbehera@iitg.ac.in

Abstract

Fe-based nanocrystalline alloy materials have found widespread utility in the electronic industry, transformers, and aerospace industry due to their large magnetic permeability, low iron loss, low coercivity (H_C), high saturation magnetization (M_S), and less magnetostriction. In the quest to improve the properties of Fe-based alloys, different alloying elements were studied [1]. Fe-Ti system possesses a large ability to form nanocrystalline in wide composition and processing conditions.

In this work, we report the synthesis of nanocrystalline $Fe_{100-x}Ti_x$ (x = 00 - 25 at.%) alloys over a wide range of compositions via a planetary ball milling process and characterized their structural and magnetic properties with varying milling time and composition. Structural studies revealed that Fe sites were substituted by Ti atoms as the function of milling time for a particular composition and also for the function of composition, forming a solid solution of Fe(Ti) after 25 hours of milling. A high degree of disorder, mainly the dislocations densities of order (~nm^{-2}), and fine crystallites of average sizes down to 10 nm were obtained. Magnetic properties showed that coercivity (H_C) increased up to a certain milling time and then decreased largely, following the random anisotropy model, but increased monotonically with the composition. Saturation magnetization (M_S) decreased with increasing milling time and also increasing the Ti content, but alloys with x = 15, 20, 25 showed a small increase of M_S after milling from 15 to 25 hours due to very fine crystallite size formation, causing a reduction in magnetocrystalline anisotropy and easier moment rotation. H_C and M_S vary from ~ 5 to 50 Oe and ~140 to 212 emu/gm in the presently investigated alloys milled for 25 hours, respectively. These remarkable properties strongly suggest the soft magnetic nature of the material, which is quite useful for the soft phase inclusion in the permanent magnet application. Also, as Fe-Ti alloys show nearly zero magnetostriction [1,2] in contrast to other Fe-TMs (TM = Mo, V, Cr), enabling them to be used in the electronic transformer core and flux gate sensor cores.

Keywords: Ball milling; Nanocrystalline; Dislocation density; Magnetocrystalline anisotropy; soft magnetic

References

[1] Shokrollahi, H., "The magnetic and structural properties of the most important alloys of the iron produced by mechanical alloying," Mater. Des. 30, 3374 (2009)

[2] Bormio-Nunes, C., Belarmino, A.R., Santos, C.T., Ugeda V.C., Baldan V.C., and Ghivelder L., "Near zero magnetostriction of Fe-Ti alloys," J. Phys. D: Appl. Phys. 42, 165006 (5pp) (2009).

[3] Turtelli, R.S., Bormio-Nunes, C., Alecrim, D.T., Atif M., Nunes, C.A., and Grossinger, R., "Magnetostriction of Fe-Ti alloys," IEEE Trans. Magn. 46(2), 498-501 (2010)

Topic Code: D

Analysis of the Structural, Optical, and Magnetic Properties of Cr-Doped SnS_2 Nanoparticles Synthesized via Hydrothermal Method

Anjali Bhattacharyya, Madhusudhana Rao N*

Department of Physics, School of Advanced Sciences, VIT-AP University, Andhra Pradesh, 522237, India.

*Corresponding Author: Email address: drnmrao@gmail.com

Abstract

The scarcity of 2D intrinsic room-temperature ferromagnetic semiconductors presents a challenge for advancing spintronic devices, and it remains unclear if ferromagnetic behavior in dilute magnetic semiconductors (DMS) is intrinsic or dopant-driven. In this study, Cr-doped SnS_2 nanocrystals were synthesized using a low-temperature hydrothermal method. Various characterization techniques were used to examine the effects of chromium doping (x = 0.01, 0.03, 0.05, 0.07) on the structural, optical, and magnetic properties of $Sn_{1-x}Cr_xS_2$ nanoparticles. X-ray diffraction showed a single-phase hexagonal structure with high crystallinity in pure and doped samples. Field emission scanning electron microscopy (FESEM) revealed flower-like or layered morphologies and energy dispersive X-ray spectroscopy (EDAX) confirmed impurity-free nanoparticles. X-ray photoelectron spectroscopy (XPS) detected Sn^{4+}, S^{2-}, and Cr^{3+} ions, while UV-visible diffuse reflectance spectroscopy revealed band gap variations due to doping. Photoluminescence spectra indicated defect-related emissions, with a strong peak in the visible range. Magnetization studies with the field and temperature variation analyzed using the modified Brillouin function and the Curie-Weiss law showed increased Cr concentration transitioned from weak ferromagnetic to superparamagnetic behavior. This research suggests that Cr-doped SnS_2 nanocrystals have potential in spintronics and magneto-optics, as tunable optical and magnetic properties can be achieved through controlled doping.

Keywords: Dichalcogenides; hydrothermal method; photoluminescence; exchange interaction

References:

[1] A. Karmakar, T. Chakraborty, S. Chakravarty, M. Nath, S. Chakraborty, S. Mitra, S. Sarkar, G. Mandal, A. Banerjee, C. Bhaumick, S. Sutradhar, A. Bandyopadhyay. The influence of Nd3+ doping on the structural, optical, magnetic, and dielectric characteristics of nanoscale hexagonal wurtzite type ZnO, J Magn. Magn. Mater. 591 (2024) 171728.

[2] H. Liu, Y. Zou, L. Zhang, L. Ling, H. Yu, L. He, C. Zhang, Y. Zhang. Magnetic order and dynamical properties of the spin-frustrated magnet Dy2xYbxTi2O7, J Magn. Magn. Mater. 349 (2014) 173–179.

Enhancement Of Magnetic Properties In Cu-Doped Mn-Mg Nanoparticles Synthesized By Hydrothermal Method

Pavan Kumar Malladi[1], Venkata Dharmendra Kumar Kalluri [2], and Aalu Boda[1*]

[1]*Department of Physics, National Institute of Technology Warangal, Hanamkonda, Telangana-506004, India.*
[2]*Department of Physics, Vignana Bharathi Institute of Technology, Hyderabad, Telangana-501301, India.*
[1]*Corresponding Author: abdop@nitw.ac.in

Abstract:

Copper-doped manganese magnesium ferrite nanoparticles, represented by the formula $Mn_{0.8}$ $Mg_{0.2-x}$ $Cu_xFe_2O_4$ (where x = 0.0, 0.01, 0.02, 0.03, 0.04, and 0.05), were synthesized using the hydrothermal method to investigate the effects of copper ion substitution on their structural and magnetic properties. Introducing copper ions into the manganese-magnesium ferrite matrix is observed to bring notable changes in these properties. To thoroughly characterize the prepared nanoparticles, we employed Powder X-ray Diffraction (XRD) to analyze crystalline structure, Scanning Electron Microscopy (SEM) for morphology, Energy Dispersive X-ray Spectroscopy (EDX) for elemental composition, and Vibrating Sample Magnetometry (VSM) to examine magnetic behavior. XRD analysis revealed that the particles are nano-sized and relatively uniform, with sizes ranging between 53 and 66nm. The Hematite (α-Fe_2O_3) phase is present in all samples. SEM images demonstrate apparent nanoparticle accumulation, indicating their cohesive distribution. The hysteresis loops show a distinct variation in magnetic properties with copper substitution, reflected in lower saturation magnetization values ranging from 5.78 to 11.62 emu/g. These findings suggest that copper doping in manganese magnesium ferrites affects their structural and magnetic characteristics, potentially enhancing their applicability in fields requiring fine-tuned magnetic properties and stability at the nanoscale level. The synthesized nanoparticles offer promising possibilities for further exploration in nanotechnology and materials science applications.

Keywords: Hydrothermal Method, Mn–Mg ferrite, Nanoparticle, X-ray diffraction, SEM and Magnetic Properties.

References:

[1]. T.A. Nhlapo, J.Z. Msomi, T. Moyo, *Journal of Magnetism and Magnetic Materials* 448 (2018)123-129.
[2]. M. M. Rashad, A. Khalifa, D. A Rayan, M.G. Fayed, *J Mater Sci: Mater Electron* 29 (2018) 3391–3400.
[3]. Rashmi Sharma, Virender Pratap Singh, Sahil Kumar, Palvee Sharma, M. Singh, Gagan Kumar, Materials Today: Proceedings 33 (3) (2020) 1568-1572.

Topic Code: D

Approaching Ferrite-Based Exchange-Coupled $(Ba_{0.5}Sr_{0.5}Fe_{12}O_{19})_{1-x}/(Ni_{0.3}Co_{0.7}Fe_2O_4)_X$ Synthesised Via One Pot Sol Gel Auto Combustion Method For Permanent Magnet Applications.

Abarna S T[1], R. Ezhil Vizhi[2*], Saravanan P

[1]*Materials Research Laboratory, School of Advanced Sciences, Vellore Institute of Technology, 632014, Tamil Nadu, India.*

[2]*Materials Research Laboratory, Centre for Functional Materials, Vellore Institute of Technology, 632014, Tamil Nadu, India.*

Defence Metallurgical Research Laboratory, Hyderabad, Telangana- 500058, India.

[*]Corresponding author: revizhi@gmail.com, rezhilvizhi@vit.ac.in

Abstract

Permanent magnets (PM's) are essential in contemporary technologies, underpinning various applications that contribute to a sustainable future, including wind turbines and electric vehicles. While magnets derived from rare-earth elements (REE) exhibit exceptional magnetic performance, the detrimental environmental consequences of extracting these resources, their uneven global distribution, and the political tensions between nations present significant challenges. As an alternate for the REE the Ferrite-based permanent magnet machines have been developed for numerous applications because of their advantageous characteristics, including cost-effectiveness and a reliable supply chain. This work focused on synthesizing $(Ba_{0.5}Sr_{0.5}Fe_{12}O_{19})_{1-x}/(Ni_{0.3}Co_{0.7}Fe_2O_4)_x$ exchange-coupled nanocomposites with controlled ratios of hard and soft ferrites to achieve superior performance and a higher energy product compared to hexaferrites. The composites were synthesized using the sol-gel auto combustion technique. Subsequently, the samples were subjected to annealing at a temperature of 1100 °C for a duration of 4 hours to facilitate phase formation within the material. The structural analysis was conducted using X-Ray diffraction (XRD), confirming the sample as M-type hexaferrite and spinel ferrite based on the lattice parameters. The analysis using Fourier transform spectroscopy (FT-IR) for the samples elucidates the stretching vibrations. The structural morphology of the sample was analysed using the Scanning Electron Microscope (SEM) to verify the existence of both hard and soft ferrite materials. The magnetic parameters of the sample, including saturation magnetism Ms, remanent magnetism M_R, squareness ratio M_r/M_s, and coercivity H_c, were confirmed by the Vibrating Sample Magnetometry (VSM). Based on the characterization results, we can optimize the novel material for PM's applications. [1-5]

Key words: Permanent magnets, Exchange coupling, Energy Product, Hexaferrites, Spinel ferrites.

[1] Torkian S, Ghasemi A, Razavi RS. Magnetic properties of hard-soft SrFe10Al2O19/Co0.8Ni0.2Fe2O4 ferrite synthesized by one-pot sol–gel auto-combustion. J Magn Magn Mater 2016;416:408–16.

Topic Code: D

https://doi.org/10.1016/j.jmmm.2016.05.050.

[2] Maltoni P, Sarkar T, Barucca G, Varvaro G, Locardi F, Peddis D, et al. Tuning the magnetic properties of hard-soft SrFe12O19/CoFe2O4 nanostructures via composition/interphase coupling. J Phys Chem C 2021;125:5927–36. https://doi.org/10.1021/acs.jpcc.1c00355.

[3] Almessiere MA, Ünal B, Ali S, Baykal A, Slimani Y, Trukhanov A V. One-pot synthesis of hard/soft SrFe10O19/x(Ni0.8Zn0.2Fe1.8Cr0.2O4) nanocomposites: Electrical features and reflection losses. Ceram Int 2022;48:25390–401. https://doi.org/10.1016/j.ceramint.2022.05.214.

[4] Granados-Miralles C, Saura-Múzquiz M, Andersen HL, Quesada A, Ahlburg J V., Dippel AC, et al. Approaching ferrite-based exchange-coupled nanocomposites as permanent magnets. ACS Appl Nano Mater 2018;1:3693–704. https://doi.org/10.1021/acsanm.8b00808.

[5] Jenuš P, Topole M, McGuiness P, Granados-Miralles C, Stingaciu M, Christensen M, et al. Ferrite-Based Exchange-Coupled Hard-Soft Magnets Fabricated by Spark Plasma Sintering. J Am Ceram Soc 2016;99:1927–34. https://doi.org/10.1111/jace.14193.

Topic Code: D

Effect of Microwave Sintering on Phase Evolution and Magnetic behavior of Barium hexaferrite

S. Bharadwaj[1], Y. Kalyanalakshmi[2*], T. Sai Santhoshi[1,3]

[1]Department of Physics, GITAM School of Science, GITAM (Deemed to Be University), Hyderabad, Telangana – 502329, India.
[2]Department of Physics, University College of Science, Osmania University, Hyderabad, Telangana -500007, India.*
[3]Department of Physics and Electronics, Bhavan's Vivekananda College of Science Humanities and Commerce, Sainikpuri, Secunderabad, Telangana -500094, India,
Corresponding Author Email: yklou@osmania.ac.in

Abstract

A systematic study on the effect of microwave sintering on structural and magnetic behavior of M-type barium hexaferrite prepared using sol-gel method is presented. Powders calcined at 700^{o}C/3 hrs were sintered in microwave sintering conditions at different temperatures of 750^{o}C, 850^{o}C, 950^{o}C and 1050^{o}C with 30 minutes as holding time. X-ray diffraction studies and Rietveld analysis confirms the hexaferrite phase along with α-Fe_2O_3 phase and this percentage decreases with sintering temperature and vanishes for temperatures 950^{o}C and 1050^{o}C. The Goodness of fit and χ^2 found from Rietveld analysis further confirms the purity of the phase. Grain size increases systematically with microwave sintering conditions and ranges between 159 nm - 225 nm. The magnetic parameters such as remanent magnetization, saturation magnetization and coercivity increases with microwave sintering temperature upto 950^{o}C but slightly drops for 1050^{o}C. These variations in the magnetic behavior of hexaferrites in microwave sintering conditions could be attributed to controlled grain size effects and the cation distributions.

Keywords:

Barium Hexaferrites; Microwave sintering; Magnetic behavior; Sol-gel; Grain size.

Topic Code: D1

Powder X-Ray Diffraction Study & Rietveld Refinement On Prussian Blue, Iron(III) Hexacyanoferrate(II) ($Fe_4[Fe(CN)_6]_3.14H_2O$)

Elankumaran Kannan[1], S. Muthukumaran[2] and Dhiyanesh Guna

[1]*School of Physical Sciences, Marudhar Kesari Jain College for women (autonomous), Vaniyambadi -635751, Tamil Nadu*
[2] *Department of Chemistry, RKM Vivekananda College, Chenna- 600004*

*Corresponding Author: dean.physci@mkjc.in

Abstract

Molecular magnet is an emerging field of magnetism that has more nano-technological applications especially in molecular spintronics, quantum technologies, metal–organic frameworks (MOFs) and 2D materials[1,2]. We report here, the synthesize and structural characterization of Prussian blue, Iron(III) Hexacyanoferrate(II) ($Fe_4[Fe(CN)_6]_3.14H_2O$), a molecular magnet. Prussian blue was synthesized by solution precipitation method in room temperature to investigate the structural properties, which will be helpful in analyzing the magnetic properties of Prussian blue, Iron(III) Hexacyanoferrate(II) ($Fe_4[Fe(CN)_6]_3.14H_2O$). Powder X-ray diffraction were carried out on these samples. Further, Rietveld refinement was carried out on the obtained raw Powder X-ray diffraction using Full Prof Suite software. From the particle size obtained from the Rietveld analysis and the shape of the crystallites, we infer that Prussian blue nanocrystals have formed.

Keywords: Molecular magnets, Nanocrystals, XRD, Rietveld analysis

References:

[1]. S. J. Blundell, Contemporary Physics, 48 (2007) 275-290.
[2]. E. Coronada, Nature reviewsMaterials , 5 (2020), 87-1

Topic Code: D

Structural, Optical and Magnetic Behaviour of Lead Ferrite Fabricated by Hydrothermal Method

Subashini. A,[1*] Dr. C. Pavithra,[1] M. Gunasekaran[2] and Seenuvasakumaran Perumal[3]

[1]*PG & Research Department of Physics,*
Marudhar Kesari Jain College for Women, Vaniyambadi. Affiliated to Thiruvalluvar University.
[2]*PG & Research Department of Physics, Muthurangam Government Arts College (A), Affiliated to Thiruvalluvar University, Vellore - 632 002, Tamil Nadu, India.*
[3]*Government Arts and Science College,*
Affiliated to Thiruvalluvar University, Thirupathur – 635901, Tamil Nadu, India
Email Id: subbuphd23@gmail.com

Abstract

Ferrites have distinct electric, dielectric and magnetic characteristics which makes the materials with potential applications in technology. One of the most intriguing material groups for researchers is lead nanoferrite ($PbFe_2O_4$). The $PbFe_2O_4$ has been notable, reflecting its increasing significance in various fields. The hydrothermal synthesis method is a most powerful technique to tune the morphology of a prepared sample by altering the synthesis conditions. The technique was carried out with extremely high ferrite purity, and the result was well-structured nanoferrite. This method is used to fabrication of lead nanoferrite. The structural analysis of the obtained nanomaterial has been revealed by XRD. The particle size has been calculated by the Scherrer formula; an average particle size is 20 nm. To investigate the inherent strain and particle size using XRD peak broadening examinations, W-H plot techniques were applied. The crystallographic formula exhibits crystal properties, which confirm that the material has a cubic structure. The spectroscopy studies of UV-Vis spectroscopy given the cut off wavelength nearby 210 nm , the band gap energy is 5.0 eV. The magnetization of the prepared nanomaterials was investigated by using VSM and the saturation magnetization (M_S), Coercivity (H_C) and Retentivity (M_r) were derived from the hysteresis loops. This study offers a cost-effective and scalable approach for producing high-quality $PbFe_2O_4$, contributing to the advancement of nanomaterials in industrial applications.

Keywords: Synthesis, Hydrothermal Route, Ferrite Nanomaterials, Nanoferrites

Hierarchical Free Energy model in Investigating the Cluster Spin-Glass behavior in Frustrated Spinel Oxides

Mouli Roy-Chowdhury[1], Sayandeep Ghosh[2], Tapati Sarkar[3], and Subhash, Thota[1,*]

[1]*Department of Physics, Indian Institute of Technology Guwahati-781039, Assam, India.*
[2] *Laboratory for Chemistry of Novel Materials, UMONS, 7000 Mons, Belgium*
[3] *Department of Materials Science and Engineering, Uppsala University, SE-75103, Sweden.*

*Corresponding Author: subhasht@iitg.ac.in

Abstract

Elemental substitution at one or both of the cationic sites (tetrahedral *A*-site and octahedral *B*-site) of a conventional spinel (AB_2O_4) often introduces magnetic frustration and random anisotropy in a system [1]. This leads to the emergence of a low-temperature spin-glass (SG) phase, characterized by non-ergodicity and a hierarchical free-energy landscape. Here, we synthesized doubly-diluted tri-cation derivatives of Co_3O_4 using the solid-state route. The investigated compounds, Zn*M*CoO_4 (*M* = Mn, Ti and Ge) consists of non-magnetic cations at 100% of their *A*-sites and 50% of their *B*-sites, leaving the system with one type of magnetic cations at only 50% of the *B*-sites. Although, it may seem simple, the magnetic behavior of all samples was complex and devoid of any long-range magnetic order. The study of rejuvenation effects, aging, and *ac*-susceptibility established a 'hierarchically organized' cluster SG ground state (Fig. 1) [2]. A non-exponential time decay of magnetization further confirmed the cluster SG state. Absence of a λ- peak in the specific heat data exhibited only short-range magnetic ordering in the systems [1]. Thus, frustration in short-range spinels provides valuable insights into the 'glassy' spin dynamics.

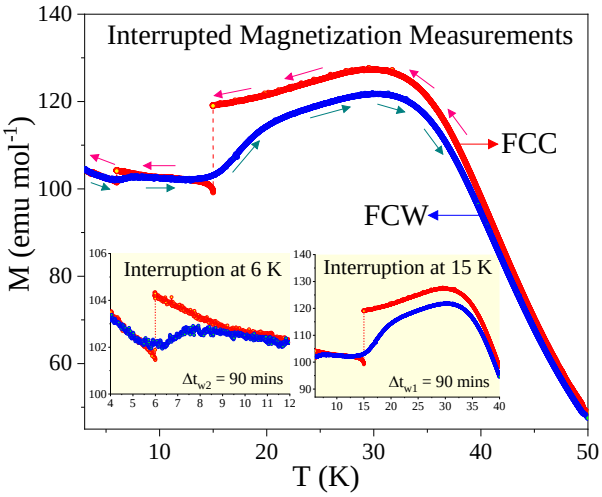


Figure 1: The magnetization curve (M vs. T) as a function of temperature under FC protocol depicts the system's memory by of its magnetization history which can be best explained by the hierarchical picture of the free-energy landscape. The insets show zoomed portions of the curve at two different halt temperatures, 15K and 6K where the system was allowed to wait and age for 90 minutes.

Keywords: Magnetic frustration, Spinels, Spin-glass, Hierarchical Free-energy

References:

[1] Chowdhury, M.R., et al., *J. Phys. Condens. Matter*, **34** (27), p.275803 (2022).
[2] Bag, P., et al., *Phys. Rev B* **98**, 144436 (2018).

Topic Code: B3

Investigation of Crystal Structure, Magnetism and Magnetocaloric Effect of $Tb_{0.33}Ho_{0.33}Er_{0.33}Cu_2$ Compound

Dame La-ai Wankhar Sutnga[1], Abhaya Prasada Mohapatra[1], J. Arout Chelvane[2], R. Nirmala*

[1]*Department of Physics, Indian Institute of Technology Madras, Chennai 600 036, India*

[2]*Defence Metallurgical Research Laboratory, Hyderabad 500 058, India*

*Corresponding Author: nirmala@physics.iitm.ac.in

Abstract

Individual rare-earth intermetallic compounds RCu_2 (R = Tb, Ho and Er) crystallize in orthorhombic structure (space group *Imma*, no. 74) at 300 K. These compounds order antiferromagnetically at Néel temperature (T_N) of 50 K, 10 K and 11 K respectively with two or three field-induced transitions below T_N [1]. It is determined from the powder X-ray diffraction study that $Tb_{0.33}Ho_{0.33}Er_{0.33}Cu_2$ exhibits the same orthorhombic crystal structure as that of the individual RCu_2 (R = Tb, Ho and Er) compounds. Energy dispersive analysis of X-rays confirm the sample composition. The compound $Tb_{0.33}Ho_{0.33}Er_{0.33}Cu_2$ orders antiferromagnetically with T_N = 19 K. An additional transition is observed at 5 K in 100 Oe applied field. In applied field of 5 kOe, the low temperature transition turns to show saturation tendency of ferromagnet. The magnetization vs. temperature curve of this $Tb_{0.33}Ho_{0.33}Er_{0.33}Cu_2$ compound looks quite similar to that of $DyCu_2$. At 3 K, two magnetic field-induced transitions and small hysteresis is seen. Magnetization - field isotherms and isothermal magnetic entropy change vs temperature curves are obtained. Maximum isothermal magnetic entropy change is observed at 10 K and is ~ -8.40 $Jkg^{-1}K^{-1}$ for 50kOe field change.

Keywords: Rare earth intermetallic compounds, magnetic properties, magnetocaloric effect.

Reference:

[1]. R. Rajivgandhi, J. Arout Chelvane, A.K. Nigam, S.K. Malik and R. Nirmala, J. Alloys. Compd. 815 (2020) 152659 1-6.

Topic Code: B3

Magnetocaloric Effect in Rare-earth Intermetallic Compound Er_3Al_2

Jeebanjyoti Sahoo[1], Abhaya Prasada Mohapatra[1], J. Arout Chelvane[2], R. Nirmala*

[1]*Department of Physics, Indian Institute of Technology Madras, Chennai 600 036, India*

[2]*Defence Metallurgical Research Laboratory, Hyderabad 500 058, India*

*Corresponding Author: nirmala@physics.iitm.ac.in

Abstract

Rare earth intermetallic compounds R_3Al_2 (R = Gd, Dy, Ho and Er) exhibit intriguing magnetic properties [1]. In the present work, magnetocaloric effect of Er_3Al_2 compound is studied. Powder X-ray diffraction data confirm the tetragonal structure of Er_3Al_2 (space group $P4_2$ / mnm, no. 136]. Nominal composition of the sample is verified using energy dispersive X-ray analysis. Magnetization measurement in applied field of 100 Oe reveals an antiferromagnetic transition at 10 K (T_N) [Fig. 1]. Erbium based intermetallic compounds host strong magnetic interaction and magnetic anisotropy and are promising candidates for magnetic cooling in the vicinity of magnetic transition. Indeed, from the field-dependent magnetization data it has been found that Er_3Al_2 shows large isothermal magnetic entropy change near T_N. Maximum isothermal magnetic entropy change value is ~ 9.1 $Jkg^{-1}K^{-1}$ at 10 K for 70 kOe field change.

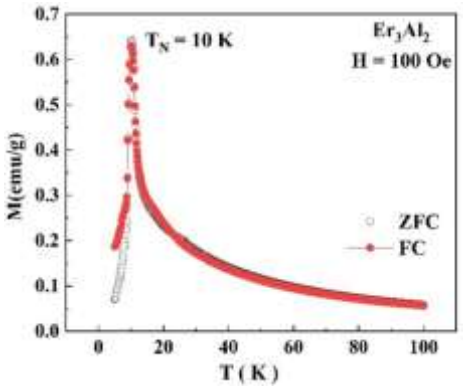


Fig. 1. Magnetization vs temperature of Er_3Al_2 compound in 100 Oe field.

Keywords: Rare earth intermetallic compounds, magnetic properties, magnetocaloric effect.

Reference:

[1]. D. I. Gorbunov, S. Palazzese, I. Ishii, A. V. Andreev, J. Šebek, V. Buturlim, T. Suzuki, S. Zherlitsyn, and J. Wosnitza, Phys. Rev. Mater. S6 (2022) 084409 and references therein.

