JAIPUR NATIONAL UNIVERSITY

in association with

Materials Research Society of India, Rajasthan Chapter

organizes

World Conference on Thermoelectrics

(WCT-2023)

Sponsored by

March 14-18, 2023

MESSAGE

I am delighted to know that Internal Quality Assurance Cell (IQAC), School of Life and Basic Sciences and School of Engineering and Technology, JNU are organizing a five-day World Conference on Thermoelectrics (WCT-2023) during March 14-18, 2023.

Humanity has been facing the challenges of energy scarcity and this is likely to worsen with time unless checked. The situation needs a radical change in the technology as about 70% of the energy is wasted in the present context machinery, vehicles, power plants and equipment. Thermoelectrics is an area which can provide solution to this situation as these materials and devices can harness the waste energy and make it useful.

Although initial studies of semiconductor materials and thermoelectric materials started simultaneously in 1960 but full potential of thermoelectric materials and devices is yet to be unraveled. Hence, this area needs to be worked rigorously.

I congratulate the organizers to choose such an area of Research and Development as the theme of the conference which will change the tectonic footings of the human understanding and provide a cheaper energy available almost at the half of the present day price.

I thank Materials Research Society, Rajasthan Chapter for associating in the organizing of this conference. I also thank the Science and Engineering Research Board (SERB), Department of Science and Technology (DST), Board of Research in Nuclear Science (BRNS), Department of Atomic Energy (DAE) and Council of Scientific & Industrial Research (CSIR), Government of India, New Delhi for financially supporting this conference.

Dr. Sandeep Bakshi
Chancellor

CHANCELLOR MESSAGE

Dr. Sandeep Bakshi

MESSAGE

I am happy that IQAC, School of Life and Basic Sciences and School of Engineering and Technology, JNU are organizing a five day World Conference on Thermoelectrics (WCT-2023) during March 14-18, 2023.

The technological changes in the world are very rapid and to tune with them such events are very useful. This Conference is aimed to drive innovations in the field Thermoelectrics and Materials and to provide an opportunity for a galaxy of leading scholars to present and share their research findings.

I sincerely hope the deliberations in different sessions will create awareness towards the dynamics of the Thermoelectrics and Material Sciences sector in different domains.

Our sincere thanks to all the participants and invited speakers and to all those who have had a hand in shaping it and contributed their mind to make the conference success.

I wish the World Conference on Thermoelectrics (WCT-2023) a grand success.

Prof. H. N. Verma
Pro-Chancellor

PRO-CHANCELLOR MESSAGE

Prof. H. N. Verma

MESSAGE

Greetings to all the invitees and delegates of WCT 2023!

I am happy that IQAC, School of Life and Basic Sciences and School of Engineering and Technology, JNU are organizing a five day World Conference on Thermoelectrics (WCT-2023) during March 14-18, 2023.

Recovery of waste energy is the most needed domain of present day research and development. Innovations in this domain will prove to be engines of growth. Hence the conference on Thermoelectrics and Materials is an event which will prove to speed up the process of design and development of new systems and measures for waste heat recovery.

I am quite confident that the discussions and deliberations on the conference theme and its different facets by eminent scientists, academics, budding scholars, industry professionals, planners, and policy makers, will go a long way in achieving not only the conference goals but get us closer to fully understanding the areas where innovations will bring positive revolution in various fields of Thermoelectrics and Materials.

On behalf of entire JNU Community, I extend a warm welcome to all the delegates, invited guests, speakers and participants and wish them a rewarding professional experience. Wish the conference a huge success.

Prof. R. L. Raina
Vice-Chancellor

VICE-CHANCELLOR MESSAGE

Prof. R. L. RAINA

MESSAGE

It is our humble privilege to cordially welcome all the participants of World Conference on Thermoelectrics (WCT-2023) during March 14-18, 2023 at Jaipur National University (JNU), Jaipur, India. It is a continuation of the series of conferences held on the theme Micro and Nano Electronic Devices and Systems earlier at Jaipur during last decade. The WCT 2023 is organised by the Material Research Society of India, Rajasthan Chapter and JNU Jaipur.

The themes of the WCT- 2023 consists of the emerging and cutting edge research and development topics of thermoelectrics, materials, devices, and related applications for energy harvesting including related Processing Strategies, Advanced Fabrication and Characterization, and other Materials-Related Interdisciplinary Areas.

This series of meetings has been a wonderful and exciting platform for exchange of high quality ideas and cutting-edge scientific research by the researchers and scientists from both academia and industries, helping all the stakeholders, including students and researchers for networking and collaborations. We sincerely believe that the scientists actively engaged in research of Thermoelectrics and materials will greatly benefit by participating in the meeting and gain deeper academic insights enabling towards developments beneficial to the society at large.

The Organizing Committee of the WCT-2023 welcomes you all.

Prof. Y.C. Sharma
Chair and Convener, WCT-2023
Director, Research & Academic Development
Jaipur National University, Jaipur
Treasurer, MRSI-Rajasthan Chapter
Vice President, IAPT-RC6

CHAIR & CONVENER, WCT-2023
MESSAGE

Prof. Y.C. Sharma

ABOUT THE UNIVERSITY

Jaipur National University came into existence in October, 2007 and is offering several technical and professional programmes. With more than 8000 students and around 600 faculty members, the University is offering number of Under Graduate, Post Graduate and Doctoral Programmes in streams, like Engineering, Pharmacy, Life and Basic Sciences, Business & Management, Education, Law, Mass Media, Hotel Management, Computer and System Sciences, Language, Social Sciences, Nursing, Medical and Para-Medical Courses. All the technical and professional programmes are approved by various regulatory bodies - AICTE, NCTE, BCI, INC, PCI and MCI.

The University is accredited by the National Assessment and Accreditation Council (NAAC), only after 7 years of establishment. The University once again has been ranked (India Today Survey 2019) among the top 25 best Private Universities of India.

The University is making continuous efforts whereby the institution can take a lead in defining and determining the quality research. We are trying to nurture the students as per the national priorities. The University has maintained high standards of teaching and research. Qualified and experienced faculty adorns its classrooms. JNU meets the demands and challenges of knowledge and learning of life-skills of students, with a difference. Quality education, merit, transparency and fulfilment of social responsibilities are the hallmarks of the University.

The focus is not just on education alone, but also on the development of key skills required to confront the challenges of life. The University believes in holistic education, enabling the students to think logically, judge & communicate critically.

With world class infrastructure and outstanding academic support services around the Campus, Jaipur National University has gained wide international exposure and recognition and has become home to hundreds of students, including those from Romania, Nepal, Malaysia, Africa, Dubai and Nigeria in pursuit of meaningful academic experience. Academic tie-ups with many national and international institutions provide a unique opportunity to the students and teachers for academic enhancement. Organisation of National and International Conferences/ Seminars at regular intervals is a regular feature of Jaipur National University. The holistic approach adopted by the University has resulted in proud placements of the students in top-notch companies. Students are absorbed at coveted positions in reputed corporate business houses and research institutions. A small percentage of enterprising students opt to form their own ventures.

JNU Hospital & Medical College is also a part of the illustrious Jaipur National University. With the Mission to create, uphold and develop an ideal academic environment for undergraduate and postgraduate quality medical education and research, the Medical College was established and received the MCI permission for the 1st batch in 2016-17. The Medical College has also received the approval of the Government and the MCI for 150 seats in MBBS for the consecutive batches.

The JNU Hospital boasts of world class environment, friendly infrastructure, cutting edge technology, highly experienced and qualified faculty and skilled paramedical staff who work with motto "care with compassion".