Magnetic Properties of $Co_{35}Cr_5Fe_{10}Ni_{30}Ti_5Al_{7.5}Mn_{7.5}$ High Entropy Alloy

Priyanka Kumari, Rohit R Shahi*

Functional and Energy Materials Research Laboratory, Department of Physics, Central University of South Bihar Gaya, Bihar 824236, India

**Corresponding Author's email: rohitrshahi@cusb.ac.in, rohitrshahi@gmail.com*

Abstract

High-entropy alloys (HEAs), composed of five or more principal elements, have gathered considerable attention for their unique properties. These materials exhibit exceptional mechanical strength, corrosion resistance, thermal stability at high temperatures, irradiation resistance, and electrical resistivity, over the performance of conventional alloys [1]. High entropy alloys can be used as an industrial soft magnetic material by optimizing its magnetic properties [1]. In this study, we synthesized $Co_{35}Cr_5Fe_{10}Ni_{30}Ti_5Al_{7.5}Mn_{7.5}$ HEA through mechanical alloying technique and investigated its phase formation and magnetic properties. Major fcc phase with small amount of bcc and σ phase has formed for $Co_{35}Cr_5Fe_{10}Ni_{30}Ti_5Al_{7.5}Mn_{7.5}$ HEA. After vacuum annealing at 700°C for 2h, phases present in the as synthesized state maintained their phase identity for $Co_{35}Cr_5Fe_{10}Ni_{30}Ti_5Al_{7.5}Mn_{7.5}$ HEA. However, the relative volume phase fraction of bcc phase increased after annealing. The value of saturation magnetization, and coercivity is found to be 83 emu/g & 6 Oe for as synthesized $Co_{35}Cr_5Fe_{10}Ni_{30}Ti_5Al_{7.5}Mn_{7.5}$ HEA. The value of Ms increased significantly and found to be 109 emu/g for 700°C annealed $Co_{35}Cr_5Fe_{10}Ni_{30}Ti_5Al_{7.5}Mn_{7.5}$ HEA. We also found better corrosion property for $Co_{35}Cr_5Fe_{10}Ni_{30}Ti_5Al_{7.5}Mn_{7.5}$ HEA as compared to conventional soft magnetic alloys. Our investigations provide detailed insight for phase formation and its corelation with change in magnetic properties for $Co_{35}Cr_5Fe_{10}Ni_{30}Ti_5Al_{7.5}Mn_{7.5}$ HEA after annealing.

Keywords: High entropy alloys; Magnetic Materials; Mechanical Alloying; Annealing.

References:

[1] Priyanka Kumari, Amit Kumar Gupta, Rajesh K. Mishra, M. S. Ahmed, Rohit R. Shahi, A Comprehensive Review: Recent Progress on Magnetic High Entropy Alloys and Oxides, Journal of Magnetism and Magnetic Materials 554 (2022) 169142. https://doi.org/10.1016/j.jmmm.2022.169142.

Topic Code: B

Dynamic pressure effect on robust critical temperature (T_c) of MgB_2 superconductor

Rajkumar, Sokkalingam[1], Abhishek, Panghal[2], Susanta Sinha, Roy[2], Arumugam, Sonachalam*[1,3]

[1]*Centre for High Pressure Research, Department of Physics, Bharathidasan University, Tiruchirappalli - 620 024, Tamil Nadu, India*
[2]*Department of Physics, School of Natural Sciences, Shiv Nadar Institution of Eminence (SNIOE), Deemed to be University, Delhi-NCR, Greater Noida - 201314, India*
[2]*Tamil Nadu Open University, Anna Salai, Saidapet, Chennai - 600 015, Tamil Nadu, India*

*Corresponding Author: sarumugam1963@yahoo.com

Abstract

Highly versatile superconducting magnets find extensive use in numerous industries such as industry, medicine, and research. Identification of materials that display great stability in high temperatures and pressures is vital for practical applications, as most functional materials are unable to keep their crystalline structure in such environments. To investigate this, experiments were carried out to recover shock waves on the MgB_2 superconductor. This work studied the structural, morphological, and magnetic features of the material in respect to the quantity of shock pulses, namely 0, 50, and 100. An study of the powder X-ray diffraction (PXRD) pattern revealed that the compounds exhibited a hexagonal crystal structure with the *P*6/*mmm* space group. In addition, the sample was analyzed using field emission scanning electron microscopy, which exhibited a distinct microstructure characterized by irregularly shaped hexagonal grains that can be attributed to the MgB_2 phase. Furthermore, the pictures revealed unreacted granules of magnesium and boron. In order to verify the elemental composition, energy-dispersive X-ray spectroscopy (EDX) was employed. Magnetic properties investigations were carried out on the superconducting MgB_2 material, with a critical temperature (T_c) of 39 K, using different magnetic fields and across a temperature spectrum spanning from 2 to 45 K. The superconducting transition temperature (T_c = 39 K) of MgB_2 was proven to be persistent by the observation of hysteresis loops of magnetization at various temperatures.

Keywords: Dynamic shock wave, MgB_2 superconductor, Morphology, Robust Critical temperature, Morphology of MgB_2.

References:

[1]. Sokkalingam, Rajkumar, Giri Devaraj Raja, *et al*., *Journal of Molecular Structure* 1318 (2024): 139215.

[2]. Patel, Dipak, Minoru Maeda, *et al*., *Scripta Materialia* 88 (2014): 13-16

[3]. Liang, Hao, Dipak Patel, *et a*l., *Journal of Magnesium and Alloys* 11, no. 7 (2023): 2217-2229.

[4]. Patel, Dipak, Akiyoshi *et al., ACS Applied Materials & Interfaces* 14, no. 2 (2022): 3418-3426.

Large magnetocaloric effect in $TbGd(MoO_4)_3$ polycrystalline compound

Athira. P[1*], Debasmita Bala[1], Abhijit Nayak[1], Devajyoti Mukherjee[2], Jyothinagaram Krishnamurthy[1]

[1]*Department of Physics, School of Sciences, National Institute of Technology, Andhra Pradesh-534101, India*

[2]*School of Physical Sciences, Indian Association for the Cultivation of Science, 2A & 2B Raja S. C. Mullick Road, Kolkata-700032, India*

*Corresponding Author: athirapganesh@gmail.com

Abstract

Rare-earth molybdates or tungstates have garnered much of research attention due to their magnetoelectric behavior with type-II multiferroicity, structural phase transition with displacive ferroelectricity, which make them an ideal choice for a range of applications from scintillators to energy storage devices [1,2]. In this report, we present the synthesis, structural, DC magnetic susceptibility and specific heat capacity studies on $TbGd(MoO_4)_3$ polycrystals. Temperature and magnetic field dependent magnetization and heat capacity studies have been performed to determine the isothermal magnetic-entropy change ($-\Delta S_m$) and adiabatic temperature change (ΔT_{adi}) in the prepared rare-earth molybdate compound. The investigated system does not exhibit any obvious long-range order down to 2 K. The estimated maximum value of $-\Delta S_m$ and ΔT_{adi} are 13.62 $Jkg^{-1}K^{-1}$ and 8.5 K at 3.5 K for 70 kOe, respectively. $TbGd(MoO_4)_3$ compound is suitable for use as promising magnetic refrigerant in the vicinity of liquid helium temperature due to its large magnetocaloric behaviour at a moderate field change with low electrical conductivity and the lack of thermal and magnetic hysteresis.

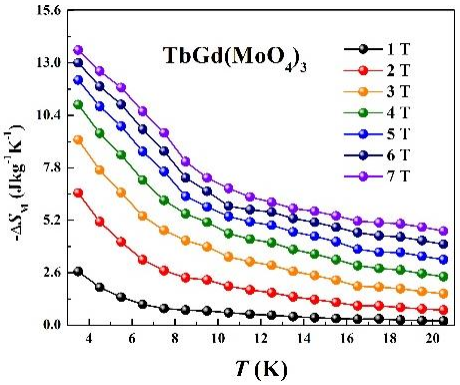


Fig. 1*: Temperature dependence of magnetic entropy changes ($-\Delta S_m$) under different H in* $TbGd(MoO_4)_3$ polycrystals.

Keywords: Rare earth molybdate; Magnetization, Heat capacity, Solid-state refrigeration,

References:

[1]. P. Athira *et al.*, "Large reversible magnetocaloric effect in rare-earth molybdate $RE_2(MoO_4)_3$ (RE : Gd and T) compounds," *J. Magn. Magn. Mater.***610** (2024)172587.

[2]. B.K. Ponomarev, A. Zhukov, Magnetic and magnetoelectric properties of rare earth molybdates, Phys. Res. Int. **22** (2012) 2012.

Magnetocaloric Properties Of Ferrimagnetic $Mn_{5-x}Co_xSn_3$ (X=0.1&0.2) Alloys Exhibiting Spin Glass Transition.

Mani Barathi A[1], Athul S R[1], Andrea Dzubinska[2], Marian Reiffers[3,4], Nagalakshmi Ramamoorthi[1]*

[1] *Intermetallics and Non-linear optics laboratory, Department of Physics, National Institute of Technology, Tiruchirappalli 620 015, India*

[2]*CPM-TIP, University Pavol Jozef Safarik, 04011 Košice, Slovakia*

[3]*Faculty of Humanities and Natural Sciences, Presov University, Presov, Slovakia*

[4] *Institute of Experimental Physics, SAS, Kosice, Slovakia.*

*Corresponding author: nagaphys@yahoo.com

ABSTRACT

Refrigeration, being a modern-day necessity, is almost completely dependent on vapour compression, which uses gasses that cause global warming. The world needs an economical, efficient, and eco-friendly alternative refrigeration technique, which might be magnetic refrigeration based on the Magnetocaloric Effect (MCE). Even though there are large pools of rare-earth based magnetocaloric materials which have been researched for decades, they tend to be expensive. The Manganese-based materials provide an excellent alternative in an economic way. In the above context, we have synthesized polycrystalline $Mn_{5-X}Co_XSn_3$ (X = 0.1&0.2) alloys using arc melting technique. The alloys have been crystallized in a hexagonal Ni_2In-type structure with space group $P6_3/mmc$. The X-ray Diffraction (XRD) patterns indicate some superlattice structures which manifest as some additional peaks. In the zero-field cooled (ZFC) measurements of magnetization, the samples show ferrimagnetic behaviour with curie temperatures T_C = 229 K and 215 K for X = 0.1 and 0.2 respectively. Further in ZFC, at low temperatures, the samples exhibit a re-entrant spin glass transition indicated by spin freezing. The lack of saturation in the isothermal magnetization curves supports the claim of the samples being ferrimagnetic in nature. The Arrot plot confirms the second-order nature of transition that leads to a maximum magnetic entropy change ($-\Delta S_M$) of 2.28 $JKg^{-1}K^{-1}$ and 2.26 $JKg^{-1}K^{-1}$ with relative cooling powers (RCP) 225 JKg^{-1} and 185 JKg^{-1} for X= 0.1 and 0.2, respectively, at 5T. The temperature-averaged entropy change (TEC) for the samples X = 0.1 and X = 0.2 are 1.9 $JKg^{-1}K^{-1}$ and 2.23 $JKg^{-1}K^{-1}$ for the same magnetic field, which is very close to $-\Delta S_M$, indicating the reliability of calculations. Apart from this, the ZFC measurements show negative

magnetization, which may be a hint for superconducting nature of this material[1]. From the above, we can conclude that the synthesized alloys having multiple magnetic transitions show a considerable MCE behaviour with RCP comparable to materials of similar compositions[1,2].

Key words : Magnetocaloric effect; ferrimagnetism; spin glass; second order transition

[1] S. Sakthivel, A. Kumar, R. Uralath Dhanavardhanan, A. Sunitha Raveendran, A. Dzubinska, M. Reiffers, N. Ramamoorthi, Reentrant spin glass transition and partial substitution induced superconductivity in magnetocaloric Mn_5Sn_3 alloys, J Mater Sci 59 (2024) 2121–2133. https://doi.org/10.1007/s10853-023-09234-4.

[2] K. Arun, S. Swathi, U.D. Remya, A. Dzubinska, M. Reiffers, R. Nagalakshmi, Evaluation of critical exponents and magnetocaloric properties in moderate heavy fermion $Mn_{4.5}Ni_{0.5}Sn_3$ alloy, J Appl Phys 127 (2020). https://doi.org/10.1063/1.5139993.

Studies on the Structural, Morphological, Magnetic, and Magnetic Hyperthermia properties of Fe_3O_4 Nanocomposites with CNT, GO and rGO

K. Rekha[1,2], R. Ezhil Vizhi[2,*], B. B. Lahiri[3,4]

[1]*Department of Physics, School of Advanced Sciences, Vellore Institute of Technology, Vellore, Tamil Nadu - 632014, India*

[2]*Materials Research Laboratory, Centre for Functional Materials, Vellore Institute of Technology, Vellore, Tamil Nadu - 632014, India*

[3]*Smart Materials Section, Materials Characterization Group, Metallurgy and Materials Group, Indira Gandhi Centre for Atomic Research, Kalpakkam, Tamil Nadu- 603102, India*

[4]*Homi Bhabha National Institute, Training School Complex, Anushaktinagar, Mumbai - 400094, India*

Corresponding authors: R. Ezhil Vizhi (revizhi@gmail.com, rezhilvizhi@vit.ac.in)

Abstract

Using superparamagnetic nanoparticles (MNPs), in diagnosis and therapy is a recent development in the domains of health and life science. Due to its low cost and tunable properties, magnetic nanoparticle guided cancer therapy is one of the developed technologies that researchers are interested in. The aim of the present work has been to synthesize iron oxide nanocomposites through a simple and inexpensive hydrothermal route. Loading MNPs onto graphene oxide (GO), reduced graphene oxide (rGO), and carbon nanotubes increases the surface area of the system, which aids in drug administration and introduces optical features suited for photothermal therapeutic applications. The structural, chemical, morphological and magnetic properties of the composites were confirmed using the X-Ray Diffraction, Fourier-Transform Infrared spectroscopy, Field Emission Scanning Electron Microscopy, Transmission Electron Microscopy and Vibrating Sample Magnetometry. Magnetic hyperthermia analysis was utilised to investigate the magnetothermal heating capabilities of the synthesised composites. Based on the characterisation data, we can optimise the material for the specific uses. The system's optical and magnetic capabilities can be used to create a multifunctional medicinal therapeutic agent.

Keywords: Graphene Oxide; carbon nanotube; superparamagnetism; induction heating

References:

[1]. X. Zuo, C. Wu, W. Zhang and W. Gao, *RSC Adv.*, 2018, **8**, 11997–12003.

[2]. A. A. M. G. Viswanathan Karthika, Mohamad S. AlSalhi, Sandhanasamy Devanesan, Kasi Gopinath, *Sci. Rep.*, 2020, **10**, 1–17.

Insights of the physical properties of multiferroic $Bi_4Ti_3O_{12}$ - $BiFeO_3$ composite thin film fabricated by pulsed laser deposition technique for memristor devices

Priyanka, Mitra[1], B. Harihara, Venkatraraman[1*]

[1]*Department of Physics, BITS-Pilani, Hyderabad Campus, Telangana - 500078, India*

*Corresponding Author: hari@hyderabad.bits-pilani.ac.in

Abstract

In the digital era, multiferroic materials are attractive owing to their simultaneous coupling of the ferroelectric and ferromagnetic order parameters. The urge to stimulate the magnetoelectric effect has driven researchers to utilise these materials for various applications like capacitors, sensors, spintronics, actuators and NVRAM devices. Usually, these material classifications exist in single or composite forms; however, due to the inherent characteristic limitations, single-phase materials may not be suitable for electronic applications compared to hybrid-phase. Keeping this in view, the $0.9Bi_4Ti_3O_{12}$ (BIT) - $0.1BiFeO_3$ (BFO) diphasic composite thin film has been prepared using the Pulsed Laser Deposition technique. This thin film sample was grown on the ITO-coated glass substrate using the KrF laser (248 nm). The X-ray diffraction pattern confirmed the co-existence of the diphasic composite thin film with a significant phase from the orthorhombic BIT and a minor Bragg reflection from the BFO (rhombohedral) phase. A sharp characteristic peak at $2\theta \sim 30.08°$ has confirmed the phase formation of a bismuth titanate associated with a low intense peak at $2\theta \sim 32.10°$ of the bismuth ferrite phase. The presence of all the constituent elements of BIT and BFO crystalline phases is validated by X-ray photoelectron spectroscopy analysis. The room-temperature ferroelectric analysis exhibited a hysteresis loop with an enhanced magnitude of $2P_r$ (~ 65 $\mu C/cm^2$) and $2E_c$ (~ 38 kV/cm) than their bulk counterpart. Hence, this uniformly deposited di-phasic composite thin film configuration could be exploited as a better candidate for capacitors and memory device-based applications.

Keywords: Multiferroic composite thin film, Pulsed laser deposition technique, Bismuth titanate, Ferroelectric and Ferromagnetic properties.

References:

[1]. Yan Liu et al., Structure and properties of $0.5Bi_4Ti_3O_{12}$-$0.5BiFe_{0.98}Mn_{0.02}O_3$ films under different annealing atmospheres, J Mater Sci: Mater Electron 34, 364 (2023).

[2]. Sadia Sarif et al., Structural, surface morphology, dielectric and magnetic properties of holmium doped $BiFeO_3$ thin films prepared by pulsed laser deposition, Thin Solid Films. 662, 83-89 (2018).

Topic Code: B1

Studies on Magneto Electric Behavior of (1-x) $BaTiO_3$ -x$MgFe_2O_4$ Magnetoelectric Composites

Durairaj, Padmapriya[1], M T, Rahul[2], Nandakumar, Kalarikkal[2], Nambi Venkadesan, Giridharan[1*]

[1]*Advanced Functional Material Laboratory, NIT-Tiruchirappalli, TamilNadu - 620015, India*
[2]*International and Inter University Centre for Nano Science and Nanotechnology, Mahatma Gandhi University, Kottayam, Kerala- 686560, India*

*Corresponding Author: giri@Nitt.edu

Abstract

Multiferroic magnetoelectric materials have ever increasing interest due to their potential for combining electric and magnetic effect to produce a single device component which can perform more than one task [1]. In this present work, room temperature multiferroic behavior of (1-x)$BaTiO_3$ - x$MgFe_2O_4$ (x = 0.05, 0.15, 0.25, 0.35 and 0.45) 0-3 particulate composites has been investigated. Powder X-Ray diffraction data confirms the formation of both perovskite tetragonal BTO and spinel cubic MFO phases coexist with the absence of impurity phases in the detectable limit. The SEM image of the composite samples provides an evidence for presence of two different phases (ferroelectric BTO and ferrite MFO) with different grain size and morphology. An enhancement of magnetization with the increase of ferrite molar fraction in the particulate composites reveals the unbalanced anti parallel spins between Fe^{3+} and Mg^{2+} ions attributes the magnetic property of the composites [2,3]. Leakage, dielectric and ferroelectric properties of the particulate composites clearly shows leaky behavior of composites with the increase of $MgFe_2O_4$ concentration. Eventually, 0.55$BaTiO_3$ – 0.45$MgFe_2O_4$ (0-3) particulate ceramic composites showed an enhanced ME coupling coefficient value of 17.21 mV/cm.Oe at magnetic field of 2.986 KOe demonstrates its suitability towards ME devices.

Keywords: Multiferroics, composites, magnetoelectric, $BaTiO_3$, $MgFe_2O_4$.

References:

[1].M. Naveed-UI-Haq, V.V. Shvartsman, S. Salamon, H. Wende, H. Trivedi, A. Mumtaz, D. C. Lupascu Sci. Rep. 6:32164 (2016) 1-10
[2].R. Grigalaitis, M.M. Vijatoicpetrovic, J. D. Bobic, A. Dzunuzovic, R. Sobiestianskas, A. Brilingas Ceram. Int. 40 (2014) 6165
[3].M.M. Vijatovicpetrovic, R. Grigalaitis, A. Dzunuzovic, J.D. Bobic, B.D. Stojanovic, R. Salasevicius J. Alloys Compd. 749 (2018) 1043

Topic Code: B

Magneto-structural studies of $MgFe_2O_4$ synthesized by Combustion method for Magnetic Fluid Hyperthermia (MFH)

Dhanashri S. Kolte[1], Dr. Ashwini B. Salunkhe[1]*,

1 Research Laboratory, Department of Physics, Rajaram College, Kolhapur, Dist.-Kolhapur-416004, (Affiliated to Shivaji University, Kolhapur) Maharashtra, India.

Abstract

Hyperthermia therapy is a type of treatment in which body tissue is exposed to high temperatures to damage and kill cancer cells or to make cancer cells more sensitive to the effects of radiation and certain anticancer drugs. The basis of magnetic hyperthermia modalities is inserted heating sources. In which macroscopic mediators are inserted inside the body by exact interventions, whereas nano-scale mediators injected in the form of colloidal dispersion of magnetic particles i.e. called magnetic fluid hyperthermia (MFH). Magnetic nanoparticles have been investigated for medical applications. Magnetic nanoparticles (MNPs) with medical applications are primarily made from magnetic iron oxide, which is also chemically stable and magnetically responsive.

In the present investigation, an efficient magnesium iron oxide nanoferrites have been synthesized by simple solid state combustion method for Magnetic Fluid Hyperthermia (MFH). The effect of various fuels on magneto-structural properties and consequently induction heating properties studied thoroughly. The samples prepared by the different fuels nomenclature as sample + Fuel used as, sample with citric acid (SC), glycine (SG), urea (SU) and egg white (SE). The structural confirmation was done with the help of X-ray Diffraction (XRD) pattern and Fourier Transmission Infrared Spectroscopy (FTIR). The crystallite size (D) of nanoparticles obtained as 8 nm for SC, 7.5 nm for SE, 23 nm for SG and 49 nm for SU. The morphology and particle size were studied by Transmission Electron Microscopy (TEM). Effect of difference fuels on magnetic properties have been studied by Superconducting Quantum Interference Device (SQUID). The specific absorption rate (SAR) of all synthesized nanoparticles were calculated and it was observed that the prepared $MgFe_2O_4$ can be a nano-agent for MFH.

Influence of Fe^{3+} and Co^{2+} Co-doping on the Electrical, Magnetodielectric, and Multiferroic Properties of Lead-Free $Ba_{0.7}Sr_{0.3}TiO_3$ Ceramics

Arbaz Reyaz Khan[1], Sumit Bhardwaj*[,1], Sanjeev Kumar*[,1]

[1] *Department of Physics, University Institute of Sciences, Chandigarh University, Gharuan, Mohali, Punjab, 140413, India*

*Corresponding Author: sumit.bhardwaj4@gmail.com, sanjeev.kd02@gmail.com

Abstract

This study explores the ambient temperature multiferroic behavior in lead-free $Ba_{0.7}Sr_{0.3}TiO_3$ ceramics co-doped with transition metal ions (Fe^{3+} and Co^{2+}) synthesized via the solid-state reaction (SSR) method. The research systematically investigates the effects of increasing transition metal co-doping on the structural, ferroelectric, dielectric, magnetic, and magnetodielectric properties of the ceramics. X-ray diffraction (XRD) analyses confirmed the formation of a monophasic crystalline structure with *P4mm* space group symmetry across all compositions. Raman spectroscopy further supported the presence of single-phase crystallinity, consistent with the XRD results. Scanning electron microscopy (SEM) revealed a decrease in grain size due to the incorporation of transition metal ions. Dielectric properties, measured across a frequency range of 1 kHz to 1 MHz, demonstrated frequency-dependent behavior. Ferroelectric P–E hysteresis curves exhibited a consistent reduction in polarization (P_s and P_r), while magnetic M–H loops showed an enhancement in magnetic properties with increased doping levels. Magnetodielectric (MD) analysis validated the coupling between ferromagnetic and ferroelectric ordering. The samples exhibited significant magnetodielectric effects, demonstrating notable magnetoelectric coupling coefficients and MC% values. These findings highlight the potential of these co-doped BST ceramics for use in advanced non-volatile multiferroic memory devices.

Effects of Magnetic Field and Temperature on the DC and AC Electrical Properties of Piezo-magnetic $Ni_{0.5}Co_{0.5}Fe_2O_4$ Nanoparticles

Sarit Chakraborty[1*], Tanmoy Majumder[2], Sritama Roy[2]

[1]*Department of Physics, National Institute of Technology Agartala, Tripura, 799046, India*
[2]*School of Electronics Engineering, Vellore Institute of Technology, Chennai-600127*
*Corresponding Author: **sarit91chakraborty@gmail.com**

Abstract

This study investigates the magnetic field and temperature-dependent DC/AC electrical properties of Zn-doped $Ni_{0.5}Co_{0.5}Fe_2O_4$ (NCFO) nanoparticles, synthesized using a chemical pyrophoric reaction process. Structural analysis, conducted via X-ray diffraction (XRD), confirmed the nanoparticles' crystalline structure, while field emission scanning electron microscopy (FE-SEM) and energy-dispersive X-ray (EDX) analysis confirmed their morphology and elemental composition. By applying varying magnetic fields and temperatures, we observed significant changes in current (DC) and impedance (AC) properties, revealing non-linear I-V characteristics and hysteresis, attributed to oxygen vacancies and interfacial polarization. Additionally, dielectric properties showed a high dielectric constant at low frequencies, influenced by the applied magnetic field, while temperature variation induced metallic-to-semiconductor transitions. These behaviors are largely attributed to grain boundary effects and polaronic hopping conduction mechanisms, with magnetic field and thermal modulation leading to variations in electrical conductivity and permittivity. Our findings highlight the potential of NCFO nanoparticles for device applications, offering insights into tuning their electrical properties for specific uses in electronics, sensors, and biomedical fields.

Keywords: Electrical Properties, Piezo-magnetic, Oxygen Vacancies, Impedance Spectroscopy, Dielectric Constant, Polaronic Hopping.

Reference:

1. S.K. Mandal, Sarit Chakraborty, P. Dey, B. Saha, T.K. Nath, Zn doped $NiFe_2O_4$–Pb $(Zr_{0.58}Ti_{0.42})O_3$ multiferroic nanocomposites: magnetoelectric coupling, dielectric and electrical transport, J. Alloys Compd. 747 (2018) 834-845.

2. S. Chakraborty, S. K. Mandal, Magnetoelectric $Zn_{0.2}Co_{0.8}Fe_2O_4$-$PbZr_{0.58}Ti0.4_2O_3$ nanocomposite for bistable memory and magnetic field sensor applications J. Magn. Magn. Mater. 491 (2019) 165573.

3. S. K. Mandal, S. Chakraborty, P. Dey, B. Saha and T. K. Nath, Zn doped $NiFe_2O_4$- Pb $(Zr_{0.58}Ti0_{.42})O_3$ multiferroic nanocomposites: Magnetoelectric coupling, dielectric and electrical transport J. Alloys Compd. 747 (2018) 834 -845.

Topic Code: B

Microwave-Assisted Synthesis and Magnetocaloric Properties of $Zn_{1-x}Gd_xFe_2O_4$ Nanoferrites

T. Prabhakaran,[1,2*] Bharani Lakshmi J,[1] F. Béron,[2] and R.V. Mangalaraja[3]

[1]*Department of Physics, School of Advanced Sciences, VIT-AP University, Amaravati, Andhra Pradesh – 522237, India*
[2]*Laboratório de Materiais e Baixas Temperaturas (LMBT), Instituto de Física Gleb Wataghin (IFGW), Universidade Estadual de Campinas (UNICAMP), 13083-859, São Paulo, Brazil*
[3]*Faculty of Engineering and Science, Universidad Adolfo Ibáñez, Diagonal las Torres 2640, Peñalolén, Santiago, Chile*

***Email:** prabhakaran.thandapani@vitap.ac.in

Abstract

Magnetic refrigeration is considered a promising green technology, and Gadolinium-based alloys are known to exhibit a magnetocaloric effect near room temperature. However, these materials are expensive and relatively scarce. In this work, we investigate a Gd-substituted spinel ferrite, $ZnFe_2O_4$, synthesized via microwave-assisted co-precipitation, as a potential alternative for refrigeration applications. The samples exhibit a significant entropy change between 2 K and 32 K, followed by a minor variation with increasing temperature. At 2 K, ZFGd1, ZFGd3, and ZFG5 show magnetocaloric effects of –5.05, –1.54, and –7.31 J/kg/K, respectively, under a magnetic field of 40 kOe. These effects are likely attributed to the antiferromagnetic nature of Gd-based compounds at low temperatures. Although Gd does not replace Zn at the crystallographic site, a notable magnetocaloric effect is observed in the superparamagnetic ferrites at cryogenic temperatures, suggesting the potential of these materials for refrigeration applications.

Keywords: Magnetic refrigeration; Spinel ferrites; Microwave assisted co-precipitation method; Superparamagnetism

References:

[1].T. Prabhakaran et al, ACS Appl. Polym. Mater. 5 (8) (2023) 5926.
[2].T. Prabhakaran et al, J. Phys. Chem. C 123, (2019) 25855.
[3].T. Prabhakaran et al, Phys. Status Solidi A, 215 (2018) 1700842.

Topic Code: B

$YFeO_3$ Single Crystals: Metamagnetic Transitions and Spin-Glass Behaviour for Advanced Applications

Ramesh Babu, Palanisamy[1], Srimathy, Balasubramanian[2*], Kalainathan, Sivaperuman[3], Veeramanikandasamy, Thiyagarajan[1], Devendiran, Shubbaiya[1]

[1]*Department of Electronics and Communication System, Sri Krishna Arts & Science College, Coimbatore - 641 008, Tamil Nadu, India*
[2]*PG & Research Department of Physics, Seethalakshmi Ramaswami College (Affiliated to Bharathidasan University), Tiruchirappalli - 620 002, Tamil Nadu, India*
[3]*Centre for Nanotechnology Research, Vellore Institute of Technology, Vellore - 632 014, Tamil Nadu, India*
*Corresponding Author: bsrimathy@gmail.com

Abstract

Yttrium orthoferrite ($YFeO_3$) with an orthorhombic perovskite structure was synthesized via solid-state reaction, avoiding garnet impurities, and $YFeO_3$ single crystals were successfully grown using the optical floating zone technique. Magnetic measurements revealed a phase transition from antiferromagnetic to paramagnetic ordering at 630 K. In the temperature range of 300-20 K, magnetization data under zero-field and field-cooled conditions indicated a metamagnetic transition, where the single crystals responded well to cooling but showed strong anisotropy when a magnetic field was applied, resulting in enhanced magnetism. At temperatures below 91 K, the samples displayed a well-defined hysteresis loop, while above this temperature, the magnetic saturation became less distinct, producing a distorted hysteresis loop due to spin transitions in $Fe3^+$ ions. A magnetic transition near 600 K further confirmed the material's spin-glass behavior. The Bloch T3/2 law was found to hold, with a B-parameter of 3.4×10^{-5} $K^{-3/2}$. Coercivity showed a wave-like trend, steadily decreasing above 550 K, attributed to weakened antiferromagnetic pinning caused by weak ferromagnetism, defining this as the "blocking" temperature. Thus, magnetic saturation decreases with rising temperatures due to the spin reorientation of canted $Fe3^+$ ions and making $YFeO_3$ single crystals excellent candidates for spintronics and magnetic memory applications.

Keywords: orthoferrites; antiferromagnetic; spin-glass; spintronics

References:

[1]. L. Suthar, V.K. Jha, F. Bhadala, M. Roy, S. Sahu, S.K. Barbar, Studies on structural, electrical, thermal and magnetic properties of $YFeO_3$ ceramic. Appl. Phys. A. 123 (2017) 1-9.
[2]. G. Padmasree, S.S. Reddy, N.P. Kumar, P.Y. Reddy, C.G. Reddy, Magnetization studies of Mn doped $YFeO_3$ multiferroics. ADVANCED MATERIALS AND RADIATION PHYSICS: 5th National e-Conference on Advanced Materials and Radiation Physics (2021).
[3]. S. Raut, P.D. Babu, R.K. Sharma, R. Pattanayak, S. Panigrahi, Grain boundary-dominated electrical conduction and anomalous optical-phonon behaviour near the Neel temperature in YFeO3 ceramics. J. Appl. Phys. 123 (2018) 174101.

Synthesis, characterizations and magnetic properties of different temperatures annealed $Co_{35}Fe_{10}Mn_5Ni_{30}Ti_{20}$ HEA

Shashi Kant Mohapatra, Priyanka Kumari, Rohit R Shahi*

Functional and Energy Materials Research laboratory, Department of Physics
Central University of South Bihar, Gaya, Bihar-824236, India

*Email: rohitrshahi@cusb.ac.in

Abstract

In 2004, J W Yeh, and Brian Cantor came up with the first publication on the multi-component alloys which were later known as High Entropy Alloys (HEAs) [1]. It has been found that HEAs have excellent combination of good thermal stability, good mechanical properties, softer magnetic properties, high electrical resistivity and good corrosion-resistance properties [2]. The freedom to select multiple elements opens up a scope to design and synthesize suitable materials for balanced magnetic, electrical, corrosion and tunable mechanical properties. In the last few years, various amorphous and crystalline nano-materials (i.e. alloys, oxides & composites etc.) have been studied for soft magnetic applications. We optimized $Co_{35}Fe_{10}Mn_5Ni_{30}Ti_{20}$ HEA synthesized through mechanical alloying and annealed the synthesized HEA at different temperatures, 200°C, 500°C, 700°C, 900°C and 1000°C for 2 hr. On magnetic measurements, the value of Ms and Hc for the as-synthesized $Co_{35}Fe_{10}Mn_5Ni_{30}Ti_{20}$ HEA are found to be 88 emu/g and 13 Oe respectively. The values of Ms changed on annealing and found to be 102, 95, 87 and 89 emu/g for 500°C, 700°C, 900°C and 1000°C for 2 hr annealed HEA respectively. However, the values of Hc were found to be 9, 5, 12 and 14 Oe for 500°C, 700°C, 900°C and 1000°C for 2 hr annealed HEA respectively. The experimental technique and the reason behind the variation in magnetic properties with the annealing temperature will be discussed in detail during presentation.

Keywords: High Entropy Alloys, Magnetic properties, Mechanical Alloying

References:

1. M.-H. Tsai, J.-W. Yeh, High-entropy alloys: A critical review, Materials Research Letters. 2 (3) (2014) 107–123, https://doi.org/10.1080/21663831.2014.912690.
2. P. Kumari, A.K. Gupta, R.K. Mishra, M.S. Ahmad, R.R. Shahi, A Comprehensive Review: recent progress on magnetic high entropy alloys and oxides, J. Magn. Magn. Mater. 554 (2022) 169142. https://doi.org/10.1016/j.jmmm.2022.169142.

Study of the Structural, Surface Morphology, and Magnetic Properties of Europium-doped $SrFeO_3$ Nanomaterials

Dipak Nath,[1, 2*], A. Robert Xavier [3]

[1]*Department of Physics, St. Joseph University, Chumoukedima, 797103, Nagaland, India.*
[2]*Department of Physics, Kohima Science College Jotsoma, Kohima, 797002,Nagaland, India*
[3]*Department of Physics, St. Joseph University,Chumoukedima,797103, Nagaland, India*

[*]Corresponding Author: dipaknath03081976@gmail.com

Abstract

This research centers on enhancing the magnetic properties of Eu-doped $SrFeO_3$ nanomaterials, synthesized successfully using the solution combustion method. The study explores doping concentrations of x = 0.0, 0.5, and 1.0 and their effects on the structural, morphological, and magnetic characteristics. Techniques such as X-ray diffraction (XRD), Field Emission Scanning Electron Microscopy (FESEM), and a SQUID magnetometer were employed. XRD analysis shows a reduction in particle size as the Eu dopant concentration increases, while FESEM images reveal uniformly formed nanoparticles with notable agglomeration. Magnetic properties were investigated through temperature and field-dependent magnetization measurements. The field dependence of magnetization at both 5K and 300K indicates ferromagnetic behavior across all samples, with the higher Eu doping concentrations resulting in enhanced magnetic moments. These findings suggest that Eu-doped $SrFeO_3$ nanomaterials hold great promise for applications in spintronics, sensors, and microwave-absorbing devices.

Keywords: $SrFeO_3$; Eu; Solution Combustion; SQUID; Ferromagnetic.

References:

[1] Kumar S, Kumar M and Singh A , Synthesis and characterization of iron oxide nanoparticles (FeO_3, Fe_3O_4): a brief review, Contemp. Phys. 62 (2021) 144–6

[2] Tummino M L, Laurenti E, Deganello F, Bianco Prevot A and Magnacca G, Revisiting the catalytic activity of a doped $SrFeO_3$ for water pollutants removal: effect of light and temperature *Appl. Catal. B* 207 (2017) 174–81

[3] Sindhu T, Ravichandran A T, Robert Xavier A and Kumaresavanji M , Structural, surface morphological and magnetic properties of Gd-doped $BiFeO_3$ nanomaterials synthesised by EA chelated solution combustion method *Appl. Phys. A* **129 (2023)** 685

[4] Zhi L, Iitaka T and Tohyama, Pressure-induced ferromagnetism in cubic perovskite $SrFeO_3$ and $BaFeO_3$ *Phys. Rev. B* **86** (2012) 094422

Topic Code: A1

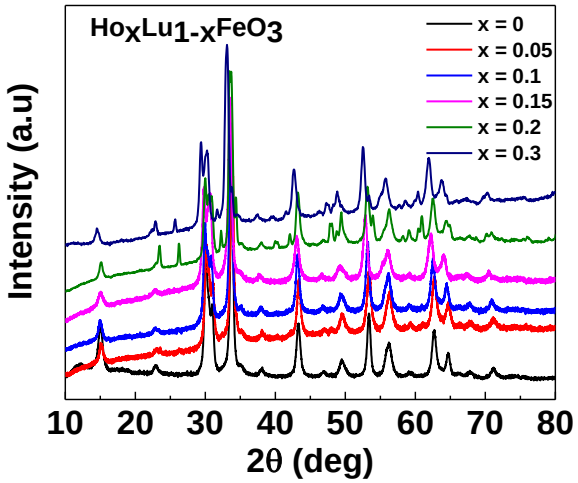
Structural stability and Magnetic properties in hexagonal $Lu_{1-x}Ho_xFeO_3$ (x = 0 - 0.3)

Pittala Suresh[1,2,*], Poojitha K U[2] and P. S. Anil Kumar[2]

[1]*Department of Physics, School of Engineering, Dayananda Sagar University, Harohalli, Bangalore, Karnataka, 562 112, India*
[2]*Department of Physics, Indian Institute of Science, Bangalore 560012, Karnataka, India*
*Corresponding Author: spittala.phy@gmail.com

Abstract

The polycrystalline samples of $Lu_{1-x}Ho_xFeO_3$ (LHFO, x = 0, 0.05, 0.1, 0.15, 0.2, 0.3 and 0.4) samples are prepared using sol-gel method. The effect of Ho substitution on structural and magnetic properties are investigated and compared with pure LFO. X-Ray diffraction results show that all the samples are in hexagonal structure till 10% of Ho doping. However, the orthorhombic phase is seen as an impurity in the hexagonal phase for the higher Ho doping levels. The unit cell parameters increase with the increase of Ho^{3+} doping concentration. Magnetic measurements for LHFO sample show a weak ferromagnetic-like behaviour at room temperature along with the antiferromagnetic component as the Ho content increases. Hence, the paramagnetic LFO transformed to the weak ferromagnetic at room temperature upon Ho doping.



Keywords: Multiferroics, Hexagonal, Phase stability, Magnetism, Ferroelectrics, Oxides

References:

[1]. Pittala Suresh, K. Vijaya Laxmi, A. K. Bera, S. M. Yusuf, Bheema Lingam Chittari, Jeil Jung, and P. S. Anil Kumar, **Phys. Rev. B** 97, 184419 (2018).
[2]. Pittala Suresh, K. Vijaya Laxmi, P.S. Anil Kumar, **Journal of Magnetism and Magnetic Materials**, 448, 117 (2018).

Topic Code: B

An optical shutter derived from hydrogen bond liquid crystal

K. Siva Parvathi[1], M L N Madhu Mohan[1*]

[1,2] *Physics Department, School of ASAH, Vignan Foundation for Science Technology and Research, Vadlamudi, Andhra Pradesh – 522213, India*

Abstract

A novel homologous series of thermotropic hydrogen bond liquid crystals (HBLC) are designed, synthesised and characterised for specific application of thermal optical shuttering. Hydrogen bond liquid crystal comprises of Chloro per benzoic acid abbreviated as ClPBAO and alkyloxy benzoic acid abbreviated as nBAO, where the hydrogen bond is formed between proton donor and electron acceptor moieties belonging to ClPBAO and nBAO resectively. The homologous series comprises of seven homologous in which the alkyloxy carbon varied from pentyloxy to dodecyloxy and are abbreviated as ClPBAO + 5BAO, ClPBAO + 6BAO, ClPBAO +7BAO, ClPBAO +8BAO, ClPBAO +9BAO, ClPBAO +10BAO, ClPBAO +11BAO, ClPBAO +12BAO. In all the above mentioned homologous nematic and smectic G phases are observed. The phase transition temperatures and corresponding enthalpy values are experimentally calculated from DSC thermal profiles. The formation of hydrogen bond is evinced by FTIR studies. An interesting observation is the thermal optical shuttering action derived from all the seven homologous in nematic phase thermal range. The liquid crystal material referred above is filled in one of the 10 micron spacer Liquid Crystal (LC) cell and it is observed that at room temperature the LC cell inhibits transmission of visible light. This state is referred as Off state when a predetermined thermal energy in the form of temperature is applied LC cell becomes transparent and allows the light to pass through it and this state is referred On state. This process is reversible and is observed in the entire thermal span of nematic phase of all the homologues. After many thermal cycles the chemical stability of compound is found to be good. This HBLC homologues are good candidates for optical shuttering action which can be used in digital camera any other electronic device.

Keywords: Hydrogen bond liquid crystal; Optical shutter; ClPBAO ; nBAO ; DSC

References:

[1]. T. Kato, JMJ Frechet, Hydrogen bonded liquid crusyals built from hydrogen bonding donars and acceptors infrared study on the stability of the hydrogen bond between carboxylic acids and pyridyl moieties. Liq. Cryst. 33 (2006) 1429 – 1437.

[2]. Pongali Satya Prabu N, MLN Madhu Mohan, Systematic studies on eight homologous series of supra molecular hydrogen bonded liquid crystal. Phas. Transit. 86 (2013) 339 – 360.

[3]. Pongali Satya Prabu N, MLN Madhu Mohan, Vijayakumar VN, Thermal and dilectric sudies of self assembly systems formed by hydro quinone and alkyloxy benzoic acids. Physica B 406 (2011) 1106 – 1113.

"Innovative Synthesis of Fe_3O_4 Nanoparticles-Loaded Activated Charcoal for Advanced Industrial Wastewater Treatment"

Komal, Verma[1], Vijayanand, Moholkar[1*]

[1] *Department of Chemical Engineering, Indian Institute of Technology Guwahati Guwahati – 781 039, Assam, India*

* Email: vmoholkar@iitg.ac.in

Abstract

This paper presents the design and synthesis of Fe_3O_4-decorated activated charcoal (Fe_3O_4@AC) nanocomposites for the mineralization of industrial wastewater. The Fe_3O_4@AC nanocomposites, synthesized through a co-precipitation method, exhibited a high surface area (538.88 m^2/g) and excellent adsorption capacity (294.31 mg/g). Central composite statistical design was employed to optimize the wastewater treatment process, identifying optimal conditions at pH = 4.2, H_2O_2 concentration = 0.71 M, and an adsorbent dose of 0.34 g/L. Under these conditions, significant reductions in COD (94.75%) and TOC (89%) were achieved. The synthesis of Fe_3O_4 nanoparticles was critical, as the leaching of Fe^{2+}/Fe^{3+} ions from the Fe_3O_4 facilitated surface Fenton reactions on the activated charcoal, enhancing pollutant degradation. The Fe_3O_4@AC nanocomposites also demonstrated excellent recovery (> 90 wt%) and maintained high performance (> 90% COD removal) over five successive treatment cycles. LC-MS analysis revealed that over 50% of significant contaminants, including herbicides and pesticides, were effectively degraded. Toxicity analysis via seed germination tests indicated a 60% reduction in toxicity post-treatment, confirming the environmental impact and reusability of the synthesized Fe_3O_4@AC nanocomposites for sustainable wastewater treatment.

Keywords: Fe_3O_4@AC nanocomposite; RSM; COD; Kinetics; LC-MS; Toxicity

References:

[1]. Kanafin, Y. N.; Makhatova, A.; Meiramkulova, K.; Poulopoulos, S. G. Treatment of a Poultry Slaughterhouse Wastewater Using Advanced Oxidation Processes. J. Water Process Eng. 2022, 47, 102694. https://doi.org/10.1016/j.jwpe.2022.102694.

[2]. Korpe, S.; Bethi, B.; Sonawane, S. H.; Jayakumar, K. V. Tannery Wastewater Treatment by Cavitation Combined with Advanced Oxidation Process (AOP). Ultrason.Sonochem.2019, 59, 104723. https://doi.org/10.1016/j.ultsonch.2019.104723.

[3]. Kausley, S. B.; Desai, K. S.; Shrivastava, S.; Shah, P. R.; Patil, B. R.; Pandit, A. B. Mineralization of Alkyd Resin Wastewater: Feasibility of Different Advanced Oxidation Processes. J. Environ. Chem. Eng. 2018, 6 (3), 3690–3701. https://doi.org/10.1016/j.jece.2017.04.001.

Topic Code: B1

Dynamics of Strain-Mediated Magnetic Transverse Domain Walls in Bilayer Heterostructure Under Transverse Magnetic Field

Sumit, Maity[1], Sharad, Dwivedi[1]

[1]*Department of Mathematics, School of Sciences,*
National Institute of Technology Andhra Pradesh, Tadepalligudem-534101, India
*Corresponding Author: sharad@nitandhra.ac.in

Abstract

In this paper, we present a theoretical study on the dynamics of a transverse domain wall within a bilayer multiferroic heterostructure consisting of a thick piezoelectric actuator and a thin magnetostrictive material that belongs to the hexagonal crystal class. The analysis is conducted on the Landau-Lifshitz-Gilbert equation, incorporating the combined effects of axial and transverse magnetic fields, spin-polarized electric currents, magnetoelastic fields, crystal symmetry, and piezo-induced strains. We first derive explicit expressions for key parameters, such as the polar angle, domain wall width, velocity, and displacement, using a trial function based on the Schryer and Walker approach and the small-angle approximation technique. Next, the theoretical findings are illustrated numerically, using realistic physical parameters from existing literature. The results indicate that the transverse magnetic field, crystal symmetry, and piezo-induced strain play crucial roles in the domain wall dynamics in the steady propagating regime. More precisely, the domain wall width increases with the strength of the transverse magnetic field, and the domain wall velocity is significantly enhanced by the transverse magnetic field in field-driven motion, whereas its effect is negligible in current-driven motion. Our results are in qualitative agreement with recent observations.

Keywords: Magnetostriction; Transverse domain wall; Landau-Lifshitz-Gilbert equation; Transverse magnetic field; Crystal symmetry; Spin-transfer torque.

References:

[1]. Consolo, G., Federico, S., Valenti, G.: Magnetostriction in transversely isotropic hexagonal crystals. Phys. Rev. B 101(1), 014405, (2020).

[2]. Lu, J.: Statics and field-driven dynamics of transverse domain walls in biaxial nanowires under uniform transverse magnetic fields. Physical Review B, 93(22), 224406 (2016).

[3]. Dwivedi, S., Consolo, G., Singh, Y.P.: On the statics and dynamics of transverse domain walls in bilayer piezoelectric-magnetostrictive nanostructures. Appl. Math. Modell. 83, 13–29 (2020).

[4]. Mathurin, T., Giordano, S., Dusch, Y., Tiercelin, N., Pernod, P., and Preobrazhensky, V.: Stress-mediated magnetoelectric control of ferromagnetic domain wall position in multiferroic heterostructures. Applied Physics Letters, 108(8) (2016).

Calcium Induced ferromagnetic behavior in $HoCoO_3$ Perovskite

A. Das, A. Radhakrishnan, O. Modak, P. Tiwari, H. Singh, A. Datta and S. Thota*

Department of Physics, Indian Institute of Technology, Guwahati, Assam 781039, India

**Corresponding author, email id:* subhasht@iitg.ac.in

Abstract

The magnetic and magneto-transport properties of Rare-earth (R.E.) perovskite oxides, (R.E.)CoO_3 are strongly interconnected to the electronic configuration of the trivalent Co (d^6) and R.E. ions [1]. In this perovskite structure Co ions resides in the octahedron cage of a sixfold coordinated oxygen. Such trivalent Co ions in the presence of octahedral crystal field exhibit two district ground state spin configurations: the low-spin (LS) state $t_{2g}^6e_g^0$ ($S = 0$) and the high-spin (HS) state $t_{2g}^4e_g^2$ ($S = 2$) [1]. In most of the cases the magnetic behaviour of the paramagnetic trivalent R.E. ions can mask the magnetic properties of the trivalent Co ions. In the present work we report the role of such crystal field and the substitution of Ca on the magnetic and electronic behaviour holmium-cobaltite ($HoCoO_3$) with resulting stoichiometry $Ho_{1-x}Ca_xCoO_3$ (for $x = 0.2$). The robust antiferromagnetic behaviour of $HoCoO_3$ with Néel temperature ($T_N \sim 3$ K) has been fragmented by the dilution of nonmagnetic divalent 20 at% Ca ions at Ho sites leading to a ferromagnetic state with Curie temperature $T_C \sim 2.77$ K (Fig 1*a*,b). The imbalance in the charge Ho^{3+} and Ca^{2+} causes the fluctuation in the electronic state of Co leading to complicated magnetic structure of this interesting perovskite.

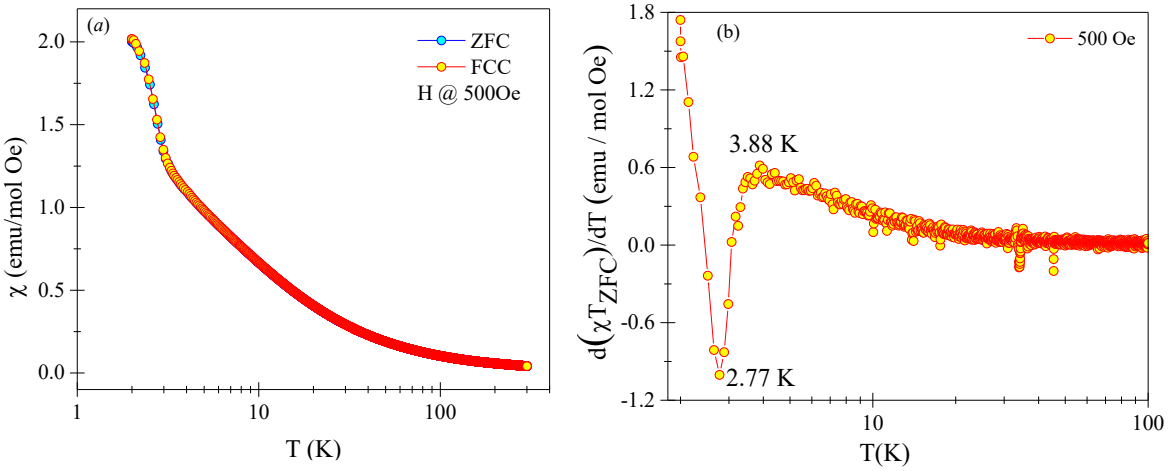


Figure 1. (*a*) Temperature dependence of dc-magnetic susceptibility χ(T) recorded under both zero-field-cooled (ZFC) and field-cooled (FC) conditions at H = 500 Oe. The differential magnetic susceptibility (d(χT)/dT vs T) plots for $Ho_{0.8}Ca_{0.2}CoO_3$ are shown in (b).

Keywords: Antiferromagnetism, Crystal field configuration, High Spin and Low Spin states, Néel temperature.

References:

[1] Tiwari *et al. J. Phys.: Condens. Matter* **35** 375402 (2023)

Dynamics of Reentrant Spin-Glass in Mixed Spinel $Mn_{1-x}Ti_xCo_{2-y}Fe_yO_4$

Arpita Deb Singha[1], P. Pramanik[1,2], D. C. Joshi[1,2], T. Sarkar[2] and S. Thota[1*]
[1]*Department of Physics, Indian Institute of Technology Guwahati, Assam 781039, India*
[2]*Department of Materials Science and Engineering, Uppsala University, SE-751 21 Uppsala, Sweden*

**Corresponding author, Email id:* subhasht@iitg.ac.in

Among the family of spinel oxides (AB_2O_4), $MnCo_2O_4$ (MCO) based composites has garnered significant attention due to their wide range of industrial applications ranging from fuel-cells/batteries to sensors [1,2]. Tuning the physical properties of MCO by means of substitution of magnetic/nonmagnetic elements is a well-established approach for studying strongly correlated phenomena at atomic level. In this context both nanostructures and bulk grains sized $Mn_{1-x}Ti_xCo_2O_4$ system has attracted immense attention because of their intriguing magnetic phenomena such as exchange bias effect below the ferrimagnetic Néel temperature (T_{FN}) [2]. In the present work we present the evidence for short-range spin correlations and reentrant spin-glass dynamics of same series of spinel except Fe^{3+} substitution at the octahedral sites of the Co leading to the configuration $Mn_{0.8}Ti_{0.2}Co_{1.6}Fe_{0.4}O_4$. The dispersive nature of frequency dependence of ac susceptibility χ_{ac} with temperature (Fig. 1 *a,b*) clearly indicates the spin glass characteristics and long range T_{FN} ordering across the cusp-II and I, respectively (Fig. 1 *a,b*). The magnitude of Mydosh parameter ($\Omega \sim 0.134$), and the spin relaxation time $\tau_0 = 1.45\times10^{-4}$ s, freezing temperature $T_F = 109.31$ K, critical exponent $z\nu = (6.01 \pm 0.15)$, activation energy $E_a/k_B = 508.7$ K, and interparticle interaction strength $T_0 = 95.1$ K have been extracted from two empirical scaling-laws: (*i*) Vogel-Fulcher law and (*ii*) Power law. These results reveal cluster spin-glass like character is predominant below the T_F.