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Jaipur National University, Jaipur

World Conference on Thermoelectrics (WCT-2023)
from March 14 - 18, 2023

Programme Schedule			
Day 1 : March 14, 2023 (Tuesday)			
11:00 AM to 12:00 Noon	**Inaugural Session**		
12:00 Noon to 01:00 PM	**Lunch**		
01:00 PM to 03:30 PM	**Session-I**	**Chair**	Prof. Y.K. Vijay, President, Rajasthan Chapter of MRSI
		Co -Chair	Dr. K. Sachdeva, MNIT, Jaipur
Time	**Topic**	**Speaker**	
01:00 PM to 01:30 PM	Topological phase transition and selective charge Anderson localization as a route to enhance thermoelectric performance	Prof. Jong -Soo Rhyee, Kyung Hee University / College of Applied Sciences, South Korea	
01:30 PM to 02:00 PM	Recent advances on organic solar cells based on non-fullerene acceptors: materials design and device optimization	Prof. G D Sharma, LNMIIT, Jaipur	
02:00 PM to 02:30 PM	Recent Development on Quantum Materials for Device Application	Prof. Kedar Singh, JNU, Delhi	
02:30 PM to 03:00 PM	Lightweight Magnesium -based Thermoelectric Generators: Prototypes, Analysis, Challenges and Prospects	Prof. Johannes de Boor, Thermoelectric Materials and Systems, German Aerospace Center, Germany	
03:00 PM to 03:30 PM	Effect of Higher -Oxidation State Cations Substitution on the Thermoelectric Properties of n -Type $CuFeS_2$ Chalcopyrite	Dr. Sahil Tippireddy, Senior Support Scientist, Diamond Light Source, UK	
03:30 PM to 04:00 PM	**Tea**		

Day 2 : March 15, 2023 (Wednesday)			
11:00 PM to 12:30 Noon	**Session - II**	**Chair**	Prof. Y.K. Vijay, President, Rajasthan Chapter of MRSI
		Co-Chair	Prof. Ramphal Sharma, IIS University, Jaipur
Time	**Topic**	**Speaker**	
11:00 AM to 11:30 AM	Unravelling problems in materials via X-ray Emmission Techniques using probes such as photons,protons and synchrotrons	Dr. Daisy Joseph, BARC	
11:30 AM to 12:00 PM	Necessity of Indian Reference Materials for Technological Applications	Dr. Anuj Krishna, NPL	
12:00 PM to 12:30 PM	Economical and Sustainable Development of Nanostructured Semiconductor Thin Films for Photovoltaic, Gas Sensors, and Energy Storage Applications	Prof. Ramphal Sharma, IIS University, Jaipur	
12:30 PM to 01:30 PM	**Lunch**		
01:30 PM to 03:00 PM	**Session -III**	**Chair**	Dr. Daisy Joseph, BARC
		Co-Chair	Dr. Anuj Krishna, NPL
01:30 PM to 02:00 PM	Teaching Condensed Matter using Physical Models	Prof. Y.K. Vijay, President, Rajasthan Chapter of MRSI	
02:00 PM to 02:30 PM	Combined structural and electronic characterization on the micro/nanoscale of magnesium silicide-based materials using Kelvin probe force microscopy, first principle calculations and SEM/EDX	Dr. Sanyukta Ghosh, German Aerospace Centre, Germany	
02:30 PM to 03:00 PM	Thin Films of metal-carbon Nanocomposite for SPR-based Sensing	Dr. Rahul Singhal, MNIT, Jaipur	
03:00 PM to 04:30 PM	**Session - IV**	**Chair**	Dr. Daisy Joseph, BARC
		Co-Chair	Dr. Rahul Singhal, MNIT, Jaipur

	Oral Presentation (10 Minutes for Each Presentation)	
03:00 PM to 04:30 PM	Role of Nanomaterial in Solar Cell	Vrinda Joshi
	MXene reinforcement in perovskite oxide for thermoelectric power generation	Pragya Dixit
	Impact of electronic defects on the thermoelectric properties of Ni doped Cu_2Se	Parvathy T
	Enhanced thermoelectric properties of aluminium and copper doped ZnO	Soumya C
	Enhancement of Thermoelectric power factor due to the inclusion of Cobalt ferrite in ZnO matrix	Hashir P
	Band structure modification and enhanced thermoelectric properties of Mg-N co doped $CuCrO_2$ thin films	Jamshina Sanam P.K
	Structural and Thermoelectric properties of burial sintered Pr doped $SrTiO_3$ crystallites	Midhun Shah
	Effect of Mechanical and Durability Properties of Recycled Aggregate Concrete by using of Supplementary Cementitious Materials and Steel Fiber	Om Prakash Singh
04:30 PM to 05:00 PM	Tea	

Day 3 : March 16, 2023 (Thursday)			
11:00 AM to 12:30 Noon	Session -V	Chair	Dr. Raj Kishora Dash, University of Hyderabad
		Co -Chair	Dr. Govind Gupta, NPL
Time	Topic	Speaker	
11:00 AM to 11:30 AM	Structural transformation with Local structure determination and Exchange Bias in Nanoparticles of Fe doped $NiCr_2O_4$ Nanoparticles	Dr. Chandana Rath, IIT BHU	
11:30 PM to 12:00 PM	Investigation of Electron-Phonon Coupling Effects on Materials Properties using Density Functional Theory based EPW Code	Dr. Rekha Verma, IIIT Allahabad	

12:00 PM to 12:30 PM	Engineering Thermoelectric transport in oxides	Dr. Vinayak Kamble, IISER, Thiruvananthapuram	
12:30 PM to 01:00 PM	Lunch		
01:00 PM to 02:30 PM	Session-VI	Chair	Dr. Chandana Rath, IIT BHU
		Co-Chair	Dr. Rekha Verma, IIIT Allahabad
01:00 PM to 01:30 PM	Development of Wearable Thermoelectric Generator for Converting Human Body Temperature to Electrical Energy	Dr. Raj Kishora Dash, University of Hyderabad	
01:30 PM to 02:00 PM	Titanium Nitride-based EGFET pH sensor for Chemical/Biochemical Sensing Application	Dr. Ravindra Mukhiya, CEERI, Pilani	
02:00 PM to 02:30 PM	Development of Highly Responsive Optoelectronic Devices based on Semiconductor Heterostructures	Dr. Govind Gupta, NPL	
02:30 PM to 04:00 PM	Session-VII	Chair	Dr. Ravindra Mukhiya, CEERI, Pilani
		Co-Chair	Dr. Govind Gupta, NPL
02:30 to 04:00 PM	Poster Session		
	Synthesis and characterization of Bismuth Telluride alloy based nanocomposites with multiwalled -CNT nanoinclusions	Monika Gandhi	
	Transition Metal Calcogenide Perovskites for Energy Applications	Sanjukta Mukherjee	
	Electronic and thermal transport properties of Co_{4-x} Al_xSb_{12} (x = 0, 0.08, 0.12)	Akshara Dadhich	
	Tea dye adsorbed cellulose as triboelectric nanogenerator; a novel energy harvesting method	Hisna P A	

	Thermoelectric study of manganate -based high entropy oxide	Vivek Kumar	
	Enhanced thermoelectric performance of Bi_2S_3 by band structure modification using Hallide doping	Farheen Anjum	
	Frequency Dependence Dielectric Properties of Gluten free grains at Microwave Frequency	Swechchha Gupta	
	Study of Structrual Proerties of Bi_2Te_3 / Sb_2Te_3 Multi Layer Periodic Thin Films	Manisha Kumari	
	Thermoelectric Properties of Bi_2Se_3 Thin Films	Harsha Sharma	
	Study of Dielectric Properties of Pomegranate at Different Frequencies	Ruchi Kulhar	
04:00 PM to 04:30 PM	**Tea**		
Day 4 : March 17, 2023 (Friday)			
11:00 AM to 12:00 Noon	**Session - VIII**	**Chair**	Dr. Pandiyarasan Veluswamy, IIITDM
		Co -Chair	Dr. Vinayak Kamble, IISER, Thiruvananthapuram
Time	**Topic**	**Speaker**	
11:00 AM to 11:30 AM	Enhanced Thermoelectric Properties of Oxides, Nitrides, Selenides and Tellurides	Prof. P. P. Pradyumnan, University of Calicut	
11:30 AM to 12:00 PM	In-situ Probing of Complex Intermolecular Interactions in a Ternary Molecular System of Ions, Water and Polymer Macromolecule	Dr. K C Jena, IIT Ropar	
12:00 PM to 01:00 PM	**Lunch**		
01:00 PM to 02:30 PM	**Session - IX**	**Chair**	Prof. P. P. Pradyumnan, University of Calicut
		Co -Chair	Dr. K C Jena, IIT Ropar
01:00 PM to 01:30 PM	Flexothermoelectric Generator on Smart Shoe	Dr. Pandiyarasan Veluswamy, IIITDM	

01:30 PM to 02:00 PM	Prompt Gamma Ray Neutron Activation Analysis Technique Based on Isotopic Am -241-Be-9 Neutron Source	Dr. Dalpat Meena, University of Rajasthan, Jaipur	
02:00 PM to 03:30 PM	Session -X	Chair	Prof. R. K. Khanna, Former Principal, Govt. College, Ajmer
		Co -Chair	Dr. Dalpat Meena, University of Rajasthan, Jaipur
02:00 PM to 03:30 PM	Oral Presentations (10 Minutes for Each Presentation)		
	Waste Heat Recovery Using Oxide based nano -composites for High Temperature Thermoelectric Power Generator	Subhra Sourav Jana	
	Study of annealing effects on structural , morphological and Optical properties of Pure SnO_2 Thin film	Muskan Jindal	
	Study of Effects of Annealing on Structural, Optical and Electrical Properties of ZTO (Zinc Tin Oxide) Thin Films	Jaya Raisinghani	
	Ananas Comosus Leaves Extract as Agent in Synthesis of Zn_1 - x Ni x O(X=0, 0.07) NP's and XRD, UV -Vis & SEM -EDX Studies	Pankaj Srivastava	
	The effect of Multi - Walled Carbon Nanotubes (MWCNT) on thermoelectric properties of Copper Selenide in enhancing power factor	Rapaka Siva Sankar	
	Design and Fabrication of Sb_2S_3 for the Opto - thermoelectric Applications	S.Nanthini	
	Hybrid photothermal power generation using fabric -based photon capture	Anshu Panbude	
	Experimental study on mechanical strength and slump properties of concrete by partial	Jitendra Kumar Mishra	

	replacement of cement by rice husk ash		
	P-N Junction Thermoelectric Generator with Ultrahigh Output Power for Wearable Devices	Suhasini S	
	Cellulose fabric with Boron doped Al_2Fe_3 nanostructure by Hydrothermal process for wearable applications	Aiswarya M	
03:30 PM to 04:00 PM	**Tea**		
Day 5 : March 18, 2023 (Saturday)			
11:00 AM to 12:00 Noon	**Session -XI**	**Chair**	Prof. H N Verma, Pro -Chancellor, JNU, Jaipur
		Co-Chair	Dr. Daisy Joseph, BARC
Time	**Topic**	**Speaker**	
11:00 AM to 11:30 AM	Defects and Interface Engineering to Realize High Performance Thermoelectric Materials & Power Generators	Dr. Ajay Singh. BARC	
11:30 AM to 11:45 AM	Address by Guest of Honor	Dr. Daisy Joseph, BARC	
11:45 AM to 12:00 PM	Address by Chief Guest	Prof. H N Verma, Pro -Chancellor, JNU, Jaipur	
12:00 PM to 01:00 PM	**Lunch**		

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20.	Flexothermoelectric Generator on smart shoe	Prof. Pandiyarasan Veluswamy, Shanmukha Priya K, Anshu Panbude, Suhasini Sathiyamoorthy
21.	Prompt gamma ray neutron activation analysis technique (PGAA) based on isotopic 241 Am- 9 Be neutron source	Dr Dalpat Meena
22.	Low Thermal Conductivity and Thermoelectric Properties of Thalium Selenide	Dr Siddu Matteppanavar
23.	Defects and interface engineering to realize high performance thermoelectric materials & power generators	Dr Ajay Singh
24.	Waste Heat Recovery Using Oxide based nano-composites for High Temperature Thermoelectric Power Generator	Mr. Subhra Sourav Jana, Tanmoy Maiti
25.	Electronic and thermal transport properties of Co_4-xAlxSb$_{12}$ (x = 0, 0.08, 0.12)	Ms Akshara Dadhich, K. Sethupathi, and M.S. Ramachandra Rao
26.	Impact of electronic defects on the thermoelectric properties of Ni doped Cu_2Se	Ms Akshara Dadhich, K. Sethupathi, and M.S. Ramachandra Rao
27.	Tea dye adsorbed cellulose as triboelectric nanogenerator; a novel energy harvesting method	Ms Hisna P A, P.P. Pradyumnan
28.	Enhanced thermoelectric properties of aluminium and copper doped ZnO	Ms Soumya C, P.P. Pradyumnan
29.	The effect of Multi-Walled Carbon Nanotubes (MWCNT) on thermoelectric properties of Copper Selenide in enhancing power factor	Mr. Rapaka Siva Sankar, Sharmistha Anwar, Shahid Anwar
30.	Enhancement of Thermoelectric power factor due to the inclusion of Cobalt ferrite in ZnO matrix	Mr. Rapaka Siva Sankar, Sharmistha Anwar, Shahid Anwar
31.	Band structure modification and enhanced thermoelectric properties of Mg-N co doped $CuCrO_2$ thin films	Shah, P.P.Pradyumnan
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33.	Thermoelectric study of manganate-based high entropy oxide	Mr. Vivek Kumar
34.	Enhanced thermoelectric performance of Bi_2S_3 by band structure modification using Hallide doping	Ms Farheen Anjum, Tanmoy Maiti
35.	Study of annealing effects on structural , morphological and Optical properties of Pure SnO_2 Thin film	Ms Muskan Jindal
36.	Study of Effects of Annealing on Structural, Optical and Electrical Properties of ZTO (Zinc Tin Oxide) Thin Films	Ms Jaya Raisinghani, Akansha Khandelwal
37.	Role of Nanomaterial in Solar Cell	Ms Vrinda Joshi
38.	Frequency Dependence Dielectric Properties of Gluten free grains at Microwave Frequency	Ms Swechchha Gupta, Ritu Jain and Nidhi Bhargava
39.	Study of Dielectric Properties of Pomegranate at Different Frequencies	Ms Ruchi Kulhar, Mukesh Kumar Alaria, Nidhi Bhargava and Ritu Jain
40.	Synthesis and characterization of Bismuth Telluride alloy based nanocomposites with multiwalled-CNT nanoinclusions	Mrs. Monika Gandhi, Kavita Laspal, Parmatma Sharan, Hemant Sharma

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Enhanced Thermoelectric Properties of Oxides, Nitrides, Selenides and Tellurides

P.P. Pradyumnan

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Thermoelectrics have received an overwhelming interest in the renewable energy field because they can efficiently maximize the utilization of waste heat without the requirement of moving components and greenhouse gas emissions. This presentation aims to provide an overview of the thermoelectric phenomena, materials, and novel approaches utilized to improve thermoelectric device performance. TE material with large conversion efficiency is essential for the development of TE devices for commercial applications. However, the low efficiency of these materials is due to the interdependency of the transport parameters limiting their wide scale development. Different strategies like nano structuring, doping, optimizing the structure, band engineering etc. are employing to obtain high conversion efficiency of thermoelectric materials. Nanostructured materials such as nano wires and thin films offer the possibility to cover large areas with a low quantity of materials. Thus, the synergistic optimization of these interconnected transport parameters leads to the enhancement in the performance of thermo electrical materials. The improvement obtained in the thermoelectric performance of nitrides, tellurides, sulfides, selenides, and oxides by adopting various strategies was discussed. This shows that different strategies like doping, quantum confinement, band engineering, nanostructuring, etc can be efficiently utilized for the enhancement of thermoelectric conversion efficiency by optimizing the electrical conductivity, Seebeck coefficient, and thermal conductivity. The development of such highly efficient n-type and p-type TE materials is essential for the fabrication of TE modules for device applications.This talk provides an advanced understanding of thermal and electrical transport properties of the thermoelectric materials undergone by my research group, opening up new avenues for increasing thermoelectric performances of sustainable energy materials.

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Unravelling problems in materials via X-ray Emission Techniques using probes such as photons, protons and synchrotrons

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Enzymes of trace elements are an important part of certain biological and chemical reactions. They work in harmony with pro¬teins and often with certain other co enzymes. They attract substrate molecules and enable their conversion to a specific end product. Some trace elements are involved in redox reactions. Modern day diet, comprising of refined foods is a cause of concern, as it may not have a sufficient amount of these trace elements. Dietary supplements may be required to combat this shortage. The present paper therefore discusses trace elements, and its effects in unraveling biological problems and challenges. Thus, a comprehensive under¬standing of these trace elements is essential and significant for disease control and for maintaining optimal health.

Keywords:

Enzymes; EDXRF; Proton Induced (PIXE); Synchrotron Induced (EXAFS).

Topological phase transition and selective charge Anderson localization as a route to enhance thermoelectric performance

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Topologically protected materials system generally share commonalities with good thermoelectric materials because of their narrow band gaps and heavy constituent elements. Here we propose that a topological crystalline insulator (TCI) and Dirac semimetal could exhibit a high thermoelectric performance by breaking its crystalline symmetry and tuning chemical potential by elemental doping. As a candidate material, we demonstrate that a weak disordering in the topological crystalline state can enhance thermoelectric performance significantly due to highly dispersive band dispersion and high band degeneracy which guarantee high electrical mobility and a high Seebeck coefficient, respectively. In addition, we demonstrate selective charge Anderson localization as a route to maximize the Seebeck coefficient while simultaneously preserving high electrical conductivity and lowering the lattice thermal conductivity. We confirm the viability of interface potential modification in an n-type Bi-doped PbTe/Ag2Te nanocomposite, and the resulting enhancement in thermoelectric figure-of-merit ZT. The introduction of random potentials via Ag2Te nanoparticle distribution using extrinsic phase mixing was determined using scanning tunneling spectroscopy measurements. When the Ag2Te undergoes a structural phase transition (T > 420 K) from monoclinic β-Ag2Te to cubic α-Ag2Te, the band gap in the α-Ag2Te increases due to the p-d hybridization. This results in a decrease in the potential barrier height, which gives rise to partial delocalization of the electrons, while wave packets of the holes are still in a localized state. Using this strategic approach, we achieved an exceptionally high thermoelectric figure-of-merit in n-type PbTe materials, a ZT greater than 2.0, suitable for waste heat power generation.