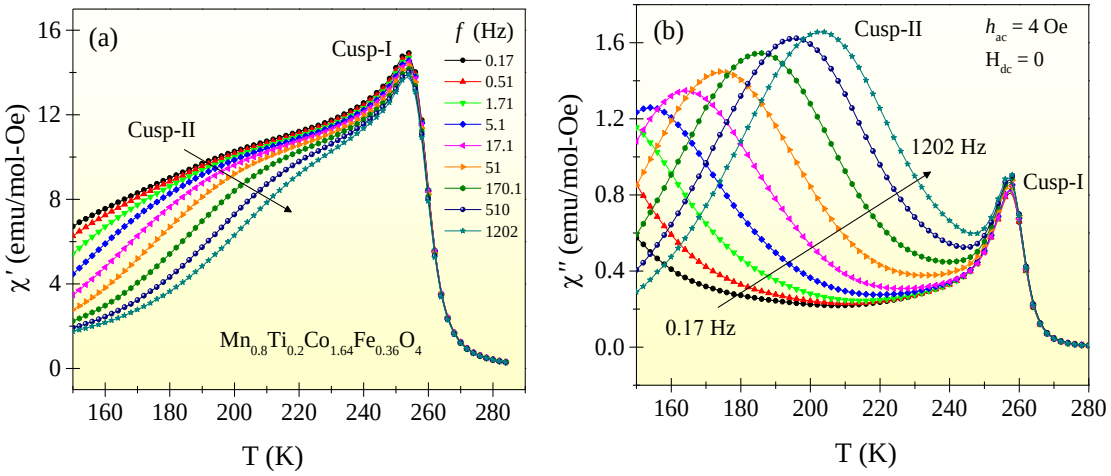


FIG. 1. (a,b) The in-phase and out-of-phase ac magnetic susceptibilities, $\chi'(T)$ and $\chi''(T)$ of $Mn_{0.8}Ti_{0.2}Co_{1.6}Fe_{0.4}O_4$ measured (*f*) between the frequencies $f = 0.17$ and 1202 Hz.

Keywords: Cluster spin-glass; Mixed spinel; Ferrimagnetism.

References: [1] Chatterjee *et al*., *Phys. Rev. Mater.* **3** (2019) 104403.

[2] Pramanik *et al*., J. Phys. Condens. Matter. **32** (2020) 245801.

Detecting Nature of Magnetic Phase Transitions in Ba Doped $La_{0.67}Ca_{0.33}MnO_3$ with Magnetocaloric Effect as a Tool

J. Vishnubharati[1], Abhishek Kumar Singh[1], V. Suresh Kuamr[1*], C. Krishnamoorthi [2]

[1] *School of Advanced Sciences, Vellore Institute of Technology, Vellore 632014, Tamil Nadu, India.*

[2] *Center for Nanotechnology Research, Vellore Institute of Technology, Vellore 632014, Tamil Nadu, India.*

*V. Suresh Kumar; Email: v.sureshkumar@vit.ac.in; Phone: 9945704529

Abstract

In this work, we have investigated the nature of paramagnetic-ferromagnetic (PM-FM) phase transition and attempted to determine the Curie temperature as Ba is doped at Ca site in $La_{0.67}Ca_{0.33}MnO_3$ and further analyzed the results using magnetocaloric effect as tool. It is observed that the compound exhibits a crossover from first-order to second-order PM-FM transition with Ba doping and based on the correlation between magnetic field and magnetocaloric effect, the correct value of Curie temperatures are determined in this series of samples. The results are analyzed in the light of modified Arrott plot and the exponent 'n' from field dependent change in magnetic entropy (ΔS_M).

Key words: Magnetic phase transitions, magnetocaloric effect, manganites

References:

1. S. N. Kaul, J. Magn. Magn. Mater. 53 5-53 (1985). https://doi.org/10.1016/0304-8853(85)90128-3.
2. V. Franco, J.S. Blazquez, J.J. Ipus, J.Y. Law, L.M. Moreno-Ramirez, A. Conde, Prog. Mater. Sci. 93 112–232 (2018). https://doi.org/10.1016/j.pmatsci.2017.10.005.

Topic Code: A5

A Comparative Study on Arc-melted and Solid-State Synthesized Mn_2FeSi Heusler Alloy

R Jayashire[1], M Inchara[2], G Karthik[1], M Manivel Raja[3], K Ravichandran[1*]

[1]*Department of Nuclear Physics, University of Madras, Guindy Campus, Chennai – 600 025, Tamil Nadu, India.*
[2]*Department of Physics, VIT-AP University, Amaravati – 522237, Andhra Pradesh, India.*
[3]*Defence Metallurgical Research Laboratory, Hyderabad – 500 058, Telangana, India.*

**Corresponding author - ravi21068@unom.ac.in*

Abstract

An analysis has been carried on the differences between solid-state and vacuum arc melting methods that were employed to produce the ternary intermetallic Mn_2FeSi Heusler alloy. The samples were annealed for 120 h at 773 K and were characterized for their structural, thermal, microstructural and magnetic studies. Mn_2FeSi Heusler alloy shows two-phase behaviour with secondary phase of Fe_5Si_3 and Mn_5Si_3 respectively. On the basis of X-ray diffraction data, it was unable to identify whether the Mn_2FeSi alloy had the inverse-Heusler (XA) structure or the full Heusler ($L2_1$) structure. Microstructural analysis of the arc melted sample confirmed the presence of both matrix and precipitate phases and the solid-state sample's surface morphology is seen to be spherical in shape. Thermal studies reveal a good thermal stability of the alloy from room temperature to 1173 K with an exothermic peak indicating the crystallization temperature of the alloy. Magnetic measurements of arc melted alloy revealed the antiferromagnetic nature with a Neel temperature around 69.90 K and solid-state samples demonstrated a ferromagnetic nature of the alloy with a curie temperature of approximately 752 K, which made them a desirable material for use in spintronics.

Keywords: Half-metallic; Heusler alloy; Intermetallic; Ferromagnetic; Antiferromagnetic.

References:

1. Životský, O.; Skotnicová, K.; Čegan, T.; Juřica, J.; Gembalová, L.; Zažímal, F.; Szurman, I. *Materials* 2022, *15*, 697.
2. Zivotsky, Ondrej, et al. *SSRN 4003189*.
3. Anil Aryal, Said Bakkar, Hassana Samassekou, SudipPandey, Igor Dubenko, ShaneStadler, NaushadAli, DipanjanMazumdar, Journal of Alloys and Compounds, Volume 823, 2020, 153770.

Emergence of Field-Induced Metamagnetic Transitions in $(La)_A$ and $(Mn)_B$ cosubstituted $NdCoO_3$ Perovskite

Priyanka Tiwari, Soham A Atkar, Priti Sharma and Subhash Thota*

Department of Physics, Indian Institute of Technology, Guwahati, Assam 781039, India

**Corresponding author, email id:* subhasht@iitg.ac.in

Abstract

Compared to manganites, cobalt based perovskites (such as $LaCoO_3$) exhibit intriguing electronic structure leading to intermediate spin state (S=1;$t_{2g}^5 e_g^1$) along with high spin state (S=1;$t_{2g}^4 e_g^2$) and low spin state (S=0;$t_{2g}^6 e_g^0$) [1]. The electronic state of Co depends on the robust competition between the crystal-field splitting (Δ_{cf}) and the Hund's intra-atomic exchange interactions (J_{ex}) which is very sensitive to the variation in the Co–O bond length which be easily tunable with the stoichiometry and site specific substitution at R and/or Co sites [1,2]. Here we report a crystal structure transformation from monoclinic (*I2/a*) to orthorhombic (*Pbnm*) in Nd and Mn cosubstituted $LaCoO_3$ at A and B-sites, respectively leading to the stoichiometry $La_{0.5}Nd_{0.5}Co_{0.5}Mn_{0.5}O_3$ (LNCMO). The temperature dependence of magnetization M(T) reveals that with the La/Co cosubstitution leads to enhanced ferromagnetic Curie temperature, T_C from 84 K to 184 K which correlates with the decrease of the JT distortion. Furthermore, LNCMO displays field induced transition (Fig. 1), large coercivity and weak M-H loop asymmetry effect including semi spin glass behaviour due to the intermediate spin state.

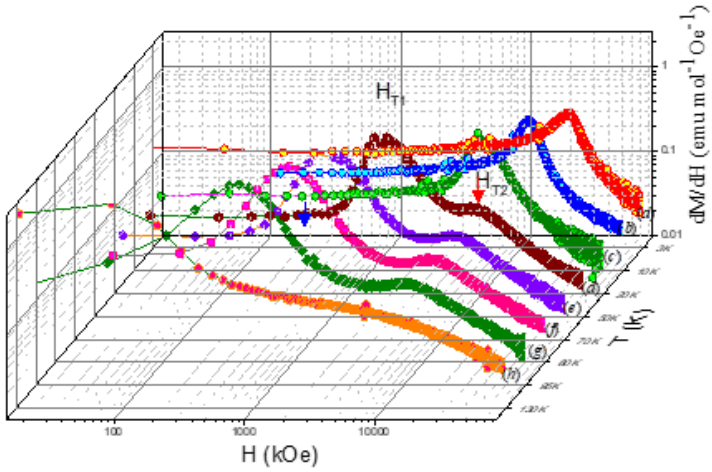


Figure 1. Differential magnetization isotherms (dM/dH vs H) of LNCMO measured at various temperature from 3 K to 80 K. Arrows across cusps indicate field induced transitions (H_{T1} and H_{T2}).

Keywords: Intermediate Spin state transition, Crystal Phase Transition, Field Induced Transition.

References:

[1] Tiwari *et al. J. Phys.: Condens. Matter* **35** 375402 (2023)

[2] Guillou *et al. Phys. Rev. B* **87** 115114 (2013).

Topic Code: C

Optimized Design of Medium-Scale HTS Coil for Power Stability Enhancement Using Multi-Objective Exact Enumeration

Garkki B[1] and Revathi S[2]*

[1]*Research scholar, Department of Electrical and Electronics Engineering*
[2]*Assistant professor, Department of Electrical and Electronics Engineering*

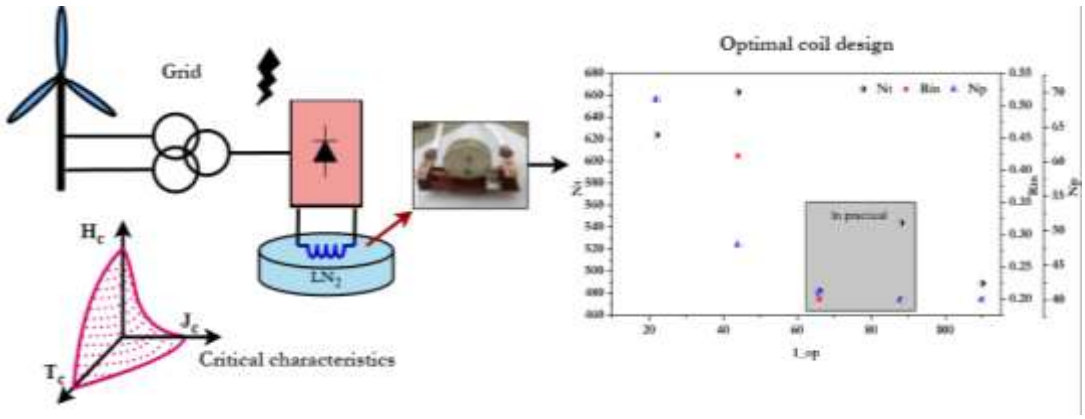
[12] *Department of Electrical and Electronics Engineering, National Institute of Technology Puducherry, Karaikal, India, 60909.*
*Corresponding Author: revathi.s@nitpy.ac.in

Abstract

High-temperature superconducting (HTS) coils store energy in an electromagnetic field at critical temperature and can be integrated with renewable energy sources to enhance power stability during disturbances. This study proposes the optimal design of a 2.5 MJ medium-scale yttrium barium copper oxide (YBCO)-based HTS coil using a multi-objective exact enumeration method. In practical operation, the time-varying current during power compensation generates AC losses, which impact the performance of the HTS coil. To address these challenges, this study carefully considers the influence of various physical, mechanical, and economic factors in the design process. The primary objectives include maximizing stored energy while minimizing AC losses, coil weight, and overall cost, in order to achieve an optimal 2.5 MJ coil design. Furthermore, critical parameters related to different operating current conditions are analysed to refine the design. The analytical results are validated against finite element simulations to ensure the accuracy and robustness of the proposed design.

Keywords: AC losses; exact enumeration method; high-temperature superconducting (HTS) coil; yttrium barium copper oxide (YBCO).

Graphical abstract



References:

[1]. Raut, Pranoti R., Himanshu J. Bahirat, and M. D. Atrey. "Analytical approach for optimal HTS solenoid design." *IEEE Transactions on Applied Superconductivity* 31.2 (2020): 1-9.

Topic Code: B

Magnetic and Magnetocaloric Properties of Bulk and Nanostructured MnP: A Dimensionality Study

T. Prabhakaran,[1,2*] Ramesh Babu K,[2] and F. Béron[1]

[1]*Materials and Low temperature laboratory (LMBT), Institute of Physics Gleb Wataghin (IFGW) University of Campinas (UNICAMP), Campinas, São Paulo, Brazil*
[2]*Department of Physics, School of Advanced Sciences, VIT-AP University, Amaravati, Andhra Pradesh, India – 522237*

*Email: prabhakaran.thandapani@vitap.ac.in

Abstract

This work explores the magnetocaloric effect in bulk MnP crystals and MnP nanostructures for potential refrigeration applications. The study focuses on the impact of dimensionality on the magnetic properties and entropy change of MnP, synthesized via the metallic flux nanonucleation method (MFNN). We investigate the influence of dimensionality on the magnetic properties of MnP for cooling applications. Both bulk needle-like crystals and one-dimensional MnP nanowires were grown simultaneously using this method. We report on the structural characteristics, magnetic properties, and magnetic entropy change of the MnP phase. Both the bulk crystals and nanostructures exhibit a second-order phase transition near room temperature, transitioning from a ferromagnetic to a screw phase at lower temperatures. At 310 K and under a magnetic field of 40 kOe, the magnetic entropy change is –2.94 J/kg/K for the bulk crystals and –0.023 J/kg/K for the nanostructures. The reduced magnetocaloric effect observed in the nanostructures, compared to the bulk crystals, is attributed to the dimensionality effect, which shifts the magnetic transition to lower temperatures.

Keywords: Refrigeration; Second order Phase Transition; Dimensionality effect

References

[1]. E. Garnett, L. Mai, and P. Yang, Chem. Rev. **119**, 8955 (2019).

[2]. K.R. Pirota, K.O. Moura, A.S.E. da Cruz, R.B. Campanelli, P.J.G. Pagliuso, and F. Béron, in *Magn. Nano- Microwires (Second Ed.*, edited by M. Vázquez, Second Edi (Woodhead Publishing, 2020), pp. 61–84.

Electronic Structure and Magnetic Properties of S = 1/2 Alternating Spin Chain System $KCuGa(PO_4)_2$

Vaibhav Kumar, Singh,[1]* Shovan, Gayen,[2] Rama Chandra, Moharana,[1] Tanmoy, Chakrabarty,[3] Swarup Kumar, Panda,[2] Sumanta, chattopadhyay[4]* and B., Koteswararao[1]

[1] *Department of Physics, Indian Institute of Technology Tirupati, Tirupati 517506, India*

[2]*Department of Physics, Bennett University, Greater Noida, Uttar Pradesh 201310, India*

[3]*Division of Sciences, Krea University, Sri City, Andhra Pradesh 517646, India*

[4]*UGC-DAE Consortium for Scientific Research, Mumbai Centre, India*

* Corresponding authors: Ph20d504@iittp.ac.in, ch.sumanta@gmail.com

Abstract

The correlation between low dimensionality and spin interactions can foster the emergence of unique and exotic states within quantum magnets. In this study, we explore the structural, magnetic, and heat capacity properties, along with density functional theory + Hubbard U (DFT + U) electronic structure calculations on the Cu-based compound $KCuGa(PO_4)_2$, which has S = ½ alternating spin chains with J_1 and J_2 couplings. The nearest-neighbor (NN) coupling J_1 forms spin dimers, and the second-NN coupling J_2 constitutes spin chains. The interactions between Cu^{2+} (S = 1/2) ions are predominantly antiferromagnetic (AFM) in nature, as evidenced by the Curie-Weiss temperature $\theta_{CW} \approx -8$ K. The magnetic data analysis based on alternating chain simulations gives out the spin gap of 10 K with the ratio of exchange interaction strengths (J_2/J_1) = 0.40. Theoretical electronic structure calculations also estimate the relative strength of exchange couplings through the total energy method and by evaluating hopping integrals. The ratio of exchange couplings derived from DFT calculations aligns well with the values obtained from our experimental findings.

Keywords: Alternating spin chain; spin gapped ground state; DFT electronic structure calculations.

References:

[1]. D. C. Johnston, R. K. Kremer, M. Troyer, X. Wang, A. Klümper, S. L. Bud'ko, A. F. Panchula, P. C. Canfield. Thermodynamics of spin S = 1/2 antiferromagnetic uniform and alternating-exchange Heisenberg chains. Phys. Rev. B 61 (2000) 9558–9606.

[2]. X. H. Chen, R. Z. Guo, Y. X. Huang, Y. Pan, J. X. Mi. Crystal structure and magnetic properties of the magnetically isolated zigzag chain in $KGaCu(PO_4)_2$. Dalton Trans. 50 (2021) 7835–7842.

$HYbO_2$: A J_{eff} = ½ Spatially Anisotropic Triangular Lattice

Vikas Kumar, Sahu,[1] M. P., Saravanan,[2] Rama Chandra, Moharana,[1] Sayantika, Bhowal,[3] Arumugum, Thamizhavel,[4] B., Koteswararao[1*]

[1]*Department of Physics, Indian Institute of Technology Tirupati, Tirupati 517 619, India.*
[2]*UGC-DAE Consortium for Scientific Research, University Campus, Khandwa Road, Indore 452001, India.*
[3]*Department of Physics, Indian Institute of Technology Bombay, Mumbai 400076, India*
[4]*Department of Condensed Matter Physics and Materials Science, Tata Institute of Fundamental Research, Homi Bhabha Road, Colaba, Mumbai 400005, India.*

*Corresponding Author: koteswararao@iittp.ac.in

Abstract

Highly Frustrated Magnets can exhibit unusual quantum ground states, such as the quantum spin liquid state (QSL) [1,2]. The two-dimensional (2D) antiferromagnetic triangular lattice is one of the simplest models to explore a variety of QSL states [3]. A family of compounds $AYbX_2$ (A = Na, K, and X= O, S, Se) hold the 2D isotropic triangular lattices and exhibit the quantum spin liquid ground state with gapless excitations stemming from the spinon Fermi surface [4]. The compound $HYbO_2$ has a chemical formula similar to the $AYbX_2$ family but with an anisotropic 2D triangular lattice. We have successfully synthesized $HYbO_2$ samples using a hydrothermal synthesis technique and confirmed the single phase using powder X-ray diffraction measurements. Magnetic susceptibility confirms the J_{eff} =1/2 state at low temperatures with AFM interactions with $\theta_{CW} \sim$ - 3 K. The system exhibits magnetic long-range order at 1.18 K, possibly due to the anisotropic triangular lattice's comparable inter-layer separation (dominant 3D interactions).

Keywords: Triangular lattice; Gerometerical frustration; Phase transition; Crystal electric field

References

[1] L. Balents, "Spin liquids in frustrated magnets," Nature **464**, 199–208 (2010).
[2] Y. Zhou, K. Kanoda, and T.-K. Ng, "Quantum spin liquid states," Rev. Mod. Phys. **89**, 025003 (2017).
[3] K. Yang, L. K. Warman, and S. M. Girvin, "Possible spin-liquid states on the triangular and kagomé lattices," Phys. Rev. Lett. **70**, 2641 (1993).
[4] L. Ding, P. Manuel, S. Bachus, F. Grußler, P. Gegenwart, J. Singleton, R. D. Johnson, H. C. Walker, D. T. Adroja, A. D. Hillier, and A. A. Tsirlin, "Gapless spin-liquid state in the structurally disorder-free triangular antiferromagnet $NaYbO_2$," Phys. Rev. B **100**, 144432 (2019).

Topic Code: A1

Observation of Inhomogeneous Magnetic Behaviour and Griffith-Like Phase In $La_{2-X}sr_xnimno_6$ (X = 0.1, 0.25, 0.4, 0.5)

Debasmita Bala*, Abhijit Nayak, Athira P, Krishnamurthy Jyothinagaram

Department of Physics, School of Sciences, National Institute of Technology, Andhra Pradesh-534101, India.

*Corresponding Author: baladebasmita@gmail.com

Abstract

Temperature and magnetic field dependent magnetic behaviour of $La_{2-x}Sr_xNiMnO_6$ (LSNMO) (x = 0.1, 0.25, 0.4 and 0.5) polycrystalline samples prepared by the sol-gel method were investigated. The hole-carrier doping changes the crystal structure of parent compound from monoclinic to orthorhombic phase and enhances the magnetic disorder with increase Sr substitution [1,2]. The samples exhibit a second-order ferromagnetic transition at (T_C) ~ 263 K for Sr = 0.1 which increases to ~270 K for higher Sr. However, the spontaneous magnetization decreases with higher doping of Sr content. The inhomogeneous magnetic state of LSNMO samples was confirmed by the large thermal hysteresis noticed between field-cool-cooling and field-cool-warming magnetization, as shown in the **Fig. (1)**. Below 150 K, a tiny shoulder like kink was observed in zero-field-cooled magnetic curve signifying the presence of either antiferromagnetic correlations among Ni^{2+}-Ni^{3+} and Mn^{3+}-Mn^{3+} sublattices or magnetic glassy features due to the disorder arises from the competition between FM and AFM correlations. Such a magnetic inhomogeneity increases with Sr doping, confirmed from the Griffith's phase behaviour from the inverse magnetic susceptibility study above T_C. The samples exhibit a conventional magnetocaloric effect near to T_C, which depends on Sr doping. Further, the first-principle calculations had been performed to verify the ground state electronic and magnetic properties and examine the effect of Sr induced disorder on its magnetic behaviour.

Keywords: Ferromagnetism; DFT calculations; Griffith phase; Magnetocaloric effect.

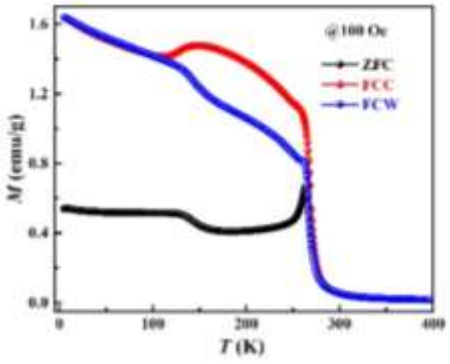


Fig.1: Temperature-dependent Magnetization study for 100 Oe in $La_{1.9}Sr_{0.1}NiMnO_6$ system.

References:

[1] T. Wang, H. Y. Wu, Y. Bin Sun, R. Xing, B. Xv, and J. J. Zhao, *Physical Properties of Sr-Doped Double Perovskite La_2NiMnO_6*, J. Supercond. Nov. Magn. **33**, 727 (2020).

[2] M. Nasira, A. K. Pathakb, J. Kubikb, D. Malaviyab, V. Krupac, A. Dasguptac, and Somaditya Sena, *Enhanced B-Site Cation Ordering and Improved Magnetic Properties: Role of A-Site Bi Substitution in La_2NiMnO_6 Double Perovskites*, J. Alloys. Compd. **896**, 1 (2022).

Topic Code: A1

Soliton Solution for Quantum Ferromagnetic Spin Chain with Impurities

Neja Prinsa N[1], E Parasuraman[1] *

[1] *Department of Physics, School of Advanced Sciences, Vellore Institute of Technology, Chennai, Tamil Nadu – 600127, India*
*nldparasu@gmail.com

Abstract

The presence of impurities in ferromagnetic spin chains plays a critical part in determining soliton excitations and significantly impacts the dynamical behaviour of such systems. In inhomogeneous spin systems, impurities introduce complexities that can drastically modify elementary excitations, making their study essential for a thorough understanding of soliton dynamics. Building on the discrete model of ferromagnetic spin chains in [1-4], this work focuses on the continuum approximation of the quantum ferromagnetic spin chain, which allows for a more detailed analysis of soliton behaviour in the presence of impurities. The governing dynamical equation, derived in the form of the nonlinear Schrödinger equation, is solved using the Jacobi elliptic function expansion method to obtain both periodic and rational wave solutions. The effects of impurities on these solutions are systematically explored by 3D and 2D plots. These results provide deeper insight into how impurities affect soliton excitations and contribute to the understanding of magnetic inhomogeneities in quantum ferromagnetic spin chains.

Keywords: Jacobi elliptic expansion method; quantum ferromagnetic spin chain; continuum approximation; solitons

References:

[1]. B. Tang, G.-L. Li, M. Fu, Modulational instability and localized modes in Heisenberg ferromagnetic chains with single-ion easy-axis anisotropy, J. Magn. Magn. Mater. 426 (2017) 429–434.
[2]. S. Rakhmanova, D.L. Mills, Intrinsic localized spin waves in classical one dimensional spin systems: Studies of their interactions, Phy. Rev B 58 (1998) 17.
[3]. Parasuraman, E. Effect of impurity on modulational instability of localized modes in a discrete quantum ferromagnetic spin chain, J. Magn. Magn. Mater. 539 (2021) 168348.
[4]. R.S. Kamburova, S.K. Varbev, M.T. Primatarowa, Interaction of solitons with impurities in anisotropic ferromagnetic chains, Phy. Lett A 383 (2019) 471–476

NUCLEATION OF SKYRMIONS IN HM (Pd, Rh, or Nb)/Fe BILAYER

Tamali, Mukherjee[1], Banasree, Sadhukhan[2], V Satya Narayana, Murthy[1]

[1]*Deapartment of Physics, Birla Institute of Technology and Science, Pilani, Hyderabad Campus - 500078, India*
[2]*Deapartment of Physics, SRM Institute of Science and Technology, Chennai - 603203, India*

*Corresponding Author: p20220034@hyderabad.bits-pilani.ac.in

Abstract

Skyrmions are small swirling topological defects in ferromagnetic materials that show promising features to be used as a 'bit' of information in future spintronic devices. We use an HM/Fe bilayer (200 x 200 nm^2 and thickness 1 nm) on Ir (111) to study skyrmion formation by applying a magnetic field ranging from 1 T to 15 T. Heavy metals like Palladium (Pd), Rhodium (Rh), and Niobium (Nb) are taken as a top layer on iron (Fe) to see the possibility of getting a skyrmion lattice. For all three systems, the ground relaxed state is a spin spiral. In the case of Pd, we see the spin spiral changing its phase and becoming a state with skyrmions in the ferromagnetic background at the threshold magnetic field of 1.7 T. Whereas, for Rh, the threshold magnetic field value to obtain a skyrmion state is higher compared to Pd, 8 T. In the range of applied magnetic field mentioned above, the two systems Pd/Fe and Rh/Fe change their states gradually from spin spiral to a single-domain ferromagnetic phase via a state of skyrmion lattice stable with a fixed window of magnetic field applied perpendicularly in the +z direction. Even with the applied magnetic field, the Nb/Fe system does not relax to a stable skyrmion state and always stays in the spin spiral phase. Skyrmion formation in all these three systems can be explained by the value of critical Dzyaloshinskii-Moriya interaction (DMI). We perform micromagnetic simulation by employing Mumax3, which solves the magnetization dynamics of the free layer, following the Landau-Lifshitz-Gilbert (LLG) equation.