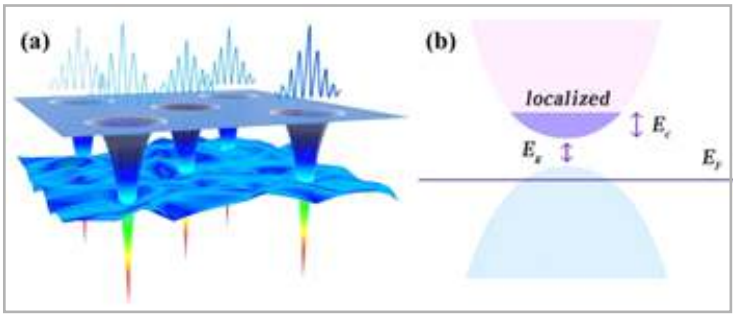

Fig. 1. Schematic representation of selective Anderson localization of electron (a) and its band diagram (b).

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Recent advances on organic solar cells based on non-fullerene acceptors : materials design and device optimization

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Bulk heterojunction (BHJ) organic solar cells (OSCs) haveattracted much attention due to advantages of flexibility, lightweight, and large area that is compatible to roll-to-roll printing,which would impart the green energy technology with low costpotential. In a BHJ -OSC whose active layer is composed bydonor and acceptor phases, the nanoscale morphology of theactive layer provides important pathways for charge generations,carrier transports, and collections at electrodes, which would significantly influence the photovoltaic performance. After the optimization of chemical structures of organic semiconductors (donor and acceptor as p-type and n-type organic semiconductors, respectively), nanoscale BHJ active layer morphology and interface engineering of devices, power conversion efficiency has been increased from 2 % in 2001 to over 19 % in 2022 for binary as well as ternary based OSCs has been achieved at low cost of fabrication. The cost of fabrication of these solar cells is 10 to 20 times lower that of present conventional solar cells based on silicon based solar cells.

In this lecture, the various low bandgap/wide bandgap conjugated polymers and small molecules as donor and non-fullerene small molecule acceptors employed for the organic solar cells will be described. Different types of mechanisms occurring in the binary and ternary BHJ based organic solar cells will be presented. Different methods adopted for the fabrication of the organic solar cells will be summarized.

Recent Development on Quantum Materials for Device Applications

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Quantum material such as semiconducting quantum dots (QDs) have shown great promise as tunable light absorbing and/or emitting layers in LED devices and displays, in photovoltaics and imaging. Semiconducting quantum dotare also important for fundamental and technological view points. Quantum confinement effects are known to enhance exchange interactions and induce magnetic properties that were previously not observed in bulk materials. Ultrafast transient absorption (TA) spectroscopy has been carried out to study the charge carrier dynamics of CdSe core and CdSe/V2O5 core/shell quantum dots (QDs). A significant red-shift accompanied by broadening in the first excitonic peak was observed in the UV-Vis absorption spectra of the core/shell QDs as the shell thickness increases. This interesting observation is related to a quasi-type-II alignment characterized by the spatial separation of an electron into the core/shell and a hole into the core. The observed optical excitonic spectra have further been used to study the energetic of CdSe and charge separated states with the concept of Marcus theory and confirmed that electron transfer takes place in the Marcus inverted region .Moreover, the growth kinetics of the CdSe core and CdSe/V2O5 core/shell QDs, studied with TA spectroscopy, exhibits slow electron cooling in core/shell QDs because of the de-coupling of the electronic wave functions with their hole counterpart. These exciting properties reveal a new paradigm shift from CdSe QDs to CdSe/V2O5 core/shell QDs for highly suitable applications in photovoltaics (PV) and optoelectronic devices. Chemically prepared Fe doped CdSe (Fe: CdSe) QDswere isolated as ~3 nm in the diameter with a wurtzite crystal structure. The oxidation state of Fe was confirmed by electron paramagnetic resonance (EPR) spectroscopy, from which it is evident that iron is in Fe+3oxidation state. Magnetic properties of Fe: CdSe QDs explored by superconducting quantum interference device, reveal multiple magnetic transitions.

Perovskite quantum material CsPbBr3 was synthesized by hot injection method and investigated experimental tools and theoretical approaches. It is found that magnetic properties occurs dur to lattice distortion induced change in Br-defects in CsPbBr3 perovskite quantum materials.

Lightweight magnesium-based thermoelectric generators : prototypes, analysis, challenges and prospects

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Magnesium silicide based solid solutions Mg2X (X = Si, Ge, Sn) are among the most promising thermoelectric (TE) materials for the temperature range of 500 K to 800 K, where a large fraction of the reusable waste heat is available. Very good TEproperties have been demonstrated repeatedly, especially for n-type Mg2X. This, combined with a high material availability, low cost of raw materials and environmental compatibility, makes these materials preferred candidatesfor large scale applications.

We have fabricated TEG module prototypes from optimized powder-compacted n- and p-type Mg2Si1-xSnx.These show efficiencies approaching 4% for T_c=300 K and T_h=673 Kand a power density of 0.9 W/cm²related to the TE leg area. This is the first reported efficiency result for anentirely Mg2X-based TEG and is among the best for TEG from sustainable and readily available materials. Measured module parameters (open circuit voltage, optimum current, power output, heat flow, inner resistance) are compared with predictions from a constant property model based on measured material and interface properties. We'll also show how to capture a possible process-related or intended inhomogeneity of the thermoelectric legs by employing a coupledmaterial-device model. This analysis allows to identify and assess potential loss and degradation mechanisms, including change of the functional material properties due to thermal load and TE material/electrode interaction, like crack development or charge carrier compensation.Approaches to overcome these challenges ranging from coating of the material surfaces to electrode design and modifications of the module assembly processare analyzed for their effectiveness. This will pave the way towards long-term stable modules exceeding 5% conversion efficiency.

Finally, the effect of substituting p-type Mg2X by the more performant, but less sustainableMgAgSb is discussed. MgAgSb is a technologically challenging material, but with an optimized synthesis route module efficiency>6% at T_h=563 Kwas demonstrated, surpassing commercial (Bi,Sb)2(Te,Se)3-based modules.

Effect of Higher-Oxidation State Cations Substitution on the Thermoelectric Properties of n-Type $CuFeS^2$ Chalcopyrite

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$CuFeS^2$, chalcopyriteis considered one of the promising n-type thermoelectric materials with high natural abundance as a mineral.We have utilized substitution of higher-oxidation state cations at the Cu and Fe sites to optimize the charge carrier concentration and transport properties of $CuFeS^2$ via the preparation of Cu1-xSnxFeS2and CuFe1-xGexS2($0 \leqslant x \leqslant 0.1$).
Substitution of Sn in Cu1-xSnxFeS2leads to the creation of small polarons, involving localized Fe^2+ states, which reduce the free-carrier concentration from the expected value, contributing to the maintenance of a relatively high Seebeck coefficient, despite the reduction in electrical resistivity. Sn substitution also induces a high level of mass and strain field fluctuation, leading to lattice softening and enhanced point-defect scattering. This, together with dislocations and twinning, leads to scattering of phonons with a wide range of mean free paths.Consequently,a maximum zT ~ 0.3 at 673 K is, therefore, achieved forCu0.96Sn0.04FeS2.In the case ofCuFe1-xGexS2, germanium is found to be present in two oxidation states: Ge2+ and Ge4+, substituting at the Fe site. The stereochemically-active 4s2 lone-pair electrons of Ge2+ induces a local structural distortion,wherebysome of the germanium ions are displaced from the centre of the GeS4 tetrahedron towards a triangular face, leading to pseudo-trigonal pyramidal coordination. This distortion is accompanied by lattice softening and an increase of the strain-fluctuation scattering parameter, leading to a substantial decrease in thermal conductivity. This, combined with an almost three-fold improvement in the power factor due to carrier concentration optimization, leads to a maximum zT ~ 0.4 at 723 K for CuFe0.94Ge0.06S2.

Our results provide new insights into the dynamical properties of these materials and further our understanding of the behaviour of the electrical and thermal properties in substituted chalcopyrite phases.

Necessity of Indian Reference Materials for Technological Applications

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Abstract -

Reference materials are of great importance owing to their usage in standardization of sophisticated instruments, to ensure safety and maintain quality of materials, food products etc. which in turn leads to improvement in quality infrastructure of our country. National Metrology Institutes (NMIs) throughout the world like NIST - USA, KRISS - Korea etc. are making efforts for the development of Certified Reference Materials in pioneering state - of - art areas. Similarly, CSIR-National Physical Laboratory (NPL), NMI of India also initiated efforts for the development of Bharatiya Nirdeshak Dravyas (BNDs) - Indian Reference Materials to boost "Make in India" program in many technological areas. The present talk focuses mainly on role of reference materials, their impact on society and efforts of CSIR-NPL for development of Reference Materials in various areas presently. Many novel approaches that may be utilized for wide variety of materials in single crystalline, powder form to enhance their properties that is required for the development of reference materials for various applications shall be presented.