Keywords: Magnetic skyrmions; Spintronics; Micromagnetic simulation; HM/Fe bilayer.

References:

[1]. Romming, Niklas, et al. "Field-dependent size and shape of single magnetic skyrmions." Physical review letters 114 (2015), 177203.
[2]. Vansteenkiste, Arne, et al. "The design and verification of MuMax3.", AIP advances 4.10 (2014), 107133.

Competing magnetic interactions in the orthorhombic $GdNiAl_3$

S. Nallamuthu[1,2], K Arun[2], Vimaljith A. R., Sergej Ilkovic[3], Ivan Curlik[3], Marian Reiffers[3], R. Nagalakshmi[2*]

[1]*Department of Physics, School of Advanced Sciences, VIT-AP University, Amaravati, 522237, AP, India*

[2]*Department of Physics, National Institute of Technology, Tiruchirappalli 620 0015, India*

[3]*Faculty of Humanities and Natural Sciences, Presov University, Presov, Slovakia*

Abstract

Magnetization and heat capacity measurements of ternary rare earth intermetallic compound $GdNiAl_3$ demonstrate paramagnetic to ferromagnetic transition at Tc=165.5K. In addition, multiple short-range magnetic transitions observed below Tc suggest competing interactions in this compound. As a result, a weak Griffiths phase-type behaviour is observed in the paramagnetic region. The random orientation of Ni rather supports this complex behaviour centered tricapped trigonal prisms with additional Al atoms in the structure. Heat capacity and resistivity data display an interesting peak at 72 K, highly unaffected by magnetic fields up to 90KOe.

Keywords: Magnetization; Heat capacity; Ferromagnetic; Competing interactions; Electrical resistivity.

*Corresponding author: Tel.: 04312503615; e-mail: nagaphys@yahoo.com, nagalakshmi@nitt.edu (R.Nagalakshmi),

Tailoring Ferrimagnetic Insulators for Spintronics via Thermomagnetism

Manoj Aravind, Sankar[1,2*], Navaneeth Kumar, Sankar[3], Prasanna, R[2]

[1]*Materials Science and Engineering, University of California Los Angeles, Los Angeles, CA 90095, United States of America*
[2]*Centre for Antenna and Electronic Materials, Vel Tech Rangarajan Dr Sagunthala R&D Institute of Science and Technology, Chennai, Tamil Nadu 600062, India*
[3]*Department of Mechatronics Engineering, Rajalakshmi Engineering College, Chennai, Tamil Nadu 602105, India*

*Corresponding Author: manoj158aravind@alumni.ucla.edu

Abstract

The growth of spintronics has been propelled by the atomistic limitations in electronics and discovery of novel forms of magnetism. Spintronic materials function by harnessing the directional spin of electrons: Spins get polarized under an external force, manifesting as magnetism. Among various external stimuli, heating has been employed in some studies to induce magnetism in insulators. With these as the basis, the present article sheds a perspective on novel approaches for tailoring insulators into spintronic nanomaterials. Insulators allow for customization into magnetic materials through thermal-gradient modification, consequently varying the spin states. Ferrimagnetism is focused as it can overcome intrinsic challenges of ferromagnetism and antiferromagnetism. Hexagonal boron nitride is chosen as a case study, and different existing ferrimagnetic tuning techniques are discussed. Then, the methodology of thermomagnetism is elaborated from the insights offered by an influential work on yttrium iron garnets. Finally, certain prospective data science algorithms are listed, with the objective of aiding in material selection, parameter optimization, and redundancy elimination.

Keywords: spintronics; thermomagnetism; magnetic Seebeck effect; insulator; resistivity

References:

[1]. Brechet, S. D., Vetro, F. A., Papa, E., Barnes, S. E., & Ansermet, J. P. (2013). Evidence for a Magnetic Seebeck Effect, Phys. Rev. Lett. 111, 087205
[2]. Kim, S.K., Beach, G.S., Lee, K.J., Ono, T., Rasing, T. and Yang, H., 2022. Ferrimagnetic spintronics. *Nature materials*, *21*(1), pp.24-34.
[3]. Papageorgiou, N. (2013), Using heat to make magnets. https://actu.epfl.ch/news/using-heat-to-make-magnets/
[4]. Sankar, M. A. and Ram, P. (2017). Generation of magnetic field from heat in thermomagnet by magnetic Seebeck effect, *International Conference on Microelectronic Devices, Circuits and Systems (ICMDCS)*.

Topic Code: D2

Dynamics of Magnetization Reversal and Enhanced Magnetic properties in FeTaC/SiO_2 Multilayer Thin Films

Camelia, Das[1], Perumal, Alagarsamy [2], Subhankar, Bedanta[3]

[1]*Department of Physics, Faculty of Science and Technology, ICFAI University Tripura, Agartala 799210, Tripura (W), India,*
[2] *Department of Physics, Indian Institute of Technology Guwahati, Guwahati -781039, India,*
[3]*School of Physical Sciences, National Institute of Science Education and Research, Bhubaneswar - 751005, India,*

*Corresponding Author: camellia.iitg@gmail.com, perumal@iitg.ernet.in

Abstract

We report systematic investigation of the effect of number of multilayer and the thickness of spacer layer on the magnetic properties of multilayer [FeTaC (*y* nm)/SiO_2 (*z* = 0-6nm)]$_{n=0-3}$/FeTaC (*y* nm) films fabricated on thermally oxidized Si substrate using magnetron sputtering technique. This study builds upon earlier findings on single-layer $Fe_{80}Ta_8C_{12}$ films [1] and focuses on the magnetization reversal dynamics and enhanced magnetic properties of multilayer films as influenced by the number of spacer layers (*n*), spacer layer thickness (*z*), and temperature (*T*). The introduction of the spacer layers transform the transcritical loop observed in thick FeTaC (> 50 nm) film into rectangular loop enabling single or multistep magnetization reversal and also results in significant reductions in coercivity and saturation fields, while improving the remanent-to-saturation magnetization ratio. Magnetic domain analysis using longitudinal MOKE microscopy exhibits angle-dependent hysteresis loops, revealing the contribution of transverse components in the loops that vary with the strength of interlayer coupling [2]. Additionally, the temperature-dependent hysteresis behavior of multilayer films shows a strong dependence on *n* and *z*, the nature of interlayer coupling, resulting in alterations in magnetic domain structure and switching dynamics. Overall, this work highlights how multilayer structures and interlayer coupling can tune the magnetic properties of FeTaC films, with significant implications for controlling domain dynamics.

Keywords: Magnetic thin films, Transcritical loop; Multilayer; Magnetization reversal; Interlayer coupling

References:

[1]. C. Das, J. Das, T. Vijayabhaskaran, S. Bedanta, A. Talapatra, J.R. Mohanty, A. Perumal, Thickness dependent surface topography, magnetic properties and magnetic domain structure of amorphous FeTaC thin films, J Mater Sci Eng. 7 (2018) 1000455.

[2]. S. Mallik, S. Mattauch, M.K. Dalai, T. Brückel, S. Bedanta, Effect of magnetic fullerene on magnetization reversal created at the Fe/C_{60}interface Scientific Reports 8 (2018) 551.

Synthesis of Pulsed Laser Deposited (La,Pr,Ca)MnO_3 Thin films

Sahana C S[1], Ankur Rastogi[2*]

[1]*Department of Physics, School of Advanced Sciences, Vellore Institute of Technology, Vellore, Tamil Nadu- 632014, India.*
[2]*Centre for Functional Materials, Vellore Institute of Technology, Vellore, Tamil Nadu-632014, India.*
*ankur.rastogi@vit.ac.in

Abstract:

Doped manganites are strongly correlated materials with correlation among charge, orbital, spin, and lattice degrees of freedom.[1] This leads to the correlation between their structural, magnetic, and transport properties, resulting in various interesting phenomena, such as colossal magnetoresistance[2] and phase separation,[3] that can be tuned using strain[4] and external perturbation.[5] In the present work, we synthesized bulk $La_{0.375}Pr_{0.325}Ca_{0.3}MnO_3$ material using the solid-state reaction method and thin films on different substrates using the pulsed laser deposition method. We used $SrTiO_3$ and $LaAlO_3$ substrates, which gave different strains ~ -0.002% and -0.006%, respectively. Our study further establishes the effect of photonic perturbation on the films deposited on $SrTiO_3$.

Keywords: Pulsed Laser Deposition; Thin films; Manganite; Phase separation

References:

[1]. Salamon, M. B., & Jaime, M. (2001). The physics of manganites: Structure and transport. Reviews of Modern Physics, 73(3), 583–628.
[2]. Ramirez, A. P. (1997). Colossal magnetoresistance. Journal of Physics: Condensed Matter, 9(39), 8171–8199.
[3]. Wollan, E. O., & Koehler, W. C. (1955). Neutron Diffraction Study of the Magnetic Properties of the Series of Perovskite-Type Compounds [(1 − x) La, x Ca] Mn O_3. Physical Review, 100(2), 545–563.
[4]. Haghiri-Gosnet, A.-M., & Renard, J.-P. (2003). CMR manganites: Physics, thin films and devices. Journal of Physics D: Applied Physics, 36(8), R127–R150.
[5]. Tokura, Y. (2003). Correlated-Electron Physics in Transition-Metal Oxides. Physics Today, 56(7), 50–55.

Spin disorder state in a site-depleted coupled trillium lattice compound $Pb_{1.5}Fe_2(PO_4)_3$

K, Boya,[1,2] R, Kumar,[3] V. K, Sahu,[1], P. L, Paulose,[3] B., Koteswararao[1*]

[1]*Department of Physics, Indian Institute of Technology Tirupati, Tirupati 517 619, India.*
[2]*Government Polytechnic, Satyavedu, Andhra Pradesh 517 588, India*
[3]*Department of Condensed Matter Physics and Materials Science, Tata Institute of Fundamental Research, Homi Bhabha Road, Colaba, Mumbai 400005, India.*
*Corresponding Author: koteswararao@iittp.ac.in

Abstract

Spin-liquids have emerged as a prominent subject of investigation in the field of magnetism owing to their notable characteristics encompassing long-range entanglement, fractional excitations, and topologically preserved phenomena. The spin-liquid is an exotic ground state of a highly frustrated magnet with no conventional magnetic long-range order (LRO) despite having magnetic solid interactions between the spins [1]. It is often found in S = ½ highly frustrated 2D spin networks [2] but rarely observed in 3D systems [3-4], especially with significant magnetic moments like S = 5/2. Here, we have studied the magnetic behavior of $Pb_{1.5}Fe_2(PO_4)_3$ (PbFPO) through magnetic and heat capacity (C_P) measurements on polycrystalline samples of PbFPO. The compound holds a complicated cubic lattice with S = 5/2 moments formed by two trillium lattices. The magnetic and C_P data reveals the data has no conventional magnetic LRO despite the relatively sizable Curie–Weiss temperature of -70K (antiferromagnetic). The absence of field-dependent behavior in the C_P data up to 110 kOe field indicates that the PbFPO system possesses elevated spin correlations. The magnetic heat capacity data follows the power-law behavior, probably stemming from the system's gapless excitations of a 3D spin-liquid ground state. The spin-liquid feature might be due to the enhanced frustration comes from the competing magnetic couplings between two trillium lattices. The spin liquid state is even robust although 20% site depletion in the PbFPO compound.

Keywords: Spin liquid; Trillium lattice; Geometrical frustration; Competing magnetic interactions.

References

[1] L. Balents, "Spin liquids in frustrated magnets," Nature **464**, 199–208 (2010).
[2] Y. Shimizu, K. Miyagawa, K. Kanoda, M. Maesato, and G. Saito, Phys. Rev. Lett. 91, 107001 (2003).
[3] I. Živković, V. Favre, C. Salazar Mejia, H. O. Jeschke, A. Magrez, B. Dabholkar, V. Noculak, R. S. Freitas, M. Jeong, N. G. Hegde, L. Testa, P. Babkevich, Y. Su, P. Manuel, H. Luetkens, C. Baines, P. J. Baker, J. Wosnitza, O. Zaharko, Y. Iqbal, J. Reuther, H. M. Rønnow, Magnetic field induced quantum spin liquid in the two coupled trillium lattices of $K_2Ni_2(SO_4)_3$, Phys. Rev. Lett. 127 (2021) 157204.
[4] K. Boya, K. Nam, K. Kargeti, A. Jain, R. Kumar, S. Panda, S. Yusuf, P. Paulose, U. Voma, E. Kermarrec, et al., Signatures of spin-liquid state in a 3d frustrated lattice compound $KSrFe_2(PO_4)_3$ with S= 5/2, APL Materials 10 (10) (2022).

Topic Code: D2

Preparation and Characterization of PVDF/$CoFe_2O_4$/g-C_3N_4 nanocomposite Films for electromagnetic shielding applications

R. Nirmal Kumar[1,2], J. Hemalatha[1,*]
[1]*Advanced Materials Lab, Department of Physics, National Institute of Technology-Tiruchirappalli, Tiruchirappalli-620015, Tamilnadu , India.*
[2]*PG & Research Department of Physics, Srimad Andavan Arts and Science College (Autonomous), Tiruchirappalli -620005, Tamilnadu , India.*
*Corresponding Author: *hemalatha@nitt.edu**

Abstract
Magnetic materials play crucial role in shielding electromagnetic waves due to their excellent magneto crystalline anisotropy, permeability and magnetic hysteresis. The present study discusses the fabrication of multifunctional polymer nanocomposite films using polyvinylidene fluoride (PVDF) matrix with cobalt ferrite ($CoFe_2O_4$) and graphitic carbon nitride (g-C_3N_4) fillers and characterization. Crystalline $CoFe_2O_4$ nanoparticles and g-C_3N_4 were prepared and used to fabricate PVDF/$CoFe_2O_4$/g-C_3N_4 composite films. The structural and compositional details of $CoFe_2O_4$ nanoparticles and the films were analyzed, along with the fraction of β-phase PVDF. The morphological, magnetic, and dielectric properties of the films were studied using field emission scanning electron microscopy, vibrating sample magnetometry, and dielectric study, respectively. The observed magnetic hysteresis loop and dielectric loss reveals that the material is suitable for shielding EM wave in microwave frequency range.

Keywords: $CoFe_2O_4$, PVDF, g-C_3N_4, nanocomposite film, shielding,

References:

[1]. Biswas, S., Kar, G. P., & Bose, S. (2015). Microwave absorbers designed from PVDF/SAN blends containing multiwall carbon nanotubes anchored cobalt ferrite via a pyrene derivative. J.Materials Chemistry A, 3(23), 12413-12426.
[2]. Ahmed, I., Khan, A. N., Jan, R., & Gul, I. H. (2022). Structure–properties relationships of graphene and spinel nickel ferrites based poly (vinylidene fluoride) hybrid polymer nanocomposites for improved dielectric and EMI shielding characteristics. Mat. Research Bulletin, 148, 111687.
[3]. Durgaprasad, P., & Hemalatha, J. (2018). Magnetoelectric investigations on poly (vinylidene fluoride)/$CoFe_2O_4$ flexible electrospun membranes. J.Mag & Mag.Mat,448, 94-99.
[4]. Hussain, I., & Yesmin, S.(2023). Enhanced microwave absorption of g-C_3N_4/poly (vinylidene difluoride)/carbon black composites. Materials Chemistry & Physics, 309, 128337.
[5]. Katheria, A., Das, P., Bhagat, A., Nayak, J., Paul, S., & Das, N. C. (2024). Fe_3O_4@ g-C_3N_4 and MWCNT embedded highly flexible polymeric hybrid composite for simultaneous thermal control and suppressing microwave radiation. J.Alloys and Compounds, 988, 174287.

Magnetic and Thermal Modulation of DC-AC Electrical Properties in $Zn_{0.3}Ni_{0.7}Fe_2O_4$ Nanoparticles

Sarit Chakraborty[1*], Tanmoy Majumder[2], Sritama Roy[2]

[1]*Department of Physics, National Institute of Technology Agartala, Tripura, 799046, India*
[2]*School of Electronics Engineering, Vellore Institute of Technology, Chennai-600127*
*Corresponding Author: **sarit91chakraborty@gmail.com**

Abstract

In the quest to identify efficient magnetic nanoparticles for device fabrication, researchers have been keenly investigating the diverse physical properties of these particles. In line with this, we synthesized Zn-doped $NiFe_2O_4$ nanoparticles via a low-temperature pyrophoric reaction process to examine their DC and AC electrical properties under varying magnetic fields and temperatures. Structural analysis and surface morphology of the nanoparticles were assessed using X-ray diffraction (XRD) and field emission scanning electron microscopy (FE-SEM), respectively. Additionally, elemental composition was confirmed through energy-dispersive X-ray (EDX) analysis. Our findings reveal significant changes in DC current and impedance in response to magnetic fields, with a ~330% increase in current and a ~-10.7% change in impedance, likely due to oxygen vacancies at the grain boundaries within the granular structure and charge carrier movement between different crystallographic sites. The presence of oxygen vacancies contributes to high impedance and a dielectric constant of approximately 3000 in the low-frequency region. Moreover, temperature-dependent electrical behavior suggests a metallic-semiconductor phase transition in the nanoparticles. The electrical conductivity mechanism is attributed to the combined effect of grain and grain boundary contributions, with the associated resistance and capacitance showing sensitivity to transition temperature. The observed metallic and semiconductor characteristics are influenced by polaronic hopping of charge carriers. Overall, the responsive electrical properties of these nanoparticles to applied fields and temperature changes highlight their potential for device applications.

Keywords: Grain Boundary, Dielectric Constant, Polaronic Hopping, Pyrophoric Reaction, Oxygen Vacancies, Metallic-Semiconductor Transition.

Reference:

1. S.K. Mandal, Sarit Chakraborty, P. Dey, B. Saha, T.K. Nath, Zn doped $NiFe_2O_4$–Pb $(Zr_{0.58}Ti_{0.42})O_3$ multiferroic nanocomposites: magnetoelectric coupling, dielectric and electrical transport, J. Alloys Compd. 747 (2018) 834-845.

2. S. Chakraborty, S. K. Mandal, Magnetoelectric $Zn_{0.2}Co_{0.8}Fe_2O_4$-$PbZr_{0.58}Ti0.4_2O_3$ nanocomposite for bistable memory and magnetic field sensor applications J. Magn. Magn. Mater. 491 (2019) 165573.

Topic Code: D

Single Step Synthesis and Structural Investigations of Nanocrystalline Magnetic Ferrites MFe_2O_4 (M=Ni, Co and Mn)

T. Shanmugavel[1], *S. Gokul Raj,[2,#] G. Ramesh Kumar[3]

[1]*Department of Physics, Mahendra Engineering College, Namakkal - 637503*
[2]*Department of Physics, Pondicherry University, Kalapet, Puducherry 605014, India*
[3] *Department of Science and Humanities, University College of Engineering Arni- Thatchur- (Anna University, Chennai), 632 326, India*

*Corresponding Author: shanmugavelnano@gmail.com / gokulraj@pondiuni.ac.in

Abstract

The formation of nano crystalline spinel ferrites plays an important role in determining its physical properties in nano and sub nano levels. Nanocrystalline spinel ferrites are MFe_2O_4 where M is usually a divalent metal ion (e.g. metals like Ni, Co, Cu, Zn, Fe, Mn) have shown several applications due to their remarkable electrical and magnetic properties and also in fields of magnetic resonance imaging (MRI) enhancement, magnetic high-density information storage etc. [1-3]

In the present investigation, a single step procedure for the synthesis of spinel type transition metal ferrite nanocrystalline materials has been developed. Our work is mainly oriented to synthesis as a single step one pot synthesis method and to evaluate its structural, topographical and physical properties of spinel ferrite and inverse spinel ferrites containing Co, Ni and Mn prepared by the low temperature route. Nanocrystalline Metal ferrite (MFe_2O_4 - M=Ni, Co and Mn) has been synthesized by sol-gel auto combustion method with citric acid as a chelating agent. Synthesized nanocrystalline ferrite samples were calcined to different temperatures and the samples were tested for its magnetic studies. The magnetisation versus temperature M-T curves were obtained in the temperature range 300- 650 K and the variation of crystallite size with respect to Ms values were discussed. The hysteresis loops show high coercivity (Hc), saturation magnetisation (Ms) and remanence ratio (Mr/Ms) were reported. From the curve, we analyse that fine particles are easier to be thermally activated to overcome the magnetic anisotropy [4,5].

Keywords: One Pot Synthesis; Metal Ferrites; Saturation Magnetization; Thermomagnetic analysis; Spinel Ferrites

References:

[1]. Andris, S & Mezinskis, G, Sol-gel auto-combustion synthesis of spinel-type ferrite nanomaterials, Frontiers of Materials Science, 6, (2012) 128-141.
[2]. Bate, G 1980, 'Ferromagnetic Materials', North-Holland, Amsterdam.
[3]. Cox 1992, 'Transition Metal Oxides: An Introduction to Their Electronic Structure and Properties', Clarendon Press, Oxford, UK.
[4]. Spaldin, N 2003, 'Magnetic Materials: Fundamentals and Device Applications', Cambridge University Press, Cambridge.
[5]. Yu & Yang, 2005, 'Formation of crystalline MnFe2O4 powder by flame-combusting freeze-dried citrate precursors', Journal of Alloys and Compounds, vol. 394, pp. 286-291.

Influence of Microwave Sintering on Erbium Iron Garnet: Structural, Magnetic, and Dielectric Studies

Malar Selvi,M,[1] Deepannita, Chakraborty,[2] Venkateswaran, C[3*]

[1]*Department of Physics with Computer Application, Agurchand Manmull Jain College (Shift-II), Chennai – 600061, India*
[2]*Department of Physics, PSG Institute of Technology and Applied Research, Coimbatore-641062, India.*
[3]*Department of Nuclear Physics, University of Madras, Guindy Campus, Chennai- 600025.*

*Corresponding Author: cvunom@hotmail.com

Abstract

Erbium iron garnet (ErIG), a promising candidate in the class of multiferroic materials, exhibits one of the highest magnetic moments among rare earth garnets. ErIG synthesized through the ball milling technique followed by microwave sintering, is explored for its structural and functional properties. The influence of microwave sintering on the ball-milled ErIG is the focus of this investigation. The single-phase garnet structure is confirmed through Rietveld refinement, yielding an average crystallite size of 32 nm and a high density of approximately 6.8 g/cm³. High-Resolution Scanning Electron Microscopy (HRSEM) reveal a homogenous morphology. The rapid grain growth observed due to the short duration microwave sintering along with the uniform morphology, suggests the dominance of superexchange interactions within the material. These interactions between Er and Fe ions induce antiferromagnetic behaviour in the garnet structure, thereby enhancing its suitability for magnetocaloric applications. The observed Néel temperature of 541 K also supports the potential of ErIG for room-temperature magnetic applications. Mössbauer spectroscopy further elucidate the superexchange interactions, with Fe ions occupying octahedral (29%) and tetrahedral (71%) sites. Dielectric measurements reveal an anomaly at the Néel temperature, supporting the material's magnetoelectric coupling property. Frequency-dependent dielectric studies indicate the presence of surface polarization and a negative dielectric constant. Nyquist plot analysis suggests a semiconductor-to-metallic phase transition around the Néel temperature, corroborated by DC conductivity measurements, with activation energies of -0.55 eV below and 0.61 eV above the Néel temperature.

Keywords: Garnet; Magnetoelectric coupling; Superexchange interaction; DC conductivity

References:

[1]. S. Charmond, C.P. Carry, D. Bouvard, The effect of microwave sintering on the properties of ball-milled ceramics, J. Eur. Ceram. Soc., 30, 1211-1221 (2010).
[2]. D.E. Clark, W.H. Sutton, Microwave processing of materials, Annu. Rev. Mater. Sci., 26, 299-331 (1996).
[3]. M. Oghbaei, O. Mirzaee, Microwave versus conventional sintering: A review of fundamentals, advantages and applications, J. Alloys Compd., 494, 175-189 (2010)

Tuning the Properties of MnAl Alloys for Rare Earth Free Magnet Applications

Sourav, Mandal[1], Harekrushna, Behara[1], Perumal, Alagarsamy[1]
[1]*Indian Institute of Technology Guwahati, Guwahati – 781 039*
*Corresponding Author: souravmandal@iitg.ac.in

Abstract

The ever-growing automobile industry with green transportation and green energy harvesting demand magnets of large quantity at the industrial scale. However, most of the magnets are made of rare-earth-based materials and hence there is a quest for making rare-earth-free magnets. In this study, we report the tuning of properties of MnAl alloys with varying milling time and composition. The high-temperature ε-phase of the MnAl alloy is formed by heat-treating MnAl powder followed by rapid quenching. The hard magnetic τ-phase is then obtained through milling and subsequent heat treatment under vacuum environment. Structural analysis reveals the presence of hard magnetic τ-phase and stable β and γ2-phases. The phase fraction of all the phases can be tuned by changing the milling time and post annealing temperature, and the phase fraction of τ-phase decreases up to 28.68 % from 83.73 % after 10 hours of milling. The sample exhibits ferromagnetic nature with magnetization ranging from 55.85 emu/g to 23.12 emu/g at 16 kOe applied field and a large coercivity of 4.59 kOe is obtained in powders milled for 10 hours and annealed at 500 ℃ and maximum energy product (BH_{max}) of 1.47 MGOe is observed after 7 hours of milling [1,2]. The second-order ferromagnetic to paramagnetic transition (Curie temperature) was observed at 611 K. These results make MnAl alloy a potential candidate for permanent magnet application.

Keywords: Permanent magnet; Ball milling; Nanocrystalline; energy product; Magnetocrystalline anisotropy.