Keywords: Reference Material, National Metrology Institutes, Crystalline, Bharatiya Nirdeshak Dravyas.

Economical and Sustainable Development of Nanostructured Semiconductor Thin Films for Photovoltaic, Gas Sensors, and Energy Storage Applications

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Nanostructured thin film technology has progressed rapidly in the direction of thin film coating and also has been developed for the need of the industry. Nanostructured thin film technology is pervasive in many applications, optoelectronics, optical coatings (anti-reflection coatings), magnetic films (data storage), environmental (smart window),energy (solar cells, batteries), gas sensors, and super hard coatings, etc. Energy is essential for economic development and growth. Especially with the development of nanotechnology, electrochemical, and material science, interest in research and production of both efficient and lower-cost semiconductor thin film materials is increasing progressively. With the rapid growth of development and the drive to expand the economy, society demands more electricity. Solar energy is the most prolific method of energy capture in nature. However, the economic drive to make solar cells more cost effective and efficient has driven developments in many different deposition technologies, including dipping, plating, thick film deposition and thin film deposition. The use of nanostructured thin films for efficient use of solar cells in production of n& p-type semiconductor materials is one of the most important sources of energy and new-generation energy. Energy storage can be most practically realized by electrochemical storage technologies using reversible conversion of chemical to electrical energy. In this sector, Lithium-ion battery (LIBs) is the good alternative energy storage device option compared to the other energy storage systems. Furthermore, it is lightweight, non-toxic, has high power and energy density and longer cycle lifetime compared to other energy storage devices. We have developed thin films of TiO_2, $LiMn_2O_4$, and MnO_2 electrode materials by employing simple, green and cost-effective methods and exploring them into energy storage devices. It shows the reversible specific capacity of 206 mAh g-1 at a current density of 33 mA g-1 and it is comparatively higher than the earlier literature reports.

Pure and doped SnO_2 nanoparticles thin films have been synthesized using remnant water collected from soaked Bengal gram beans extract. The synthesis method described in this work is facile and versatile, providing opportunities to control the morphology of various other semiconducting metal oxides, with particular promise for application in gas sensors. The pure and doped biosynthesized SnO_2 nanoparticles were coated onto the glass substrate using doctor blade method to form thin films. These thin films were investigated for their gas sensing properties and were found to be highly sensitive to different gases. The pure SnO_2 sample showed a response of 34% for 600ppm NH_3 at room temperature (~30 °C). With cobalt doping, this response got enhanced to 43% for 100ppm NH_3 gas at room temperature. The gold and nickel doped SnO_2 thin films were found to be sensitive to NO_2 gas at 200 °C operating temperature. The gold doped SnO_2 exhibited a response of 30% while Ni-doped SnO_2 showed 40% response. The Cu doped SnO_2 thin films were found to be highly sensitive to H_2S gas at 200 °C operating temperature. It gave a response of 38.33% for 100ppm H_2S gas. Considering the indicated trends and energy requirements, it has been important to transfer this technology in detail regarding the surface technologies related to the semiconductor materials produced with thin film technologies instead of bulk materials.

Structural transformation with Local structure determination and Exchange Bias in Nanoparticles of Fe doped NiCr2O4 Nanoparticles

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Transition metal based spinel oxides, ACr2O4, Cr3+ ions forms a pyrochloresublattice, surrounded by octahedral network of oxygen anions, while A2+ ions occupy tetrahedral network of oxygen anions and forms a diamond sublattice.1,2 What makes these chromium based spinel oxides so important, is the ability to tune their structural and magnetic properties in an additional way by adjusting the magnetic and chemical nature of A2+ ions. In NiCr2O4, when A2+cations are Ni2+, the orbital degeneracy induced cooperative Jahn-Teller distortion results in a cubic to tetragonal structural transition above 320K and transforms into an orthorhombic phase at Curie temperature (TC ~ 71 K).3 Below TC, distortion within orthorhombic structure gives rise to a spin spiral ordering at ~ 31 K, known as spiral ordering temperature (TS). Thus, the competition between AFM between Cr3+ ions and FM ordering among A2+ ions results in some peculiar magnetic properties like negative magnetization, exchange bias effect etc.

Here, in this report, the structural and magnetic phase transitions in NiCr2O4 nanoparticles of size ~60 nm after doping Fe show a stable cubic phase at RT in contrast to tetragonal phase in bulk NiCr2O4. Below RT, a complete tetragonal symmetry is observed at 50 K, followed by a coexistence of cubic and tetragonal phases in the intermediate temperature range (Fig. 1). Interestingly, no tetragonal to orthorhombic phase transformation has been observed down to 12K. The plausible structural transformation examined from temperature dependent EXAFS. Magnetic studies demonstrate two-fold increase in para to long range ferrimagnetic transition, TC, due to increase in A-B exchange interaction and no change in spiral ordering temperature, TS indicating strong B-B interaction4,5. Unusually high spontaneous exchange bias of ~1.265kOe at 60 K and tunable exchange bias observed with temperature highlight the potential applications of these materials in spintronics devices.

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Development of Wearable Thermoelectric Generator for Converting Human Body Temperature to Electrical Energy

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Transition metal based spinel oxides, ACr2O4, Cr3+ ions forms a pyrochloresublattice, surroNow-a-days, wearable thermoelectric devices for energy harvesting from the body temperature have attracted a lot of interest for commercial applications such as operating portable devices, smart watches, health care devices, sensors, military and space applications etc.The low energy efficiency in conjunction with the complexity of producing generators isthe main bottleneck for commercial applications. In this presentation, a cost-effective approach to produce a wearable thermoelectric device that is capable of producing milli volts by a small temperature difference when mounted on the human body will be presented by utilizing thermoelectric nanomaterials as the key components for the generators. The current challenges and issues to producing efficient wearable TE generators, the cost-effective approaches to overcome such challenges for utilizing wearable generators for continuous power supply to portable devices, IoT and smart watches etc.will be also addressed.

Teaching Condensed Matter using Physical Models.

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Teaching condensed matter to young students is challenging, when they start learning about the three phases of matter, i.e. gases, liquids and solids. The important theme is that no any atom touches each other and have a self-organization behavior. In order to demonstrate the atomic arrangement ordering and defects, the ring magnets are fixed on plastic balls with identical polarity. Once they are kept in a water tray, able to float and move freely as dipoles. Depending upon the number of balls and size and shape of the tray of the water tray, one can have triangular, cubic, pentagon or hexagon symmetry configurations can be demonstrated through this model. The concept of meta-stable states and temperature can be introduced.

Fig. 1(a) Hexagon symmetry in a circular tray and (b) Cubic arrangement with defect in rectangle tray.

Using large number of steel balls, size (1 mm), between two transparent sheets, one can show the Dense Random Packing of Hard Spheres (DRHS). The defects like vacancy, dislocation and grain boundaries are visible range.

Combined structural and electronic characterization on the micro and nanoscale magnesium silicide-based materials using Kelvin probe force mi-croscopy, first principle calculations and SEM/EDX

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Thermoelectric generators can convert waste heat into useful electricity. Magnesium silicide-based materials have been established as promising cheap, environment-friendly materials with excellent thermoelectric properties in the mid-temperature range. Controlled unmixing of the solid solutions can be used in an advantageous manner by forming nanostructures in situ. Nanostructures can reduce the lattice part of the thermal conductivity by enhanced pho-non scattering and improve electronic properties by blocking low energy charge carriers at the interfaces. Hence, the objective is to exploit and quantify energy filtering of the charge carriers for further performance optimization. Kelvin probe force microscopy (KPFM) measures the local contact potential difference between the probe tip and sample surface with sub-nanome-ter resolution. The combination of KPFM and scanning electron microscopy will allow a na-noscale correlation between the local work functions and topography of multiphase materials. Ab initio calculations of Fermi level (differences) between materials will assist in the inter-pretation of the measured work functions with the aim to get locally resolved carrier concen-trations and eventually to quantify the impact of energy filtering.