References:

[1] S. Zhao, Y. Wu, C. Zhang, J. Wang, Z. Fu, R. Zhang, and C. Jiang, *Stabilization of τ-Phase in Carbon-Doped MnAl Magnetic Alloys*, J. Alloys Compd. 755, 257 (2018).

[2] J. Y. Law et al., *Study of Phases Evolution in High-Coercive MnAl Powders Obtained through Short Milling Time of Gas-Atomized Particles*, J. Alloys Compd. 712, 373 (2017).

Study of impedance spectroscopic and magnetic properties of $LiMn_2O_4$ and $LiMn_{1.98}(SmFe)_{0.02}O_4$ ceramic materials for energy storage applications

Suresh Kumar, N[1], Sumithra, M[1], Thirmal, C[1*], Ramarao, S. D[2], Satya Narayana Murthy, V[3]

[1]*Battery Technology Lab, Department of Physics,*
VNR Vignana Jyothi Institute of Engineering and Technology,
Bachupally, Hyderabad, Telangana-500 090, India.
[2]*Department of Physics, School of Advanced Sciences, VIT-AP University, Amaravati,*
Andhra Pradesh – 522237, India.
[3]*Department of Physics, BITS Pilani Hyderabad Campus, Medchal District,*
Telangana-500078, India.

*Corresponding Author: thirmal_ch@vnrvjiet.in

Abstract

The nanoparticles of $LiMn_2O_4$ and $LiMn_{1.98}(SmFe)_{0.02}O_4$ were synthesized using chemical solution method. The samples were tested for their structural phase purity using X-ray diffraction and FTIR. The room temperature magnetic properties of the nanoparticles were studied using M-H curves. To study the impedance properties of the samples, the nanoparticles were converted into pellets using hydraulic press followed by sintering at 850 ^oC. The surface morphology of the sintered pellets shown the pore free structure which confirmed the good density of the pellets. The sintered pellets were converted as capacitors by giving silver conducting coating on both sides of the pellets. The frequency dependent impedance measurements and dielectric properties were analysed using the appropriate equivalent electrical circuits and explained their grain and grain boundary contributions to the electrical impedance [1-2]. The detailed study of the ceramics elevated the application potential in the energy storage such as high dense capacitors.

Keywords: Energy storage, Impedance, LiMn2O4, Ceramic

References:

[1]. C. Thirmal, P. Nikhil Mohan, G. Suresh, K.C. James Raju, T. Vishwam, Improved dielectric and AC conductivity properties of P (VDF-TrFE)-Nafion blends for high-temperature flexible capacitor applications, Curr. Appl. Phys. 44 (2022) 63 – 70.

[2]. R. Dhama, C. Nayek, C. Thirmal, P. Murugavel, J. mag. Mag. Mater. 364 (2014), 125-128.

Impact of Chemical Etching on Magneto-Impedance Response of As-Quenched Amorphous Microwires

Somnath Das[1,2], Dev Kumar Mahato[2], Ashis Kumar Panda[1,*]

[1]*AMC Division, CSIR-National Metallurgical Laboratory, Jamshedpur – 831007, India*
[2]*Department of Physics, National Institute of Technology Patna, Patna – 800005, India*
*Corresponding Author: akpanda@nml.res.in / akpanda2_in@rediffmail.com

Abstract

Giant Magneto-impedance (GMI) is the significant alteration in electrical impedance of a microwire under an external magnetic field, driven by the skin effect, wherein high-frequency AC currents are confined to the surface, interacting with the magnetic domains. GMI behaviour is associated with magnetic anisotropy and skin depth [1], rendering it optimal for magnetic sensors. In the quest to unravel the surface-related GMI phenomena, the present investigation addresses the impact of chemical etching (aqua regia) on the magneto-impedance properties.

Fig.1. GMI plots of as-quenched and etched microwires.

Results indicated that on etching the microwires even as low as 5µm (initial diameter : 75µm), GMI increased from 360% to 411% and also shifted in peak value towards higher frequency. The anisotropy field $<H_k>$ was also found to increase from 24 A/m to 35 A/m. Interestingly, etching not only modified the peak asymmetry behaviour of the dual peak but also a reversal in the intensities of the two peaks. To understand this phenomenon, data has been obtained through a series of etchings and correlated to modification in the anisotropies viz; circumferential, axial, and transverse. The study is expected to provide a scope for enhancement in GMI properties through surface modification of as-quenched microwires.

Keywords: GMI; Amorphous Microwires, Chemical Etching, Anisotropy, Skin Depth

References:

[1]. Panda et al, Impact of stress induced anisotropic modifications on magneto- impedance behaviour of rapidly quenched CoFe based microwires, J. Magn. Magn. Mater. 960 (2023) 170751. DOI: https://doi.org/10.1016/j.jallcom.2023.170751.

Topic Code: C2

Structural, Magnetic, and Dielectric properties of bulk $CoFe_2O_4$ synthesized by Microwave sintering and Solid-state reaction

Arya, Rose Thomas[1], Ankur, Rastogi[2]

[1]*Department of Physics, School of Advanced Sciences, Vellore Institute of Technology Vellore, Tamilnadu-632014, India*
[2]*Centre for Functional Materials, Vellore Institute of Technology, Vellore, Tamilnadu-632014, India*

*Corresponding Author: ankur.rastogi@vit.ac.in

Abstract

Bulk Cobalt ferrite is synthesized by microwave sintering and solid-state reaction methods. The formation of single-phase partially inverse spinel cobalt ferrite is confirmed from the Rietveld Refinement of the XRD patterns, further supported by X-ray photoemission spectroscopy (XPS). The deconvolution of the high resolution XPS peaks of Co and Fe indicated the occupation of Co and Fe cations in the tetrahedral and octahedral sites.[1] The average grain size of the synthesized samples by the microwave sintering and solid-state reaction is estimated to be ~ 345 nm and 535 nm, respectively. Magnetic measurement infers a change in the magnetization and coercivity values, which is attributed to the difference in average grain size.[2] The observed dielectric behavior is in accordance with Koop's theory. Due to the high dielectric constant value, saturation magnetization, and low dielectric loss, cobalt ferrite synthesized via solid-state reaction is likely suitable for high-frequency electromagnetic devices. In contrast, microwave-sintered cobalt ferrite's high squareness ratio and low coercivity make them ideal for use in magnetic recording devices. This study demonstrates an alternative approach to synthesizing high-quality bulk cobalt ferrite using microwave sintering.

Keywords: Cobalt ferrite; Solid-state reaction; Microwave sintering; Dielectric properties; Magnetic properties

References:

[1] T. Magno De Lima Alves *et al.*, "Wasp-waisted behavior in magnetic hysteresis curves of CoFe2O4 nanopowder at a low temperature: Experimental evidence and theoretical approach," *RSC Adv.*, vol. 7, no. 36, pp. 22187–22196, 2017, doi: 10.1039/c6ra28727a.

[2] R. S. Yadav *et al.*, "Impact of grain size and structural changes on magnetic, dielectric, electrical, impedance and modulus spectroscopic characteristics of CoFe2O4 nanoparticles synthesized by honey mediated sol-gel combustion method," *Adv. Nat. Sci. Nanosci. Nanotechnol.*, vol. 8, no. 4, p. 045002, 2017.

A High magnetic Permeability Metamaterial Superstrate as a Gradient Index Lens for 2.4 GHz Patch Antenna Gain Enhancement

Bhrarath reddy Gudibandi[1], Muniyandi Muneeswaran[2]

[1]*School of Electronics Engg, VIT-AP University, Vijayawada, India.*
[2]*Department of Physics, School of Advanced Sciences, VIT-AP University, India.*

*Corresponding Author: bharathreddy.gudibandi@vitap.ac.in[1]

Abstract

This paper presents a novel approach to enhance the gain of a 2.4 GHz patch antenna by utilizing an array of single ring split-ring resonators (SRSRRs) as a superstrate. The SRSRRs, exhibiting a strong magnetic response at the operating frequency, create a high effective magnetic permeability, leading to a significant increase in the refractive index of the metamaterial array. This high refractive index, combined with the periodic arrangement of the SRSRRs, results in a gradient index lens effect, effectively focusing the radiation from the patch antenna. The λ/2 spacing between the patch antenna and the metamaterial array further contributes to gain enhancement by facilitating leaky-wave radiation. Simulation results demonstrate a substantial gain improvement from 2.8 dB for the standalone patch antenna to 7.8 dB with the SRR superstrate. This study highlights the potential of utilizing metamaterials with engineered magnetic properties for achieving significant performance enhancements in antenna design.

Keywords: magnetic permeability; metamaterials; refractive index; SRSRR; graded index.

References:

[1]. Lovat, G., Burghignoli, P., Capolino, F., & Jackson, D. R. (2007). Combinations of low/high permittivity and/or permeability substrates for highly directive planar metamaterial antennas. IET Microwaves, Antennas & Propagation, 1(1), 177-183.

[2]. H. Attia, L. Yousefi, M. M. Bait-Suwailam, M. S. Boybay and O. M. Ramahi (2009). Enhanced-Gain Microstrip Antenna Using Engineered Magnetic Superstrates. IEEE Antennas and Wireless Propagation Letters, 8, 1198-1201.

[3]. H. Attia, L. Yousefi and O. M. Ramahi (2011). Analytical Model for Calculating the Radiation Field of Microstrip Antennas with Artificial Magnetic Superstrates: Theory and Experiment. IEEE Transactions on Antennas and Propagation, 59(5), 1438-1445.

[4]. Gao xi, Zhang Yan, Li Simin (2020). High Refractive Index Metamaterial Superstrate for Microstrip Patch Antenna Performance Improvement. Frontiers in Physics, 8.

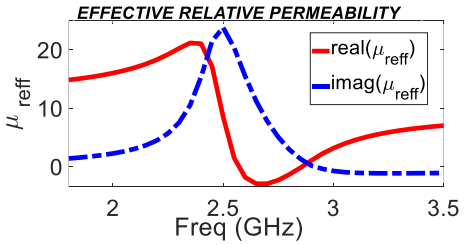


Fig. 1. Extracted effective relative magnetic permeability of the SRSRR metamaterial unit cell

Topic Code: D

Preparation and Characterization of $NiCo_2O_4$/RGO/Fe_3O_4 Hybrid Electrode Materials for High-Performance Supercapacitor Applications

T. Kavinkumar[1], Durga Prasad Pabba[2], Arun Thirumurugan[3]*
[1]*Centre for Energy and Environment, Department of Physics, Karpagam Academy of Higher Education, Coimbatore 641021, India*
[2]*Departamento de Electricidad, Facultad de Ingeniería, Universidad Tecnológica Metropolitana, Santiago, 7800002, Chile*
[3]*Sede Vallenar, Universidad de Atacama, Costanera 105, Vallenar 1612178, Chile*
*Corresponding Author: arun.thirumurugan@uda.cl

Abstract

In this work, $NiCo_2O_4$/reduced graphene oxide (RGO)/Fe_3O_4 hybrid nanocomposites were successfully synthesized via a modified chemical oxidation method for high-performance supercapacitor applications. The $NiCo_2O_4$ nanostructures were uniformly deposited on RGO sheets, followed by the integration of Fe_3O_4 nanoparticles to enhance electrochemical properties. Field Emission Scanning Electron Microscopy (FESEM) revealed a uniform and interconnected network of $NiCo_2O_4$ and Fe_3O_4 nanoparticles on the RGO sheets, while Transmission Electron Microscopy (TEM) further confirmed the nano-scale morphology and excellent dispersion of the composite components. Vibrating Sample Magnetometry (VSM) analysis demonstrated the soft magnetic properties of the hybrid composite, attributed to the presence of Fe_3O_4, which may offer advantages in enhancing charge transport. Electrochemical measurements, including cyclic voltammetry (CV) and galvanostatic charge-discharge (GCD), revealed that the $NiCo_2O_4$/RGO/Fe_3O_4 composite exhibited a high specific capacitance of 385 F g^{-1} at a current density of 0.5 A g^{-1}. Furthermore, the composite demonstrated excellent cycling stability, maintaining 92% of its initial capacitance after 5000 cycles, outperforming the individual components. The synergistic effect between $NiCo_2O_4$, RGO, and Fe_3O_4 enhances the electrochemical performance, making this hybrid nanocomposite a promising electrode material for next-generation supercapacitors.

Keywords: Ferrite, Supercapacitor, Stability, Saturation Magnetization

References:

[1]. T. Arun, K. Prabakaran, R. Udayabhaskar, R.V. Mangalaraja, A. Akbari-Fakhrabadi, Carbon decorated octahedral shaped Fe3O4 and α-Fe2O3 magnetic hybrid nanomaterials for next generation supercapacitor applications, Appl. Surf. Sci. 485 (2019) 147–157. https://doi.org/10.1016/j.apsusc.2019.04.177.

[2]. T. Kavinkumar, N.R. Reddy, D.P. Pabba, A. Ramadoss, U. Rednam, S.S. Dhanabalan, N. Chidhambaram, P. Asaithambi, S.A. Hevia, A. Thirumurugan, Design of highly stable Co3O4/RGO/CoFe2O4 hybrid nanocomposites with multiple nanointerfaces for enhanced supercapacitor performance, Inorg. Chem. Commun. 168 (2024) 112920. https://doi.org/10.1016/j.inoche.2024.112920.J. van der Geer, T. Handgraaf, R.A. Lupton, The art of writing a scientific article, J. Sci. Commun. 163 (2020) 51 – 59.

Topic Code: A1

Investigation of the Magnetic Characteristics of Cr-Zn and Cr-Co Nanoferrite Systems

M, Lakshmi[1], P, Sarah[1]

[1] *Department of Physics, Vidya Jyothi Institute of Technology, Aziznagar Gate, C.B.Post, Hyderabad, Telangana 500075, India*
*Corresponding Author: lakshmimamilla@vjit.ac.in

Abstract

The series of Cr-Zn and Cr-Co nanoferrite systems having the chemical composition $Cr_xZnFe_{2-x}O_4$ and $Cr_xCoFe_{2-x}O_4$ ($0.0 \leq x \leq 0.5$) were synthesized using sol–gel method. The present investigation aims to compare the effect of Cr^{3+} ion concentration on the magnetic characteristics of Zn and Co-nanoferrite systems. The investigation on various magnetic characteristics was conducted using Vibrating Sample Magnetometer (VSM) under an external magnetic field of ±15kG. The measurements were conducted at room temperature. In case of both ferrite systems, the abrupt change observed in the magnetization vs. magnetic field plots upon substitution of Cr^{3+} ions in ferrite samples. In the current study, $Cr_xZnFe_{2-x}O_4$ (x=0.3) and $Cr_xCoFe_{2-x}O_4$(x=0.1) ferrite samples were found to possess very low coercivity values. The low coercivity makes these nanoferrites useful for soft ferrite applications. According to VSM reports, Cr^{3+} ion doping has significantly altered the magnetic characteristics of both Zinc and Cobalt ferrite systems. The possible factors accountable for these outcomes are thoroughly analysed in this paper.

Keywords: Cr-Zn nanoferrites; Cr-Co nanoferrites; saturation magnetization; coercivity; remanent magnetization

References:

[1]. Kudr, J.; Haddad, Y.; Richtera, L.; Heger, Z.; Cernak, M.; Adam, V.; Zitka, O. Magnetic nanoparticles: From design and synthesis to real world applications. Nanomaterials 2017, 7 (9), 243, DOI: 10.3390/nano7090243

[2]. Ansari, A. A.; Abushad, M.; Arshad, M.; Naseem, S.; Ahmed, H.; Husain, S.; Khan, W. Microstructure, optical and dielectric properties of cobalt-doped zinc ferrite nanostructures. J. Mater. Sci.: Mater. Electron. 2021, 32, 21988– 22002, DOI: 10.1007/s10854-021-06647-2

[3]. Lakshmi, M., K. Vijaya Kumar, and KJJoNiC Thyagarajan. "An investigation of structural and magnetic properties of Cr–Zn ferrite nanoparticles prepared by a sol–gel process." Journal of Nanostructure in Chemistry 5 (2015): 365-373. https://doi.org/10.1007/s40097-015-0168-8

[4]. Lakshmi, Mamilla, Katrapally Vijaya Kumar, and Krishnan Thyagarajan. "Structural and magnetic properties of Cr-Co nanoferrite particles." Advances in nanoparticles 5.01 (2016): 103-113. https://doi.org/10.4236/anp.2016.51012

Topic Code: C (Applied Magnetism)

Sm Doped Cu-Ni Spinel Ferrite Nanoparticles for Hyperthermia Application

Mritunjoy Prasad Ghosh*, Devasish Chowdhury

Material Nanochemistry Laboratory, Physical Sciences Division, Institute of Advanced Study in Science and Technology, Paschim Boragaon, Guwahati-781035, Assam, India

*Corresponding Author: mritunjoy.phy23@gmail.com

Abstract

Magnetic hyperthermia using superparamagnetic spinel ferrite nanoparticles is a well-established method to elevate the temperature of the cancerous cells between 42 ^{0}C to 46 ^{0}C for a while in order to rupture and reduce the size of the tumour. It is expected that the ferrite nanoparticles in the form of ferrofluid dissipate thermal energy when they are subjected to an alternating magnetic field. In this work, we have tuned the physical properties of nanocrystalline Sm-doped Cu-Ni spinel ferrites, with special emphasis on hyperthermia application [1]. Samarium doped Cu-Ni spinel ferrite nanoparticles with varying Sm content have been prepared synthesized via the conventional co-precipitation method. Careful examination of the registered powder x-ray diffractograms (XRD) ensured the presence of pure spinel cubic crystal structure. Determination of average crystallite size together with developed microstrain for all the samples was done by using the Williamson-Hall technique. Both the coercive field and saturation magnetization were observed to decrease gradually as noticed in M(H) loops. The superparamagnetic phenomenon has been aroused at room temperature for higher Sm ions content ferrite samples which favoured the magnetic controlled hyperthermia through induction heating. Bare Sm doped Cu-Ni ferrite samples showed excellent induction heating obeying clinical safety limits. Hence, Sm doped Cu-Ni spinel ferrite nanoparticles with proper surface coating can be used in hyperthermia application.

Keywords: Ferrite nanoparticles; Tauc plots; Hyperthermia; Magnetization

References:

[1] M.P. Ghosh, N.J. Mondal, R. Sonkar, B. Boro, J.P. Borah, D. Chowdhury, Sm Doped Cu–Ni Spinel Ferrite Nanoparticles for Hyperthermia and Photocatalytic Applications, ACS Applied Nano Materials 7 (2024) 7028–7042.

Magnetic hyperthermia Studies of CoS/Fe_3O_4 and ZnS/ Fe_3O_4 Composites

Savitha Pillai S[1], Gopika M S[1] and B.B. Lahiri[2]

[1]*Department of Physics, India Department of Physics, University of Kerala, Karyavattom 695581, Thiruvananthapuram, Kerala, India,* [2] *Smart Materials Section, Metallurgy and Materials Group, Indira Gandhi Centre for Atomic Research, Kalpakkam, Tamil Nadu PIN 603102, India*

*Corresponding Author: savitha@keralauniversity.ac.in

Abstract

Magnetite (Fe_3O_4) nanoparticles have shown great promise as effective agents for magnetic hyperthermia in cancer treatment. This therapy takes advantage of the nanoparticles' ability to generate heat when subjected to an alternating magnetic field, allowing for targeted destruction of tumor cells. Despite their size tunability, excellent magnetic properties, biocompatibility, easy synthesis, and morphology-dependent heating characteristics, Fe_3O_4 nanoparticles face challenges, particularly their low optical absorbance, which limits their use in advanced biomedical imaging. To address these issues, combining magnetic nanoparticles with inorganic conjugates into multifunctional hybrids can enhance biomedical applications by integrating imaging, diagnosis, and therapy into a single system. This study focuses on the structural, morphological, optical, magnetic, and AC induction heating properties of CoS/Fe_3O_4 and ZnS/Fe_3O_4 composite nanoparticles, a topic that has not been previously reported. The results show that these composites demonstrate improved optical absorption compared to pure Fe_3O_4 nanoparticles. Magnetic studies confirm their superparamagnetic nature with high moment for ZnS/Fe_3O_4. Heating efficiency for hyperthermia applications was assessed at various magnetic field amplitudes, using a fixed frequency of 126 kHz. The specific absorption rates (SAR) obtained were 23 W/g for CoS/ Fe_3O_4 and 4.2 W/g for ZnS/ Fe_3O_4 composites at a field amplitude of 33.1 kA/m. Although CoS/Fe_3O_4 exhibits lower magnetic moment and colloidal stability compared to the ZnS/ Fe_3O_4 system, it shows higher magnetic heating performance. This enhanced performance is attributed to the greater effective magnetic anisotropy of the CoS/Fe_3O_4 composite. Our study highlights the important role of magnetic anisotropy in determining the heating performance of these composites.

Keywords: (Magnetic hyperthermia, Composites, Magnetite)

References:

[1]. Szwed, M., & Marczak, A. (2024). Application of nanoparticles for magnetic hyperthermia for cancer treatment—the current state of knowledge. *Cancers*, *16*(6), 1156.

[2]. Zhang, Yun-Fei, and Mai Lu. "Advances in magnetic induction hyperthermia." *Frontiers in Bioengineering and Biotechnology* 12 (2024): 1432189.

Magnetic Fluid Hyperthermia Properties of Polyethylene Glycol-Coated Cobalt Ferrite Nanoparticles

Fouzia, Khan[1,2*], B. B., Lahiri[1,2], Arup, Dasgupta[1,2]

[1]*Smart Materials Section, Physical Metallurgy Division, Materials Characterization Group, Metallurgy and Materials Group, Indira Gandhi Centre for Atomic Research, Kalpakkam, Tamil Nadu, PIN 603102*

[2]*Homi Bhabha National Institute, Training School Complex, Anushaktinagar, Mumbai, PIN 400049*

*Email of corresponding author: fouzia@igcar.gov.in

Abstract

Magnetic nanoparticles (MNPs) are being increasingly used in magnetic fluid hyperthermia (MFH)-based cancer therapy, where the temperature at a tumour site is locally raised by exploiting the magneto-thermal energy conversion of the MNPs exposed to an alternating magnetic field (AMF) [1]. The microwave-assisted coprecipitation technique was utilized to prepare polyethylene glycol (PEG)-functionalized cobalt ferrite MNPs for average crystallite size ~ 13 ± 2 nm, and saturation magnetization of ~ 67 emu/g. Dynamic light scattering experiments revealed a hydrodynamic diameter and a zeta potential of ~ 28 nm, and ~ -27 mV, respectively, and the presence of the PEG coating was confirmed using Fourier transform infrared spectroscopy. Magneto-calorimetric studies indicated temperature rise beyond the hyperthermia limit (> 42 ^{o}C) within ~ 30-60 s for varying AMF (~ 126 kHz) amplitudes of ~ 33.1-22.1 kA/m (Fig.1). The highest specific absorption rate (SAR) was found to be ~ 326 W/g for ~ 1 wt. % MNP concentration. *In vitro* cyto-toxicity studies on HeLa cell lines showed good bio-compatibility for the PEG-coated MNPs. The obtained results clearly indicated the suitability of the prepared PEG-coated cobalt ferrite MNPs for MFH applications.

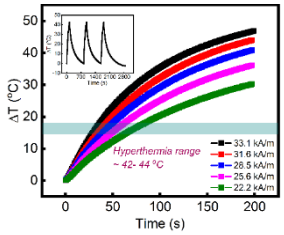


Fig. 1 Time-dependent temperature rise of the PEG-coated cobalt ferrite MNPs.

Keywords: Microwave-assisted synthesis; Magnetic fluid hyperthermia; Cobalt ferrite; PEG

References:

[1] R. E. Rosensweig, J. Magn. Magn. Mater. 252 (2002) 370–374.

pH-Responsive Magnetic Hyperthermia in Chitosan-Coated $MnFe_2O_4$ Nanoparticles: Experimental and Finite Element Analyses

Srujana, Mahendravada[1,3], B.B, Lahiri[1,3], Arup, Dasgupta[1,3], Anindya Bhattacharyya[2,3]

[1]*Smart Materials Section, Physical Metallurgy Division, Materials Characterization Group, Metallurgy and Materials Group, Indira Gandhi Centre for Atomic Research, Kalpakkam, Tamil Nadu, PIN 603102, India.*
[2]*RTSD, EIG, IGCAR, Kalpakkam, Tamil Nadu, PIN 603102, India*
[3]*Homi Bhabha National Institute, Training School Complex, Anushaktinagar, Mumbai, PIN 400094, India*
*Corresponding Author: srujanaphysics1@gmail.com

Abstract

Here, we report the synthesis, physicochemical characterization, magnetic fluid hyperthermia (MFH) and finite element modelling (FEM) of MFH-induced temperature increase for chitosan-coated $MnFe_2O_4$ nanoparticles of average crystallite size ~ 13 nm and saturation magnetization of ~ 51 emu/g. Magneto-calorimetry studies at varied medium pH indicated a lowering of MFH efficiency at higher pH, which was attributed to the deprotonation of the amide groups [1] that caused the hydrodynamic diameter to increase by ~ 23 times on 4-fold increase in pH, thereby slowing the Brownian relaxation dynamics. On the other hand, at a fixed pH of ~ 2, concentration-dependent studies indicated an increase in MFH efficiency with MNP loading due to the lack of significant aggregation. FEM was utilized to estimate the MNP distributions within simulated tumour regions of various porosities and for varied injected fluid volumes. FEM indicated better thermal distributions with nearly uniform heating for tumours with lower porosity and increased number of injection sites. The obtained findings provide deeper insights into the distributions of MNPs within tumour tissues and the associated thermal patterns.

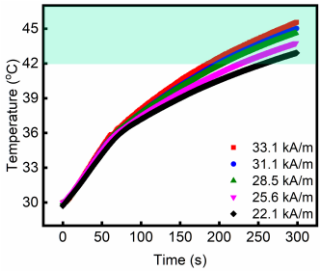


Fig. 1 Typical time-temperature curves for the chitosan coated $MnFe_2O_4$ MNPs.

Keywords: Magnetic fluid hyperthermia; manganese ferrite; finite element model

References:

[1] G. F. Payne and S. R. Raghavan, Chitosan: a soft interconnect for hierarchical assembly of nano-scale components, Soft Matter 3 (2007) 521–527.