Thin Films of metal-carbon Nanocomposite for SPR-based Sensing

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Nanocomposite thin films containing noble metal-carbon matrix have been synthesized with theaim of analyzing their enhanced non-linear optical properties under the effect of high energyion beam irradiation followed by subsequent thermal annealing. Thin films of Au-C 60nanocomposite have been grown up by thermal co-evaporation resistive heating method in avery high vacuum of 10 - 7 torr on carbon-coated Cu grid, quartz, and silicon substrate in which nanoparticlesof noble metal Gold (Au) are incorporated in fullerene (C60) matrix. Rutherford Backscatteringspectroscopy (RBS) technique has been executed in order to get the accurate concentration of Au NP and thickness of the film and the values comes out to be ~ 4.2% and ~ 45 nm respectively. Toinduce the SPR peak, the as-deposited thin films then were treated with 90 MeV Ti beam atdifferent fluence ranging from 1x1012 ions/cm2 to 5x10 13 ions/cm2 . The sample irradiated at the highest fluence was annealed at 200°C, 400°C and 500°C for 30 minutes at each temperature in a high-temperature tube furnace in the atmosphere of Argon gas. At 500°C SPR peak was observedwhich confirms the evolution of Au nanoparticles of considerable size in the fullerene (C60)matrix. The TEM analysis is used to measurethe size of Au nanoparticles after irradiation and annealing and anenhancement in the size with increasing the fluence and on annealing is observed. Surface features of Au-C60 thin filmwere reported with the help of AFM and SEM tools and concluded that the films become moreuniform after annealing. A complete transformation of fullerene into amorphous carbon is confirmed by the Ramanspectroscopy measurements where the presence of characteristic D and G bands ofamorphous carbon in the Raman spectra are seen. X-ray Photoelectronspectroscopy (XPS) has been exercised to study the chemical states present inthe nanocomposite thin films before and after irradiation/annealing.

Investigation of Electron-Phonon Coupling Effects on Materials Properties using Density Functional Theory based EPW Code.

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Electron-phonon coupling (EPC) is a fundamental process that plays a crucial role in many materials properties, such as superconductivity, thermoelectricity, and phase transitions. To accurately calculate the electronic, optical or vibrational properties of a material, estimation of the effect of EPC in a periodic system is must. The EPC effects can be accurately captured using Density Functional Theory (DFT) with the help of EPW (Electron-Phonon coupling using Wannier functions) code. EPW is a highly efficient Fortran90 computer program that utilizes density-functional perturbation theory and maximally localized Wannier functions to calculate electron-phonon coupling matrix elements and the resulting EPC effects. The proposed DFT based study discusses: the calculation of temperature dependent relaxation time τ (T) of the charge carriers as a result of EPC; the effect of inclusion of this τ (T) on the thermoelectric (TE) transport properties of 2D layered materials eg. Silicene and germanene ; the effect of EPC on electrical conductivity or mobility of a material using EPW code. The proposed theoretical research aims to deepen our understanding of the fundamental processes that underlie the properties of materials.

Engineering Thermoelectric Transport in Oxides

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A number of oxides, including ZnO, ITO, SrTiO3 and cobalt oxides are promising candidate as environment friendly thermoelectric (TE) materials1-3. However, high thermal conductivity is the primary factor which hinders their application and leads to poor TE figure of merit (zT). Here we demonstrate that microstructure engineering through Al doping and reduced graphene oxide /graphite additives leads to selective enhancement in phonon scattering in ZnO thereby increasing its TE efficiency4. The incorporation of trace Al doping with 1.5 wt% RGO into ZnO (AGZO) has been found to show significant improvement in zT (=0.52 at 1100 K) which is an order of magnitude larger compared to that of bare undoped ZnO. Tunneling spectroscopy performed on bare as well as composite particles reveals that the band gap of ~ 3.4 eV for bare ZnO reduces effectively to ~ 0.5 eV upon RGO encapsulation, facilitating charge transport. The Al doping, defect engineering and RGO encapsulation synergistically brings about drastic reduction of thermal conductivity, through enhanced interfacial and point defect-phonon scatterings. These opposing effects on electrical and thermal conductivities leads to enhancement in the power factors as well as the zT value5. Our subsequent efforts with highly ITO oxides will be presented in the later half.

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Titanium Nitride-based EGFET pH Sensor for Chemical/ Biochemical Sensing Applications

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A number of electrochemical sensors has been used in chemical and medical industries, pH sensor is one of the most widely sensors. An Extended-Gate Field-Effect Transistor (EGFET) pH sensor is an economical and well-suited sensor for the pH sensing applications. EGFET sensor constitutes by integrating a sensing electrode with an electronic circuit. An EGFET sensing electrode fabricated by depositing a sensing material film over a sensing area of conducting surface. These sensing materials can be either of metal-based, carbon-based or polymer-based. Sometime these sensing films need to be functionalised for improving the sensor's selectivity as well as sensitivity for particular ions/bio-markers. In the present pH sensor, sensing electrode was fabricated by depositing a Titanium Nitride (TiN) film on an Indium-Tin Oxide (ITO)deposited glass substrate. Titanium nitride sensing film selected due to its amphoteric behaviour, stability and insolubility of the film in the solution. A number of deposition technique were used for the titanium nitride sensing film deposition, these are Physical Vapour Deposition, Chemical Vapour Deposition, Pulsed-Laser Deposition andElectro-deposition. Present work uses pulsed-DC reactive sputter deposition technique for the TiN deposition, using pure Titanium (99.99%) target along with argon and nitrogen as sputter and reactive gases, respectively.About 70 nm TiN sensing film was deposited over a sensing area defined over an ITO- coated glass substrate, sensing area was sub-merged in the analyte (pH solution) and ITO is used for contact. Further, these sensing electrodes were integrated with in-house developed electronic readout circuit for pH measurement. The developed pH sensor was tested with solutions of pH 2-12 and sensitivity of the sensor is found to be about 61mV/pH (at 35°C). The developed sensor has a linear and fast response over the range of 2-12pH. Drift and hysteresis responses were found to bearound0.5 μA/min.and 10 μA, respectively, for the pH cycle of4-10.The developed sensor is also a suitable platform for chemical/biochemical sensing applications.

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Development of Highly Responsive Optoelectronic Devices based on Semiconductor Heterostructures

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Heterostructure based devices has shown great potential in optoelectronic field especially in optical communication. Heterostructure optoelectronic devices have been fabricated with unique morphology which exhibit higher photocurrent generation and significantly enhanced responsiveness towards UV illumination. The fabricated device display substantial low dark current and fast time-correlated transient response and very high photo responsivity in self-powered mode of operation. Further, chemically synthesized novel quantum dots have been utilized as sensitizer alongwith various metal selenides for the fabrication heterostructure. The fabricated device exhibits broadband optical response with state-of-the art performance parameters. I'll discuss these findings in details with possible mechanism.

In-situ probing of Complex Intermolecular Interactions in a Ternary Molecular System of Ions, Water and Polymer Macromolecule

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A ternary system of ions, water and macromolecule is ubiquitous and find huge applications in atmospheric, membrane biology, electrochemistry, microfluidic devices etc. Henceforth, knowledge of extracting a detailed molecular level insight about the presence and role of intermolecular interactions is crucial to adopt a comprehensive understanding of the ternary system. The current understanding treats the structural stability of the macromolecule in the aqueous electrolyte solution in terms of ion-water and ion-macromolecule interactions. However, it lacks to provide any information about the ion-induced water-macromolecule interaction in the solution phase. Here, we have utilized a state-of-the-art polarization dependent sum frequency generation (SFG) vibrational spectroscopy to distinctively probe the complex bonding environment at the air/macromolecule-water interface. SFG spectroscopy is a second order nonlinear optical process that carries the potential to investigate molecular structural information at the interfacial region. Here we use two pump beams (Vis and tunable IR) and allow them to satisfy the spatial and temporal coherence to generate the SFG signal. The signal caries the vibrational signature of the molecules which are residing at the air/aqueous interface. I will provide a detailed qualitative and quantitative discussion on the ion-specific structural stability of the macromolecule governed by the presence of ion-specific water-macromolecule interactions which gets perturbed in the presence of kosmotropic and chaotropic ions at the air/aqueous interface. I will also cover some fundamental aspects of hydrolysis and condensation process during the formation of silica nanoparticle from tetraethyl orthosilicate.