Topic Code: C

Fe_3O_4 Mesocrystals: A Multifunctional Platform for Magnetic Hyperthermia and pH-Responsive Drug Delivery in Cancer Treatment

Akash Marsalin[1], and Rajaboopathi Mani*[1]

[1] *Key Laboratory of Emergent Materials, Department of Physics and Nanotechnology, SRM Institute of Science and Technology, Kattankulathur-603 203, Chengalpattu, Tamil Nadu, India.*
* Corresponding author e-mail: rajaboom@srmist.edu.in

Abstract

In recent years, magnetic nanostructures have garnered significant interest due to their collective magnetic behavior, surface anisotropy, and high surface-to-volume ratio[1]. Their unique magnetic properties make them highly effective for drug delivery, hyperthermia treatments, and multimodal therapies[2]. Based on this, we synthesized Fe_3O_4 mesocrystals (FM) using a modified solvothermal method with ethylene glycol and diethylene glycol as solvents (1:1 ratio). X-ray diffraction (XRD) confirmed the phase purity of the FM sample which validates the formation of a cubic structure with the Fd-3m space group. The morphology was analyzed using Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM). Notably, the Selected Area Electron Diffraction (SAED) pattern revealed a single-crystal-like spot pattern, which confirmed the formation of a mesocrystal structure. The magnetic properties were studied using a Vibrating Sample Magnetometer (VSM), and it exhibits a saturation magnetization of ~ 87 emu/g. The heating efficiency of the sample was evaluated for various concentrations, among them 10 mg/mL of FM reached therapeutic temperatures in 248 s at 20 kA/m and 91 seconds at 26.7 kA/m. In addition to the heating potential, the drug delivery potential was evaluated for Fe_3O_4 FM, and the encapsulation efficiency was determined to be 49%. The drug release kinetics were evaluated at pH 7.4 (PBS) and at pH 5.5 (acetate buffer) revealing release rates of 28% and 41%, respectively. The cytotoxicity of FM sample was tested against the L-929 cell line, and it exhibits excellent biocompatibility, making Fe_3O_4 mesocrystal a promising candidate in cancer treatment.

Keywords: Iron Oxide, Mesocrystals, Magnetic Hyperthermia, Drug delivery, Cytotoxicity.

References:

1. Fu, H., Gao, X., Zhang, X. & Ling, L. Recent Advances in Nonclassical Crystallization: Fundamentals, Applications, and Challenges. Cryst. Growth Des 22 (2022) 1476–1499.
2. Zhou, L. & Obrien, P. Mesocrystals - Properties and applications. J. Phys. Chem. Lett (2012) 620–628.

Topic Code: C

Structural, Magnetic, Electrical and Dielectric properties of Iron Oxide (Magnetite Phase) and Hyperthermia

Amrutha K, Niroj Kumar Sahu*

Centre for Nanotechnology Research, Vellore Institute of Technology, Vellore, Tamil Nadu - 632014, India

* Corresponding Author: nirojs@vit.ac.in

Abstract:

Iron oxides in nanoform are associated with exciting properties for various applications such as energy storage, magnetic recording, biomedicine and sensing. These applications demand the tuning of the physico-chemical properties of iron oxide especially Fe_3O_4 phase. Even though, the magnetic properties are being extensively studied for iron oxide, their electrical and dielectric characteristics are rarely reported. Here, we report the solvothermal processed surface active iron oxide nanoparticles using P123 triblock copolymer along with urea and hexamethylenetetramine (HMTA). The iron oxide crystallizes in inverse spinel structure of Fe_3O_4 with crystallite sizes of 8 to 11 nm. The use of copolymer with urea and HMTA lead to flake-shaped morphology with various dispersity as revealed in TEM morphology. The nanoparticles possess nearly superparamagnetic behaviour whereas the magnetic parameters vary significantly with the morphology and crystallinity of the samples. Four-probe measurements confirmed ohmic behaviour in all samples whereas they exhibit frequency and temperature dependent dielectric behaviour. Furthermore, the hyperthermia behaviour found to be dependent on the concentration of the nanoparticles. A highest Specific absorption rate value of 609.06 W/g is achieved within 90 seconds for a concentration of 1mg/ml. The remarkable heating efficacy and insight physical properties of the iron oxide will be useful for specific biomedical applications.

Keywords: Fe_3O_4; Oxidation; Nanoflakes; Magnetic heating; Specific absorption rate

References:

[1] R. M. Cornell and U. Schwertmann, *The Iron Oxides: Structure, Properties, Reactions, Occurences and Uses*, 1st ed. Wiley, 2003. doi: 10.1002/3527602097.

[2] A. Rajan and N. K. Sahu, "Inductive calorimetric assessment of iron oxide nano-octahedrons for magnetic fluid hyperthermia," *Colloids and Surfaces A: Physicochemical and Engineering Aspects*, vol. 603, p. 125210, 2020.

[3] A. Rajan, M. Sharma, and N. K. Sahu, "Assessing magnetic and inductive thermal properties of various surfactants functionalised Fe3O4 nanoparticles for hyperthermia," *Sci Rep*, vol. 10, no. 1, p. 15045, Sep. 2020, doi: 10.1038/s41598-020-71703-6.

Topic Code: C

Characterization and Induction Heating Response of Co-Cu Nanoparticles

Ramakrishna Rao Akurati[1*], Nitchal Kiran Jaladi[1], Srinivasa Rao Kurapati[2]

[1]*Department of Physics, Vignan's Foundation for Science Technology and Research, Deemed to be University, Vadlamudi, Guntur, 522213, Andhra Pradesh, India*
[2]*Department of Physics, PBN College, Nidubrolu, 522124, Andhra Pradesh, India.*

*Corresponding Author email Address: arkr4378@gmail.com

Abstract

In recent years, magnetic hyperthermia acquired importance as magnetic nanoparticles are used to produce required threptic temperature, to destroy the cancerous cells, by the application of external alternating magnetic field. This study provides the process of acquiring cobalt-copper ferrite nanoparticles with required characteristics and investigation on magnetic hyperthermia. Samples of cobalt-copper nanoferrite with composition $Co_{0.88}Cu_{0.12}Fe_2O_4$ were prepared by sol-gel method using polyethylene glycol (PEG) as the chelating agent. Samples were prepared keeping ferrite to PEG weight ratios of 1:1, 1:2, and 1:3, to observe optimum ratio for maximum saturation magnetisation. The estimation of crystalline formation, spinel structures, and mean particle sizes of the samples annealed at 400 ℃ have been obtained by Fourier-transform infrared spectroscopy, X-ray diffraction, and transmission electron microscopy techniques. Here the mean particle sizes are ranging from 7.1 nm to 5.4 nm. Based on the variation of saturation magnetization of the samples annealed at temperatures of 1000 ℃, 1050 ℃, and 1100 ℃, the optimum weight ratio of ferrite to PEG was found to be 1:2. Self-heating characteristics under applied magnetic field of 200 Oe at frequency of 746 kHz with concentrations of 10 mg/mL, and 15 mg/mL in a water medium produced the required threptic temperature range (42 ℃ - 46 ℃). The values of specific absorption rate 54 W/g and 83.3 W/g for nanoparticle concentrations of 10 mg/mL and 15 mg/mL reveal the ability of cobalt-copper nanoferrite particles as a heating agent.

Keywords: Nanoferrite; Sol-gel method; chelating agent; magnetic hyperthermia

References:

[1] P. V. Ramana, K. Srinivasa Rao, K. Raghu Kumar, Govinda Kapusetti, Mounika Choppadandi, J. N. Kiran, and K. H. Rao, A study of uncoated and coated nickel-zinc ferrite nanoparticles for magnetic hyperthermia, Mater. Chem. Phys. 266 (2021) 124546

[2] Nandhini G., and Shobana M.K., Role of ferrite nanoparticles in hyperthermia applications, J. Magn. Magn. Mater. 552 (2022) 169236

Topic Code: A1

Color Center Induced Defects Impacting Magnetic, Optical, and Catalytic Activity of Zinc Ferrites

Deepannita Chakraborty[1], N Priyadharsini[2*], Chaitanya Kumar Kunapalli[3]

[1]*Department of Physics, PSG Institute of Technology and Applied Research, Coimbatore- 641 062, India*
[2]*Department of Physics, Dr. N.G.P. Institute of Technology, Coimbatore- 641 048, India*
[3]*Department of Physics, Marri Laxman Reddy Institute of Technology and management, Hyderabad -500 043*
[*]Corresponding author mail id*:* prsr72@gmail.com

Abstract

A significant impact of color center defects on optical, magnetic, and catalytic property of lemon peel extract assisted chemical route synthesized pure and doped zinc ferrite nanoparticles are studied in detail. The structural characteristics from X-ray diffraction report single phase cubic spinel structure of pure and doped zinc ferrite nanoparticles. The diffuse reflectance studies confirm the formation of color centers with the reported decreasing trend in observed optical band gap value from 4.78 to 3.34 eV. Additionally, the decrease in the intensity of the photoluminescence spectra upon doping supports the presence of color centers. It is seen that the doping of magnesium (alkaline earth metal), and aluminium (post transition metal) individually induced F, F^+ center defects while the co-doping of them leads to creation of M center. Magnesium-doped zinc ferrite, aluminium-doped zinc ferrite, and co-doped zinc ferrite exhibited dye degradation efficiencies of 83%, 80%, and 75% respectively for MB dye at 120 minutes under sunlight. The aluminium doped zinc ferrite nanoparticles also attained cyclic stability of 81.4% degradation retentivity even after 7 cycles. The doped ferrites exhibit different magnetic property depending on the presence of color centers.

Keywords: M center; F center; F^+ center; magnetic catalyst; color center defects; oxygen vacancies.

Topic Code: D

Investigating the Magnetic Properties of Magnetite Containing Stones Found at Palakkad Gap, India for Advanced Industrial Applications

Nithyananda S, Senthil K*

Department of Physics, School of Advanced Sciences, VIT-AP University, Amaravati, Andhra Pradesh – 522237, India

*Corresponding author: senthil.k@vitap.ac.in

Abstract

The southern side of Palakkad Gap, a region in the Western Ghats, India, is observed to have an abundance of rocks and stones that exhibit magnetic attraction. This study investigates the physicochemical and magnetic properties of the stones collected from Palakkad Gap. The collected stone samples are powdered and separated into magnetic and non-magnetic fractions using a magnet and characterized using various techniques. The X-ray diffraction measurements clearly showed the presence of a large amount of magnetite (M) phase in the samples. XRD measurements for the thermally treated samples indicated the change in crystalline phase from magnetite to hematite (H). The obtained result is confirmed by the Thermogravimetric Analysis (TGA), which showed phase transition and thermal stability. The magnetic properties investigated using Vibrating-Sample Magnetometer (VSM) measurements revealed good ferromagnetic properties when compared with magnetite nanoparticles. The surface morphology, optical and electrical properties of the samples are also analyzed by using Scanning Electron Microscopy, Photoluminescence (PL), Ultraviolet-Visible Diffuse Reflectance Spectroscopy (UV-DRS) and I-V characteristics analysis. This research provides valuable insights into the composition and magnetic properties of these magnetite-rich stones, opening avenues for exploring novel magnetic materials for potential applications.

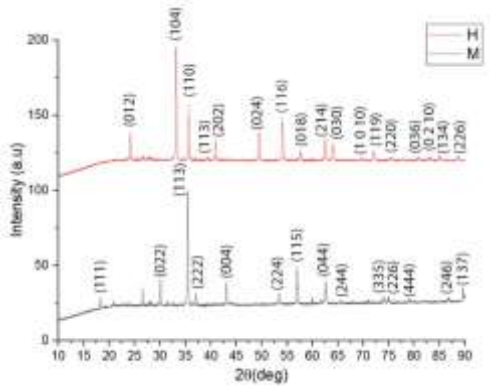


Fig 1: XRD of the magnetic sample before (M) and after (H) thermal treatment

Keywords: Magnetite, Magnetic Minerals, Palakkad Gap

References:

[1]. M. Reethu, V. Jyothi, K. Sandeep, A.K. Rafaz, G.H. Aravind, J. Jithin, Rock Magnetic and Mineralogical Properties of Lateritic Soil Profiles Developed on Two Different Parent Rocks in Northern Kerala, South- Western India. *Journal of Geosciences Research* **2023**, *8* (2), 110–117.2)

[2]. V. Sureshkumar, S.C.G. Kiruba Daniel, K. Ruckmani, M. Sivakumar, M. Fabrication of Chitosan Magnetite Nanocomposite Strip for Chromium Removal. *Applied Nanoscience (Switzerland)* **2016**, *6* (2),277–285.

Selenium-Doped Manganese Ferrite Nanoparticles: Structural Analysis and Applications In Environmental Remediation

Aparna Unnikrishnan[a], Subhapraba [b], J.Balavijayalakshmi[c*]

[a] *Research scholar, Department of Physics, PSGR Krishnammal College for Women, Coimbatore, Tamilnadu, India*

[b] *PG Student, Department of Physics, PSGR Krishnammal College for Women, Coimbatore, Tamilnadu, India*

[c*] *Associate Professor and Head, Department of Physics, PSGR Krishnammal College for Women, Coimbatore, Tamilnadu, India,*

*Corresponding Author: **balavijayalakshmiroopa@gmail.com**

Abstract

Spinel ferrite materials are metal oxides with spinel structures that have the general chemical formula AB_2O_4, where A and B represent various metal cations that are located at tetrahedral (A site) and octahedral (B site) positions, respectively. Manganese ferrite is one of the spinel-ferrites which can be used for various applications. Manganese ferrite ($MnFe_2O_4$) and selenium-doped manganese ferrite (Se-$MnFe_2O_4$) nanoparticles with varying concentrations of selenium (in the ratios of 1:3 and 3:3) were synthesized using the coprecipitation method. Prepared nanomaterials are characterised by FTIR, XRD, FESEM, and EDX to analyse their functional, structural and morphological properties. FTIR shows characteristic bands at 601 cm^{-1} for tetrahedral group stretching and 647 cm^{-1} for polarized oxygen ion vibrations. Low-frequency bands at 454 cm^{-1} and 401 cm^{-1} for octahedral group stretching. An additional peak at 495 cm^{-1} indicates Se-O bond formation. Structural analysis reveals crystallite sizes of 35 nm for manganese ferrite and 31 nm, 28 nm, for Se-$MnFe_2O_4$ in the ratios of 1:3 and 3:3. FESEM shows irregular, clustered morphologies for pure manganese ferrite nanoparticles. In the case of selenium-doped manganese ferrite nanoparticles, the clusters are composed of individual particles that appear spherical or nearly spherical. EDX confirms purity in manganese ferrite and the presence of selenium in the doped samples. This study shows the potential application of synthesized manganese ferrite and selenium-doped manganese ferrite nanoparticles, at various concentrations, for wastewater treatment. These materials can be effectively utilized for removing contaminants, making them valuable for environmental remediation processes.

Keywords: wastewater treatment, nanoparticle, manganese ferrite, selenium-doped manganese ferrite.

Synthesis of Biomass-Derived Carbon Support Embedded With Magnetite for Waste Water Treatment

Aswathy C. T[1], J. Balavijayalakshmi[2]

[1]*Research scholar, aswathysaas481@gmail.com*
[2]*Associate Professor and Head, balavijayalakshmiroopa@gmail.com*

[1]*Department of Physics, PSGR Krishnammal College for Women, Coimbatore, Tamilnadu - 641004 India*

Abstract

With growing concerns over water pollution and the detrimental effects of industrial effluents, there is an urgent need for effective and sustainable remediation strategies. This study presents the synthesis of biomass-derived carbon support embedded with magnetite (Fe_3O_4) for enhanced wastewater treatment applications. In this research, magnetite nanoparticles through a co-precipitation method are synthesized and incorporated them into cellulosic biomass-derived carbon to form a composite material. The precursor materials used in this study are Areca Catechu (arecanut husk), Saccharum Officinarum (sugarcane bagasse) and Oryza Sativa (rice husk). The adsorption performance of the synthesized composite is evaluated using aqueous solutions of common pollutants, including heavy metals and organic dyes. The resulting magnetic composite is characterized using techniques such as X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FT-IR), Energy dispersive X-ray (EDX), Raman spectroscopy, Field emission scanning electron microscopy (FESEM) and vibrating sample magnetometry (VSM) to confirm the formation and properties of the composite.

Keywords: Magnetite, Biomass derived Carbon

References:

[1]. Sami Ullah, Syed Shoaid Ahmad Shah, Muhammad Altaf, Ismail Hossain, Mohamed E. El Sayed, Mohamed Kallel, Zeinhom M. El-Bahy - *Activated carbon derived from biomass for wastewater treatment: Synthesis, application and future challenges.*

[2]. Shwetharani Ramu, Itika Kainthla, Lavanya Chandrappa, Jyothi Mannekote Shivanna, Brijesh Kumaran, R. Geetha Balakrishna - *Recent advances in metal organic frameworks–based magnetic nanomaterials for waste water treatment.*

Topic Code: D6

Photocatalytic Activity of Green Synthesised Canted Ferromagnetic Hematite Iron Oxide Nanoparticles for Methyl Orange Removal in Wastewater Remediation

Biplab Kumar Mandal[1, 2], Pratap Singh Chauhan[3] and Rahul Das[1*]

[1]*Department of Physics, The University of Burdwan, Bardhaman – 713104, India*
[2]*Department of Physics, Krishnagar Government College, Krishnagar – 741101, India*
[3]*Department of Physics, Government Dau Kalyan Arts and Commerce College, Chhattisgarh – 493332, India*
*Corresponding Author: rdas@phys.buruniv.ac.in

Abstract

In this study, iron oxide nanoparticles (NPs) were synthesised in an environmentally friendly manner utilising $FeCl_3$ as the precursor salt in the presence of *Nyctanthes arbor-tristis* L. leaf extract. The particle size was estimated using scanning electron microscopy (SEM) and transmission electron microscopy (TEM) to be between 18 nm and 66 nm. Several microscopic portions of the high-resolution transmission electron microscopy (HRTEM) image were subjected to fast Fourier transforms (FFT) and inverse fast Fourier transforms (iFFT) to calculate the crystallographic interplanar spacing (d_{hkl}). The Rietveld refinement of XRD data indicates that synthesised iron oxide nanoparticles (NPs) belong to the pure hematite (α-Fe_2O_3) rhombohedral lattice symmetry of the R-3c (167) space group with lattice constants of $a = b =$ 0.49 nm, c = 1.35 nm. Crystallites in this sample have an average size of 40.31 nm. The 2-D and 3-D electron density (ED) maps provide detailed information regarding the distribution of ions. UV-vis analysis provided an overall assessment of the band gap (E_g) of approximately 2.43 eV. According to magnetic measurements (M–H and M–T), the produced α-Fe_2O_3-NPs were determined to be canted ferromagnet with a room temperature coercive force of 129.87×10^{-4} T and a Morin temperature of 201 K. The photocatalytic activity of these wide-bandgap n-type semiconducting canted ferromagnetic α-Fe_2O_3-NPs was examined for the degradation of methyl orange (MO) dyes. The results demonstrated substantial catalytic activity towards MO degradation in the presence of a small amount of $NaBH_4$, suggesting their potential application in wastewater treatment.

Keywords: Green synthesis; Iron oxide; Hematite nanoparticles; Canted ferromagnetism; Photocatalytic activity

Experimental investigation on size-induced ferromagnetism and enhanced magnetoresistance in nanoparticles of overdoped $Nd_{1-x}Sr_xMnO_3$ (x = 0.55, 0.6, 0.75) manganites

Sourav Kundu[1], T.K., Nath[2]

[1] *Department of Physics, Saldiha College, Saldiha, Bankura-722173, India*
[2] *Department of Physics, Indian Institute of Technology, Kharagpur-721302, India*
*Corresponding Author: souravphy@gmail.com

Abstract

The rare earth perovskite manganites are considered to be one of the most fascinating materials to study due to the complexity in their electronic, magnetic and other physical properties [1]. The underdoped manganites often display very high negative magnetoresistance (colossal magnetoresistance) and for this reason they have attracted a significant amount of research interest since very long time. However, the overdoped manganites also offers a variety of phenomena like magnetic, charge, orbital ordering. In the present study, we have investigated the effect of reduction of particle size down to nanometric regime (average particle size of around 40 nm) on the magnetic electronic- and magneto-transport properties of the overdoped $Nd_{1-x}Sr_xMnO_3$ (x = 0.55, 0.6, 0.75) manganites. Reportedly, $Nd_{1-x}Sr_xMnO_3$ displays A-type antiferromagnetic order for x = 0.55 and 0.6 [2]. Further, it shows C-type antiferromagnetic order for x = 0.75 [2]. Interestingly, on reduction of particle size all these manganites exhibit signatures of ferromagnetism. Such ferromagnetic behaviour has been detected through measurement of linear as well as non-linear ac magnetic susceptibilities. Moreover, we have observed that the nanoparticles display very high negative magnetoresistance compared to their bulk antiferromagnetic counterparts which shows negligible magnetoresistance. This clearly indicates that such enhancement of negative magnetoresistance is originating due to the reduction of particle size. We have investigated and discussed the underlying mechanism of such magnetoresistance employing different theoretical models.

Keywords: (manganite; nanoparticles; ferromagnetism; ac susceptibility; magnetoresistance)

References:

[1]. E. Dagotto, T. Hotta and A. Moreo, Colossal magnetoresistant materials: the key role of phase separation, Physics Reports, 344 (2001) 1.
[2]. R. Kajimoto, H. Yoshizawa, H. Kawano, H. Kuwahara, Y. Tokura, K. Ohoyama and M. Ohashi, Hole-concentration-induced transformation of the magnetic and orbital structures in Nd1-xSrxMnO3, Physical Review B 60 (1999) 9506.

Topic Code: D

Investigation Of Structural, Magnetic and Electrical Properties of Monovalent (Li+) Ion Doped Ni-Zn Nanocrystalline Ferrites Synthesized Via Citrate Gel Auto-Combustion

D Venkatesh[1*], K V Ramesh[2*], and T Ramesh[3]

[1]*Department of Physics, B V Raju Institute of Technology, Narsapur, Medak, India*
[2]*Department of Physics, GITAM School of Science, GITAM Deemed to be University, Rushikonda, India*
[3]*Department of Physics, BVRIT HYDERABAD College of Engineering for Women, Hyderabad, India*

*Corresponding Author: dvsphy@gmail.com , kvramesh11@gmail.com

Abstract

In the present study, Li+ ion-doped Ni-Zn ferrites with the chemical formula $Ni_{05}Zn_{0.5}LixFe_{2-x}O_4$ (x= 0.00 to 0.25) were prepared by the nitrate citrate-gel auto-combustion method. The synthesized samples were subjected to X-ray Diffraction, Raman spectroscopy, and Scanning Electron Microscopy (SEM) to study the structural and morphological aspects of the Li+-doped Ni-Zn ferrites. XRD confirmed a single-phase cubic spinel structure; no detectable secondary phases were found. The crystallite size obtained using the Debye–Scherrer method was found to be approximately 30–40 nm. The lattice parameter decreases monotonically with the addition of Li^+ ions. In addition, Raman spectroscopy revealed that all the Li^+-doped Ni-Zn ferrite samples showed a single-phase cubic structure belonging to the Fd3m space group. SEM studies indicated that the grain size increased with increasing Li^+ ion concentration. Magnetic studies were carried out using a Vibrating Sample Magnetometer (VSM), and the variations in magnetic properties were explained based on cation distribution, bond lengths, and bond angle calculations. Dielectric studies were done using an impedance analyzer; the enhancement of dielectric properties with Li^+ ion substitution suggests that these samples are suitable for high-frequency applications [1-2].

Keywords: Ni-Zn-Li ferrite; XRD; Raman spectra; Dielectric Properties; VSM.

References:

[1]. Md. M. Alam, Md. M. Hossain Sarkar, A. Parvez, Md. K. Alam Khan, Mn-enhanced Li-Ni-Mn-Zn nano-ferrites: synthesis, characterization, and evaluations of structural, morphological, magnetic, and dielectric features, J. Magnetism Magn. Mater. 593 (2024) 171783.

[2]. T.A. Wani, G. Suresh, R. Masrour, K.M. Batoo, A. Rasool, A structural, morphological, optical and magnetic study of nickel-substituted zinc (Ni–Zn) ferrite nanoparticles synthesized via glycine assisted gel autocombustion synthesis route, Mater. Chem. Phys. 307 (2023) 128169.

Topic Code: E

Comprehensive Analysis of CoFeMnZ (Z=Sb, In) QuaternaryHeusler Alloys: Structural, Thermoelectric and Magnetic Properties Using Experimental and Ab-Inito Method

Shabeer, Ali PC[1,3], Manoj, Raama Varma[2,3] and KN Narayanan, Unni[1,3]

[1]*Centre for Sustainable Energy Technologies, CSIR-National Institute for Interdisciplinary Science and Technology (CSIR-NIIST), Industrial Estate, P.O. Thiruvananthapuram, 695019, India.*

[2]*Materials Science and Technology Division, CSIR- National Institute for Interdisciplinary Science and Technology (CSIR-NIIST), Industrial Estate, P.O., Thiruvananthapuram, 695019, India.*

[3]*Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, 201002, India.*

*Corresponding Author: unni@niist.res.in

Abstract

In this work, we examine the CoFeMnZ (Z=Sb, In) quaternary heusler alloys that have emerged as promising candidates due to their potential applications in magnetic storage, spintronics, and thermoelectric devices [1]. The material's electronic structure and thermoelectric properties were investigated using Density Functional Theory (DFT) calculations [2]. The full potential linearized augmented plane wave (FP-LAPW) method is implemented in the WIEN2k and BoltzTraP codes. PBE-GGA handles the exchange-correlation potentials. The results exhibit half-metallic ferromagnetism. We have estimated the optimized volume-energy curves of three structural phases (LiMgPbSb-type, Hg_2CuTi-Type, and Cu_2MnAl-Type) are considered for the study of these quaternary Heusler compounds; among them Cu_2MnAl-Type and Hg_2CuTi-Type are more stable for CoFeMnSb and CoFeMnIn respectively. Both compounds show negative Seebeck(N-type), good power factor, and a total spin magnetic moment of 5.06 μ_B/f.u, 7.13 μ_B/f.u for CoFeMnSb and CoFeMnIn respectively. Experimental studies show CoFeMnZ (Z=Sb, In) are N-type, and the Figure of merit (ZT) is 1×10^{-3} at 323 K for CoFeMnSb and 0.87×10^{-5} for CoFeMnIn. And CoFeMnSb has a high saturation magnetization of 20 emu/g at room temperature.

Keywords: (Quaternary heusler alloys, DFT, Wien2K, FP-LAPW, BoltzTrap codes)

References:

[1]. Gutiérrez Moreno, J. Julio, et al. "A review of recent progress in thermoelectric materials through computational methods." Materials for Renewable and Sustainable Energy 9.3 (2020): 16.

[2]. Elahmar, M. H., et al. "Structural, mechanical, electronic and magnetic properties of a new series of quaternary Heusler alloys CoFeMnZ (Z= Si, As, Sb): a first-principle study." Journal of Magnetism and Magnetic Materials 393 (2015): 165-174.