Flexothermoelectric Generator on smart shoe

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In the recent years there are remarkable changes in energy harvesting technology in the applications of self-powering and self-charging electronics and wireless sensors. In order to overcome the challenge of inadequate energy with single energy harvester, they proposed a solution of hybrid energy harvesting systems. Here, we focus on thermal and vibrational harvesters that play an ascendant role in hybrid energy harvesting. Our aim is to develop a hybrid generator by integrating thermoelectric and flexoelectric generators. In this paper we discussed about methodology of designing, fabricating and characterization of flexothermoelectric generator for energy harvesting. Theoretical design ad analysis is done using COMSOL as a reference where we observed a voltage output of 0.03V for a temperature gradient of 40K and pressure of 1MPa. After the fabrication of module of hybrid energy system observed an output voltage of 1.7V at temperature gradient of 40C with pressure. The flexoelectric material with desired properties and the integration of the flexothermoelectric generator module in shoes for real time application will be discussed further. Keywords: Flexoelectric, Thermoelectric generator; Conductive fabric; Wearable Devices

Fig. 1. Schematic representation of the flexothermoelectric device

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Prompt gamma ray neutron activation analysis technique (PGAA) based on isotopic 241Am-9Be neutron source

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Prompt Gamma-ray neutron Activation Analysis (PGAA) is a non-destructive, in-situ, and multi-element analysis technique that can detect all elements in solid, liquid, and gaseous samples, with the exception of helium, from hydrogen to uranium. The objective of the current work is to use the PGAA approach to detect and quantify the elements in aqueous solutions. The PGAA setup was developed using the isotopic 241Am-9Be neutron source and high purity HPGe gamma detector. Materials science, chemistry, geology, mining, archaeology, environment, food analysis, medicine, and other fields have used the PGAA approach.

Low Thermal Conductivity and Thermoelectric Properties of Thalium Selenide

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Understanding the mechanism that correlates phonon transport with chemical bonding and solid-state structure is the key to envisage and develop materials with ultralow thermal conductivity, which are essential for efficient thermoelectrics and thermal barrier coatings. We synthesized thallium selenide (TlSe), which is comprised of intertwined stiff and weakly bonded substructures and exhibits intrinsically ultralow lattice thermal conductivity (κL) of 0.62–0.4 W/mK in the range 295–525 K. Ultralow κL of TlSe is a result of its low energy optical phonon modes which strongly interact with the heat carrying acoustic phonons. Low energy optical phonons of TlSe are associated with the intrinsic rattler-like vibration of Tl+ cations in the cage constructed by the chains of (TlSe2)nn–, as evident in low temperature heat capacity, terahertz time-domain spectroscopy, and temperature dependent Raman spectroscopy. Density functional theoretical analysis reveals the bonding hierarchy in TlSe which involves ionic interaction in Tl+–Se while Tl3+–Se bonds are covalent, which causes significant lattice anharmonicity and intrinsic rattler-like low energy vibrations of Tl+, resulting in ultralow κL.

Key words: Phonons, Lattices, Oscillation, Raman spectroscopy and Thermoelectrics

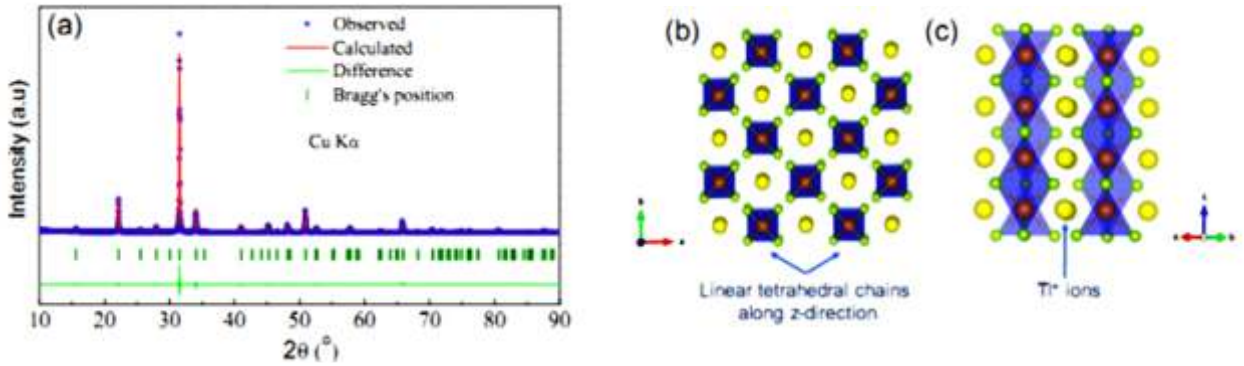

Figure 1. (a) Reitveld retinement of the PXRD of TlSe. (b) Structure of TlSe viewed down the c-axis © Tl* rattles in the channel. Yellow. Orange and Green balls represent Tl*, Ti1* and Se atoms respectively

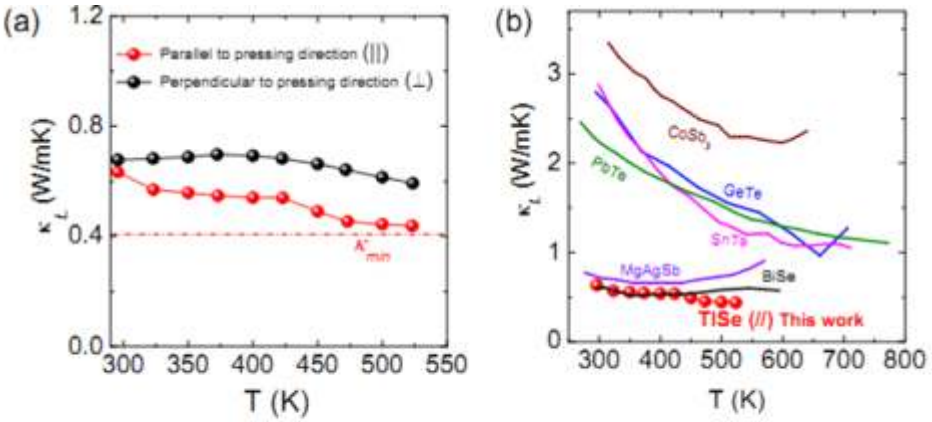

Figure 2. (a) Lattice thermal conductivity (κ_L) of TlSe measured (||) and (⊥) to SPS pressing directions. (b) Comparative plot of κ_L *vs.* Temperature with some well-known ultralow thermal conductive compounds. References imported for the plot are SnTe,[1a] PbTe[1b], BiSe[17], GeTe[22a], $CoSb_3$[22b] and MgAgSb[22c].

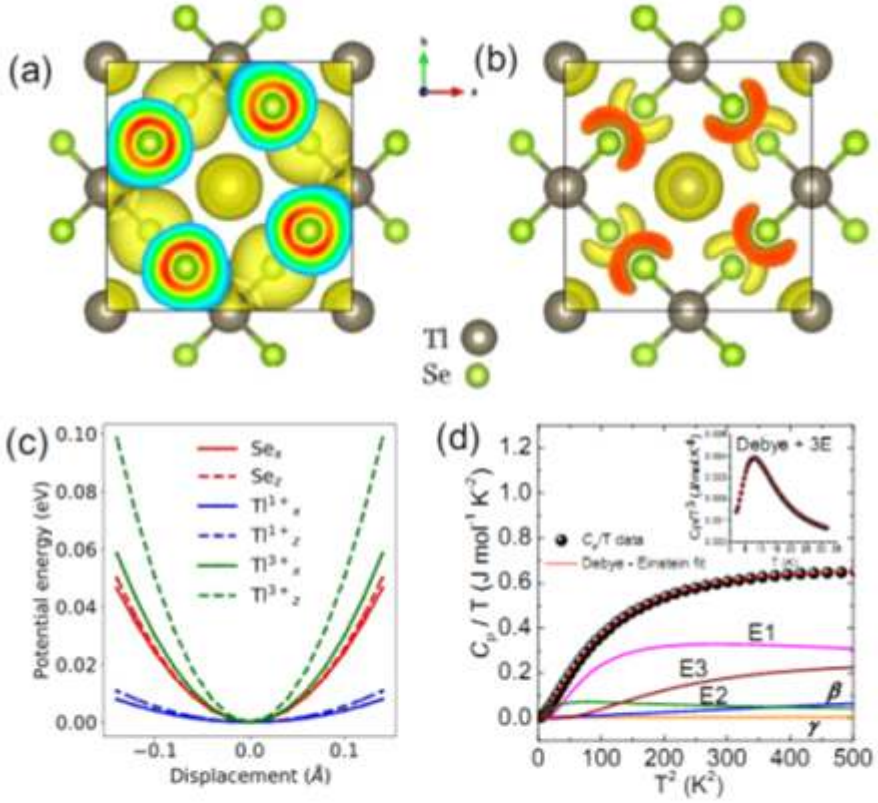

Figure 3. Isosurface of (a) electronic charge density plotted at isovalue of 0.0225 and of (b) electron localization function (ELF) of TlSe at isovalue of 0.85. Grey balls signify Tl atoms while green balls represent Se atoms. (c) Plot of total energy governing the dynamics of atomic displacements along x and z-directions. (d) Debye-Einstein fit of C_P vs T^2 along with individual contributions of low energy Einstein modes. Inset of Figure 3 (d) shows Boson like peak and can only be fitted using a combination of Debye and Einstein model.