Topic Code: A2

Effects of Superconductivity and Non-Linear Electron-Phonon Interaction On Impurity Bound States in BCS Superconductor

Navashreya B[1], Narasimha Raju Chebrolu[1], Anusha Kachu[2], and Aalu Boda[2]

[1]*Department of Physics, Central University of Karnataka, Kalaburagi, Karnataka, 585367, India.*
[2]*Department of Physics, National Institute of Technology Warangal, Hanamkonda-506004, Telangana, India.*
*Corresponding Author: narasimharaju.phy@cuk.ac.in

Abstract

We have considered a quantum impurity with local Coulomb, linear and quadratic electron-phonon interactions embedded in a Bardeen-Cooper-Schrieffer (BCS) superconducting medium, modeled by a single spin-degenerate impurity Anderson-Holstein model Hamiltonian. We have employed the canonical transformations combined with the Kikuchi–Morita Cluster Variation (CV) method to analyze the conditions necessary in the superconductor for the formation of the magnetic moment, impurity bound states, and transition from single to bipolaron at the impurity site as a function of Coulomb, quadratic electron-phonon interactions, and the superconducting gap.

Keywords: Quantum Impurity, BCS Superconductor, Electron-phonon interaction.

References:

[1.] Ch. Narasimha Raju*, and Ashok Chatterjee, Properties of a localized magnetic impurity in a superconducting host: The Anderson Holstein-BCS model, J. Magn. Magn. Mater. **396**, 71 (2015).

[2.] Denis Golež, Janez Bonča, and Rok Žitko, Vibrational Andreev bound states in magnetic molecules, Phys. Rev B 86, 085142, (2012).

Topic Code: E2

Quantum Correlations in Nickel-Radical Molecular Complex $(Et_3NH)[Ni(hfac)_2L]$

R. Muthuganesan

[1]*Department of Physics and Nanotechnology, College of Engineering and Technology, SRM Institute of Science and Technology, Kattankulathur- 603202, Tamil Nadu, India.*
*Corresponding Author: rajendramuthu@gmail.com

Abstract

Quantum correlation (beyond entanglement) is an important resource for various information tasks in the quantum realm. In the perspective of quantum resources, we characterize the mononuclear molecular complex $(Et_3NH)[Ni(hfac)_2L]$, where HL denotes 2-(2-hydroxy-3-methoxy-5-nitrophenyl)-4,4,5,5-tetramethyl-4,5-dihydro-1H-imidazol-3-oxide-1-oxyl and hfacH stands for hexafluoroacetylacetone. The considered molecular magnet compound consists of an exchange-coupled spin-1 Ni^{2+} magnetic ion and a spin-1/2 nitronyl-nitroxide radical substituted nitrophenol. We examine the bipartite nonlocal correlations of pairs of spin-1 and spin-1/2 particle systems for the thermal equilibrium states. The effects of the system's parameter and Zeeman splitting are also expounded. In particular, the existence of quantum resources is identified at room temperature and extremely high magnetic fields.

Keywords: Molecular magnetic material; Heisenberg dimer; Quantum correlation; Entanglement;

References:

[1]. C.-A. Spinu, C. Pichon, G. Ionita, T. Mocanu, S. Calancea, M. Raduca, J.-P. Sutter, M. Hillebrand, M. Andruh, Synthesis, crystal structure, magnetic, spectroscopic, and theoretical investigations of two new nitronyl-nitroxide complexes. J. Coord. Chem. **74**, 279-293 (2021).
[2]. R. Muthuganesan, R. Sankaranarayanan. Fidelity based Phys. Lett. A 381, 3028-3032 (2017).
[3]. A. Peres, Separability Criterion for Density Matrices. Phys. Rev. Lett. **77**, 1413 (1996).

Tuning The Piezoelectric Polaron Properties Of An Asymmetric Gaussian GaAs, CuCl And RbCl Quantum Wells: A Study Of Weak, Intermediate And Strong Coupling Strength Effects

Swapna Vemula[1], Anusha Kachu[1], Thara Angoth[1], Narasimha Raju Chebrolu[2*], and Aalu Boda[1*]

[1]*Department of Physics, National Institute of Technology Warangal, Hanamkonda, Telangana-506004, India.*
[2]*Department of Physics, Central University of Karnataka, Kalaburagi, Karnataka-585367, India.*
[1]*Corresponding Author: abdop@nitw.ac.in
[2]*Corresponding Author: narasimharaju.phy@cuk.ac.in

Abstract:

This theoretical study investigates the weak, intermediate, and strong coupling strength dependence of piezoelectric polaron properties of an asymmetric Gaussian GaAs, CuCl, and RbCl quantum wells. We employed the modified Lee-Low-Pines (LLP) transformation and the linear combination operation method to compute the ground state energy, binding energy, magnetic moment, and magnetic susceptibility. It is shown that the magnetic field, electric field, quantum well range, well depth, the Debye cut-off wavenumber (DCOW), and electron-phonon coupling strengths are important factors that have a significant influence on the piezoelectric polaron properties of an asymmetric Gaussian quantum wells.

Keywords: Piezoelectric polaron; Asymmetric Gaussian GaAs, CuCl, and RbCl quantum wells; coupling strength effects; Magnetic moment; Magnetic susceptibility.

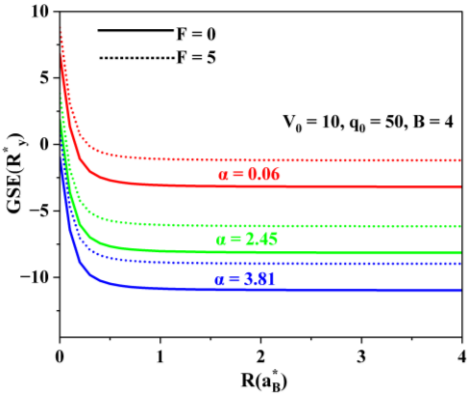


Fig. 1. The ground state energy as a function of well range for different values of electric field and coupling strength.

References:

[1]. K.D. Zhu, T. Kobayashi, Phys. Lett. 190 (3-4), (1994) 337–340.
[2]. F. Manfouo, I. Nsangou, M.F.C. Fobasso, A.J. Fotue, Heliyon 8, (2022) e10505.
[3]. Swapna Vemula, Anusha Kachu, Thara Angoth, Aalu Boda, Physics Letters A 526, (2024) 129948.

Magnetocaloric Effect of 2D and 3D Ising Model for Honeycomb, Square, and Hexagonal Lattices: A Monte-Carlo Study

Basit, Iqbal[1], Kingshuk, Sarkar*[1]

[1]*Department of Physics, School of Advanced Sciences, VIT-AP University, Amaravati, Andhra Pradesh – 522237, India.*
*Kingshuk Sarkar: kingshuk.sarkar@vitap.ac.in

Abstract

We present a comprehensive analysis of the thermodynamic and magnetic quantities of the Ising model using the Monte Carlo simulations. We study magnetization, energy, susceptibility, specific heat, magnetic entropy, susceptibility, and Binder cumulant. In addition, we focus, on the magnetocaloric effect which is the isothermal change in magnetic entropy and we study the relative cooling power. The magnetocaloric effect of the Ising model for the following three scenarios (i) dimensional comparison of 2D and 3D lattices; (ii) structural comparison of 2D square, honeycomb, and hexagonal lattices; and (iii) size dependency comparison for 2D square lattice for lattices sizes = 20×20, 40×40, and 60×60 has been investigated for the ferromagnetic case. Effective mean field theory analysis is carried out which gives approximate results. Monte-Carlo studies by the Metropolis algorithm are used for accurate quantitative investigation, comparative analysis, and better insights. It has been observed that different types of lattices show different magnetic responses. The main reason is that they have different coordination numbers and geometry. For the dimensional comparison case, as we go from the 2D honeycomb, square, and hexagonal to their 3D variant lattices for the same system size, the magnetocaloric effect changes due to the influence of out-of-plane interactions. For the second case of 2D structural comparison, the magnetocaloric effects decrease as we move from honeycomb to square and hexagonal lattices. For the lattice size comparison, as we move from the size of 20×20 to 40×40 and 60×60, we see almost no change in the magnetocaloric properties.

Keywords: Ising model; Monte-Carlo simulations; magnetic response; magnetocaloric effect.

References:

[1]. E. P. Nobrega et al., Magnetocaloric effect in $(Gd_xTb_{1-x})_5Si_4$ by Monte Carlo simulations, *Physical Review B* 74, Vol. 74, Iss. 14-1 October 2006, 144429. DOI: 10.1103/PhysRevB.74.144429

[2]. Regeciová, L., & Farkašovský, P. (2023). Magnetization processes and magnetocaloric effect of the Ising model on the octahedral lattice. *Journal of Magnetism and Magnetic Materials, 586,* 171153. https://doi.org/10.1016/j.jmmm.2023.171153.

[3]. Bo-chen Li, Wei Wang, Influence of a new long-range interaction on the magnetic properties of a 2D Ising layered model by using Monte Carlo method, *Chinese Journal of Physics*, Volume 87, February 2024, Pages 525-539.

[4]. Daisuke Yamamoto, Correlated cluster mean-field theory for spin systems, Physical Review B, Vol. 79, Iss. 14 — 1 April 2009.

Characterizing the Magnetic Dipolar Quantum Battery Via Quantum Resources

Ramya Parkavi, Jayachandran[1], and Muthuganesan, Rajendran[2]

[1]*Department of Physics, SRM Institute of Science and Technology Tiruchirappalli Campus, Tiruchirappalli 621105, Tamil Nadu, India*
[2]*Department of Physics and Nanotechnology, College of Engineering and Technology, SRM Institute of Science and Technology, Kattankulathur 603 202, Tamil Nadu, India*
*Corresponding Author: ramyaparkji@gmail.com

Abstract

Quantum batteries are designed to store energy efficiently with fast charging speed and high stability. To enhance the performance or functionality of the devices, it incorportaes quantum resources such as quantum entanglement and quantum coherence. However, beyond entanglement and coherence, other new quantum resources also offer a highly versatile and powerful tool for studying the charging process. In light of this, we exploit the connection between the quantum resources (beyond entanglement) and ergotropy in a pair of spin-1/2 particles coupled with dipolar and Dzyaloshinsky-Moriya (DM) interactions, serving as a quantm battery. The role of DM interaction in enhancing the quantum correlation and efficiency of the battery is also expounded. By controlling magnetic interactions, spin-orbit coupling, temperature, and quantum effects, we can improve the charging process and energy storage efficiency in quantum batteries. Our findings pave the way for the theoretical framework of spin-based quantum batteries and potentially unlock quantum advantages contributing to the development of energy storage devices in terms of power and efficiency.

Keywords: Quantum correlation, Dipolar system, Ergotropy

References:

[1]. H. L. Shi, S. Ding, Q. K. Wan, X. H. Wang and W. L. Yang, Entanglement, Coherence, and Extractable Work in Quantum Batteries, Phys. Rev. Lett. 129 (2022) 130602.
[2]. D. Zhang, S. Ma, Y. Jiang, Y. Yu, G. Jin, A. Chen, Entanglement and steering in quantum batteries, arxiv:2406.06373 (Submitted on 10 Jun 2024).
[3]. A. Ali , S.Al. Kuwari, M. I. Hussain , T. Byrnes, M. T. Rahim, J. Q. Quach, M. Ghominejad, and S. Haddadi, arxiv:2408.00133 (Submitted on 10 Jun 2024).
[4]. R Muthuganesan and V. K. Chandrasekar, Quantum Fisher information and skew information correlations in dipolar spin system, Phys. Scr. 96 (2021) 125113.

Topic Code: E1

Anomalous Hall effect in full Heusler alloy V_2FeGa: A First Principles Study

Hrishikesh Sinha[1], K Venkanna[2], Krishnamurthy Jyothinagaram[2], Bheemalingam Chittari[3], P. Rambabu[1]

[1]*Department of Pure and Applied Physics, Guru Ghasidas Vishwavidyalaya, Koni, Bilaspur, C. G. - 495009.*
[2]*Department of Physics, School of Sciences, National Institute of Technology, Andhra Pradesh-534101, India.*
[3]*Department of Physical Sciences, Indian Institute of Science Education and Research Kolkata, Mohanpur 741246, West Bengal, India.*
*Corresponding Author: sinhahrishikesh03@gmail.com

Abstract

Spintronics is one of the emerging areas in the technological world. This technology not only uses the charge degrees of freedom of electron but also uses its spin degrees of freedom. The practical use of spin degree of freedom covers wide range of applications such as spin-transfer torque, spin-valve device, development of magnetic storage devices etc. [1]. Several ferromagnetic materials, magnetic oxide materials, multiferroics, Heusler compounds etc. are found to have several applications [2]. A first principles approach using Density functional theory (DFT) is employed on the ferromagnetic Heusler alloy V_2FeGa to investigate the ground state electronic, magnetic and topological features etc. both in L21 and XA-type orderings. The Berry curvature driven Anomalous Hall conductivity along the high symmetry path is calcualted for V_2FeGa. The Heisenberg magnetic exchange interactions are calculated using Green's formalism as implemented in SPRKKR package and hence the Curie temperature from the Mean filed approximation is determined.

Keywords: Berry curvature; Anomalous Hall conductivity, Spintronics

References:

[1]. Igor Žutic, Jaroslav Fabian, S. Das Sarma, Rev. Modern Phys. 76 (2004) 323.
[2]. S. Palchoudhury, K. Ramasamy, A. Gupta, Mater. Matters 11 (2016) 4.

Theory of Spin Transport for Two Terminal Rashba-Zeeman Tunnel Junction

Kingshuk Sarkar[1*]

[1]*Department of Physics, School of Advanced Sciences, VIT-AP University, Amaravati, Andhra Pradesh – 522237, India*

*Corresponding Author: kingshuk.sarkar@vitap.ac.in

Abstract

We investigate a system comprising two unmagnetized terminals connected by a weak-link wire where spin-orbit interaction (SOI) is active. We calculate the spin-dependent propagator (Green's function) between two points along the link and find the propagator reduces to a unitary operator while only the SOI is considered in the link therefore the spin-orbit interaction (SOI) alone cannot generate a nonzero spin current. We demonstrate that the non-zero spin current is only achieved when a Zeeman field is applied externally in conjunction with the Rashba SOI and the magnitude and the direction of the spin current is determined on the direction of the Zeeman field. We find while the Zeeman field is applied perpendicular to the direction of the effective field due to the SOI, the charge and spin current oscillate along the length of the wire. The oscillating anisotropic magnetoresistance can be compared with experiments and the strength of the SOI can be obtained. These features are tuned by applying a magnetic and electric field, which could be used for spintronics applications.

Keywords: (Spin-orbit Interaction; Zeeman Interaction; Spin Current; Green's function; Quantum Interference)

References:

[1]. S. A. Wolf, D. D. Awschalom, R. A. Buhrman, J. M. Daughton, S. von Moln´ar, M. L. Roukes, A. Y. Chtchelkanova, and D. M. Treger, Spintronics: a spin-based electronics vision for the future, Science 294, 1488 (2001).

[2]. A. Manchon, H. C. Koo, J. Nitta, S. M. Frolov, and R. A. Duine, New Perspectives for Rashba Spin-Orbit Coupling, Nat. Mater. 14, 871 (2015).

[3]. Kingshuk Sarkar, A. Aharony, O. Entin-Wohlman, M. Jonson, and R. I. Shekhter. Effects of magnetic fields on the Datta-Das spin field-effect transistor. *Physical Review B* 102, no. 11 (2020): 115436

[4]. Shekhter, R. I., O. Entin-Wohlman, M. Jonson, and A. Aharony. "Magnetoconductance anisotropies and Aharonov-Casher phases." *Physical Review Letters* 129, no. 3 (2022): 037704

The Impact Of The External Magnetic Field On D_2^+ Ion Ground State Properties In A Gaussian GaAs Quantum Dot

Siddartha Gone[1], Divya Rani Gunty[1], Madhusudan Gorre[2], Narasimha Raju Chebrolu[3*], and Aalu Boda[1*]

[1]*Department of Physics, National Institute of Technology Warangal, Hanamkonda, Telangana-506004, India.*
[2]*Department of physics, Government College (A) Anantapur, Andhra Pradesh-515001, India.*
[3]*Department of Physics, Central University of Karnataka, Kalaburagi, Karnataka-585367, India*
[1]*Corresponding Author: abdop@nitw.ac.in
[2]*Corresponding Author: narasimharaju.phy@cuk.ac.in

Abstract:

This manuscript is devoted to studying the effect of the external magnetic field on the hydrogen molecule (D_2^+) ion in a 3-dimensional Gaussian potential quantum dot. One donor impurity is assumed to be on-center, and the other can move on the positive x-axis, which is assumed to be off-center. Using the Ritz variational method, the system's ground state energy and binding energy are obtained as a function of quantum dot size, donor impurity distance, and magnetic field. The magnetic moment and magnetic susceptibility of the D_2^+ ion impurity is also calculated.

Keywords: D_2^+ ion; Gaussian quantum dot; Ritz variational method; Binding energy; Magnetic susceptibility.

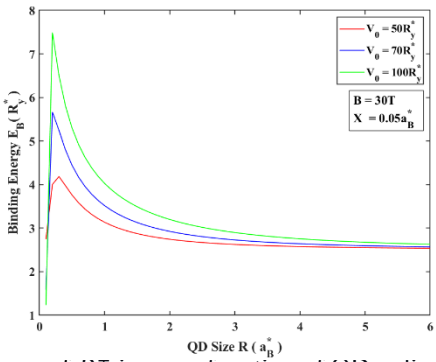


Fig. 1. The ground state binding energy of D_2^+ ion as a function of QD radius for different values of confinement depth.

References:

[1]. A. Boda, M. Gorre, A. Chatterjee, Superlattices and Microstructures 71, (2014) 261-274.
[2]. Y.A. Suaza, D. Fonnegra-García, M.R. Fulla, J.D. Salazar-Santa, J.H. Marín Superlattices and Microstructures 103, (2017) 127-138.
[3]. Y.A Suaza, D. Laroze, M. R Fulla, and J. H Marín, Chemical Physics Letters 699 (2018) 267-274.
[4]. H. Sari, and S. Sakiroglu, Physica B: Condensed Matter 669, (2023) 415291.

Theory of Thermoelectric Transport in Magnetic Graphene

Purnendu Ray[1], Kingshuk Sarkar[1,*]

[1]*Department of Physics, School of Advanced Sciences, VIT-AP University, Amaravati, Andhra Pradesh – 522237, India*

*Corresponding Author: kingshuk.sarkar@vitap.ac.in

Abstract

The thermoelectric transport properties of magnetic graphene are systematically investigated within the framework of Boltzmann transport formalism under linear response approximation. Comprehensive numerical analyses are performed to evaluate key thermoelectric coefficients, including spin-dependent and charge Seebeck coefficients, along with the thermoelectric figure of merit. Our theoretical calculations demonstrate that while conventional graphene exhibits standard temperature gradient-induced charge transport, magnetic graphene manifests distinct spin-dependent transport phenomena. Most significantly, in the case of undoped magnetic graphene, where spin-polarized carriers are distributed asymmetrically between conduction and valence bands, a pure spin current emerges in response to applied temperature gradients without accompanying charge transport. Furthermore, we studied the Wiedemann-Franz law in graphene under the influence of an external exchange field. Analytical expressions for thermoelectric coefficients are derived in both high- and low-temperature regimes utilizing Sommerfeld and binomial expansions of the Fermi integral, respectively. These findings establish a comprehensive theoretical framework for understanding spin-dependent thermoelectric phenomena in magnetic graphene, with potential implications for next-generation spintronic devices and thermal spin current applications.

Keywords: Magnetic Graphene; Seebeck Coefficient; Spin Current; Wiedemann Franzs law; Fermi Integral

References:

[1]. Castro Neto, Antonio H., et al., The electronic properties of graphene., Reviews of Modern Physics 81 (2009) 109-162
[2]. Rameshti Babak Zare, and Ali G. Moghaddam. Spin-dependent Seebeck effect and spin caloritronics in magnetic graphene., Physical Review B 91.15 (2015) 155407.
[3]. Sierra, Juan F., et al. Thermoelectric spin voltage in graphene., Nature Nanotechnology 13 (2018) 107-111.
[4]. Limelette Patrice., Thermopower, figure of merit and Fermi integrals., Scientific Reports 11 (2021) 24323.

Structural, Electronic, and Magnetic Properties of Co_2HfZ (Z = Al, Sn) Heusler Alloys for Spintronic Applications

K Venkanna[*1,2], C.H. Prashanth[*5,1], Abhijit Nayak[1], P Rambabu[3], Bheema Lingam Chittari[4], and Krishnamurthy Jyothinagaram[1]

[1]*Department of Physics, School of Sciences, National Institute of Technology, Andhra Pradesh-534101, India*
[2]*Department of Physics, SGA Government Degree College, Yellamanchili, Andhra Pradesh-531055, India.*
[3]*Department of Pure and Applied Physics, Guru Ghasidas Vishwavidyalaya, Koni, Bilaspur-495009, India.*
[4]*Department of Physical Sciences, Indian Institute of Science Education and Research Kolkata, Mohanpur,*
West Bengal -741246, India.
[5]*Department of Physics, National Sun Yat-sen Univeristy, Taiwan.*

**Corresponding Author: karumuri.venkanna@gmail.com*

Abstract

This study investigates the structural, electronic, magnetic, phonon, thermoelectric, and magnetocaloric properties of Co_2HfZ (Z = Al, Sn) full-Heusler alloys using density functional theory and Monte Carlo simulations. Both alloys show half-metallic behavior, with lattice parameters of 6.019 Å for Co_2HfAl and 6.22 Å for Co_2HfSn, and indirect band gaps of 1.02 eV and 1.61 eV, respectively, in minority spin channels. Estimated Curie temperatures are 193 K for Co_2HfAl and 394 K for Co_2HfSn. Phonon studies confirm dynamic stability, and thermoelectric analyses reveal superior performance of Co_2HfAl at high temperatures and p-type behavior in Co_2HfSn at low temperatures. The alloys demonstrate temperature-dependent magnetization and entropy changes, indicating potential in spintronics and magnetic refrigeration applications.

Keywords: Half-metallic ferromagnetism; Temperature-dependent magnetization; Relative cooling power (RCP); Spintronics; Exchange interactions.

References:

[1] L. Zhang, Y.C. Gao, Electronic structures, magnetic properties and half-metallicity in the Heusler alloy Hf2VAl, Chinese J. Phys. 55 (2017) 1466–1472. https://doi.org/10.1016/j.cjph.2017.04.012.

[2] J.P. Perdew, K. Burke, M. Ernzerhof, Generalized gradient approximation made simple, Phys. Rev. Lett. (1996). https://doi.org/10.1103/PhysRevLett.77.3865.

Topic Code: E1

Characterization and Deconvolution of Soft and Hard Magnetic Phases in Pulsed Electrodeposited Cobalt-Nickel Films.

Anand Raj, Mohanraj[1,2], Stephen, Arumainathan[1]

[1]*Materials science centre, Department of Nuclear Physics, University of Madras, Guindy Campus, Chennai 600 025, India,*
[2]*Rajalakshmi Engineering College (Autonomous), Thandalam, Chennai – 602 105, India.*

*Corresponding Author: anandraj.m@rajalakshmi.edu.in

Abstract

This work uses pulsed electrodeposition, which uses an 80% on time and 20% off time throughout an hour, to examine the magnetic characteristics of Cobalt-Nickel (Co-Ni) thick films produced on copper printed circuit boards (PCBs). Pyramid-like, anisotropic growth structures were discovered during post-deposition examination using scanning electron microscopy (SEM). Hysteresis loop magnetic deconvolution revealed discrete soft and hard magnetic phases Fig1, indicating complex domain-level interactions impacted by the film shape and deposition conditions. The Jiles-Atherton model was used to quantify the magnetic parameters for these phases, providing information about their magnetic behaviours. In this talk, the effects of deposition circumstances on the magnetic characteristics of Co-Ni films and their possible uses in precision magnetic devices will be covered.

Keywords: Cobalt-Nickel thick films, pulsed electrodeposition, SEM, magnetic deconvolution, Jiles-Atherton model, hysteresis loops.

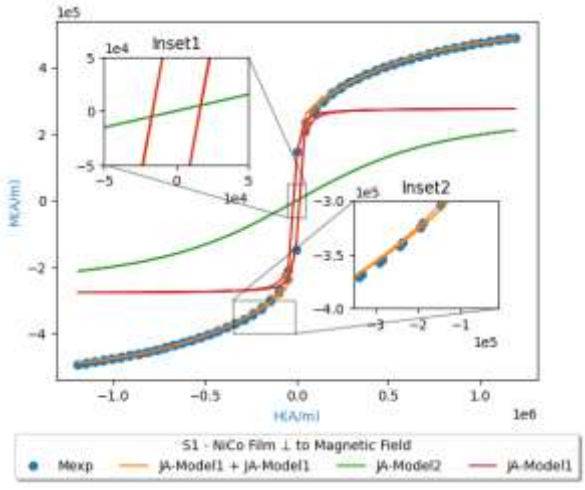


Fig1. Magnetic characterization of soft and hard phases in a Cobalt-Nickel thick film, derived from hysteresis loop deconvolution.

References:

[1]. Gyanendra Panchal, D.K. Shukla, R. J. Choudhary, V.R. Reddy, and D.M. Phase, Journal of Applied Physics 122, 085310 (2017).

Topic Code: E1

Anomalous Nernst effect in full Heusler alloy Co_2FeSb: A First Principles Study

Abhipsha Pattnaik[1], Bheemalingam Chittari[2], P. Rambabu[1]

[1]*Department of Pure and Applied Physics, Guru Ghasidas Vishwavidyalaya, Koni, Bilaspur, C. G. - 495009.*
[2]*Department of Physical Sciences, Indian Institute of Science Education and Research Kolkata, Mohanpur 741246, West Bengal, India.*
*Corresponding Author: abhipshapattnaik18@gmail.com

Abstract

Magnetic Heusler compounds are a versatile class of materials renowned for their tunability and exceptional properties [1-3]. These compounds uniquely combine magnetism with topological band structures, resulting in an exceptionally large Berry curvature (BC) [2]. Unlike time-reversal symmetric systems, magnetic materials exhibit distinctive linear response effects such as the anomalous Hall effect (AHE) and the anomalous Nernst effect (ANE). A systematic first principles study using Density functional theory (DFT) is conducted on the ferromagnetic Heusler alloy Co_2FeSb to investigate the electronic, magnetic and topological features etc. The Berry curvature driven Anomalous Nernst conductivity which is useful for energy harvesting applications is calculated for Co_2FeSb and will be discussed. The Heisenberg magnetic exchange interactions are calculated and hence the Curie temperature from the Mean filed approximation is estimated.

Keywords: Berry curvature; Anomalous Nernst conductivity, Spintronics

References:

[1]. H. F, Verh. Dtsch. Phys. Ges. 5, 219 (1903).
[2]. H. Liu, J. Liang, T. Sun, and L. Wang, Materials Today Physics 41, 101343 (2024).
[3]. K. Manna, Y. Sun, L. Muechler, J. Kübler, and C. Felser, Nature Reviews Materials 3, 244 (2018).