Defects and interface engineering to realize high performance thermoelectric materials & power generators

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Thermoelectric generators (TEGs) are devices that convert temperature differences into electrical energy through the phenomenon of Seebeck effect. A TEG consists of large numbers of p-n legs electrically connected in series and thermally in parallel. The development of an efficient TEG requires the fulfilment of several factors, which includes developing n- and p-type thermoelectric materials with high figure-of-merit (ZT), preparation of Ohmic contacts between thermo-elements and metallic interconnects and management of maximum heat transfer though the device. From materials perspective the key parameter for obtaining high conversion efficiency is figure-of-merit i.e. $ZT = (S2\sigma/k)T$, where S, σ, k, and T are respectively, Seebeck coefficient, electrical conductivity, thermal conductivity and temperature. For a given thermoelectric material S, σ and k are interdependent and therefore their ZT is limited to $\leqslant 1$ [1]. One of the challenges to maximize ZT of a material is decouple the electrical and thermal transport, which can be achieved by designing a material that allows facile transport of charge carriers but blocks phonon flow. In this talk an overview on the various aspects of TEG development i.e. from synthesis of high ZT thermoelectric materials to issues & design aspects of the TEG will be discussed. In addition the strategies employed by our group to enhance ZT in variety of thermoelectric materials including silver telluride [2], bismuth telluride [3], tin telluride [4], SiGe alloys [5]and conducting polymers [6,7] will be presented.

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Waste Heat Recovery Using Oxide based nano-composites for High Temperature Thermoelectric Power Generator

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Waste heat recovery using thermoelectric generators has been a potential alternative for renewable energy sources at the time of global energy crisis. Doped SrTiO3 (STO) is considered one of the promising oxide thermoelectrics, due to its high Seebeck coefficient and high temperature stability. However, its performance can't match the state-of-the-art chalcogenides due to its poor electrical conductivity (σ). According to one hypothesis, this poor σ attributes to the presence of Schottky barrier at the grain boundaries. In our present study, we have fabricated a STO based oxide composites with graphite, which shows 423% enhancement in ZT. We have also observed a phenomenal increase in electrical conductivity (1000%) after CNT incorporation, where the Seebeck remains almost unchanged. We have shown that Schottky barrier theory cannot hold good in many factors for such improvement in electrical transport. We have proposed that Anderson localization (due to multivalent cations and defects) is mainly responsible for supressed electrical conductivity in doped STO. Furthermore, these carbon-based materials such as graphite acts as mobility boaster of electrons. We have also constructed a 4-legged thermoelectric device in uni-leg configuration where we have achieved a milli-watt level of power output, which is unattainable up until now.

Electronic and thermal transport properties of Co4-xAlxSb12 (x = 0, 0.08, 0.12)

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Thermoelectricity is one of the eco-friendly and sustainable energy harvesting techniques to address the current energy crisis. The phenomenon is based on converting thermal energy into electrical energy under the effect of a temperature gradient. The enhancement in thermoelectric efficiency has been a key challenge because of the coupling relation between thermal and electrical transport of charge carriers in the material. CoSb3 based skutterudite systems [1] are the promising candidates for intermediate temperature range (300 K – 900 K) thermeoelctric applications beacause of their caged type complex crystal structure and non-toxic constituting elements. Here, we have studied the effect of Aluminium doping at the Cobalt site on the electronic and thermalproperties of Co4-xAlxSb12 (x = 0, 0.08, 0.12). The charge carrier mobility enhanced drastically upon doping with slight change of carrier concentration from 2.4 x 1018 cm-3 to 8.6 x 1018 cm-3 for Co3.92Al0.08Sb12. As a result an enhanced σ value of 3600 S/cm was obtained for Co3.88Al0.12Sb12.Also, thermal conductivity value of 1.6 W/m.K was observed for Co3.92Al0.08Sb12at room temperature. This work will focus on the understanding of material physics aspects of these doped phases for harnessing thermoelectric power from thermal energy.

Keywords:Thermoelectric, Skutterudites, Thermal

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Impact of electronic defects on the thermoelectric properties of Ni doped Cu2Se

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Scrutinizing the current scenario regarding the consumption and conservation of existing energy resources, Thermoelectricity (TE) exhibits as a future promising renewable energy source that may effectively convert a thermal gradient into useable electrical energy and vice versa without the requirement of moving components and greenhouse gas emissions [1,2].To manufacture TE devices for commercial purposes, a high conversion efficiency TE material is necessary.The focus of research should be on improving the TE properties of these materials by employing various strategies capable of decoupling these transport parameters in a favourable manner in order to achieve high conversion efficiency.In this work method of doping is adopted to enhance the thermoelectric properties of Cu2Se.Phase pure copper selenide and nickel doped copper selenide were synthesized by hydrothermal method and the effect of doping on the structural,optical and thermoelectric properties of the synthesized samples were discussed. The phase purity of the synthesized samples was confirmed by structural studies using XRD and Raman analysis, which also confirmed that Ni2+ is well incorporated into the Cu2Se lattice.A simultaneous enhancement in the carrier concentration and mobility is achieved due to the presence of nickel in the intersitial sites of Cu2Se.Tuning the mobility and narrowing band gap help to achieve a maximum power factor of614 μW/mK2 at 3000C for the Cu2Se sample doped at 1.5 wt% Ni.

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Tea dye adsorbed celluloseas triboelectric nanogenerator; a novel energy harvesting method

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In the present global scenario,the quest for the environment friendlyrenewable and sustainable energy sources draws immenseattention.As a solution, a low cost, easily manufacturing, new and green technology to reap electrical energy from low frequency mechanical energy can be done by triboelectric nanogenerators (TENGs). Mechanical energies such as vibration, wind energy, human motionsor any mechanical disturbances from the environmentare converted to useful electrical energy. The only needed to fabricate the TENGs are any two oppositely tribopolarized surfaces. When the twomaterials are come into contact, there leaves static charges on the surfaces of the materials. On separation of the material surfaces, respective opposite charges are induced on the electrodes which are attached on the other sides of the surfaces to balance the potential.This causes the current flow through the outer load. So, the combined process of contact electrification and electrostatic induction are taking place behind a TENG operation which is nothing but our everyday static electricity.In this research work, we report a simple and cost-effective fabrication of cellulose based TENG using tea dye adsorbedpaper, polypropylene sheet and aluminium foil [1]. The output peak to peak voltageof free standing mode of TENG by manual sliding was investigated. As fabricated TENG can lighting up commercial white LEDs directly and the rectified output from TENG stored in capacitors. Since paper is biodegradable and recyclable, paper based TENGs are becoming more relevantand will have significant concussion in the nearest future and the potent field of self-powered portable and wearable electronic devices instead of batteries.

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Enhanced thermoelectric properties of aluminium and copper doped ZnO

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Abstract: Thermoelectric materials effectively convert thermal energy in to electrical energy, and they are widely used in the field of waste heat recovery. ZnO is a promising high-temperature thermoelectric oxide material with high thermoelectric efficiency. The improvement in thermoelectric properties can be achieved through structural modifications such as doping and nanostructuring. Herein, the effect of aluminium and copper doping on the thermoelectric properties of ZnOwas investigated. The structural and morphological analysis of the doped materials confirmed the substitution of dopants into the ZnO structure.Al, Cu doping causes an increment in the carrier concentration leading to an increase in electrical conductivity.A largeincrease in the Seebeck coefficientis observed in the doped materials thanin the undoped ZnO. Since both the electrical conductivity and Seebeck coefficient were enhanced upon doping, the thermoelectric power factor of ZnOis also increased.

The effect of Multi-Walled Carbon Nanotubes (MWCNT) on thermoelectric properties of Copper Selenide in enhancing power factor

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Abstract :

Copper Selenide (Cu_2Se), a lead-free thermoelectric (TE) material, have been gaining attention from several research and industrial applications due to its great capacity for capturing energy from heat. Among various strategies used to improve the TE performance of Cu_2Se, Nano structuring is a very effective and prevailing approach, which has been used to successfully enhance transport properties in single phase compounds by introducing nano-scale grain boundaries. Multi-Walled Carbon Nanotubes (MWCNT) are very unique one-dimensional materials with intriguing physical, chemical, and mechanical properties [1]. MWCNTs are a great choice of nanoscale additives and can improve mechanical properties as well as electrical and thermal conductivity in the products you add them to [2]. In this work, we successfully incorporated MWCNTs in the Cu_2Se matrix, there by preparing nanocomposite with homogeneity where MWCNTs dispersed along the nano-grained Cu_2Se boundaries and studied the thermoelectric performance.

We report the thermoelectric properties of different weight percentages of MWCNT dispersed (0, 0.5, 1,1.5, and 2 % Wt.) in the Cu_2Se matrix. The sample with 1 % wt. MWCNT distributed in the Cu_2Se matrix significantly enhanced the electrical conductivity and retained the Seebeck coefficient, thereby improving the power factor compared to bare Cu_2Se. In this system, MWCNTs acted as a

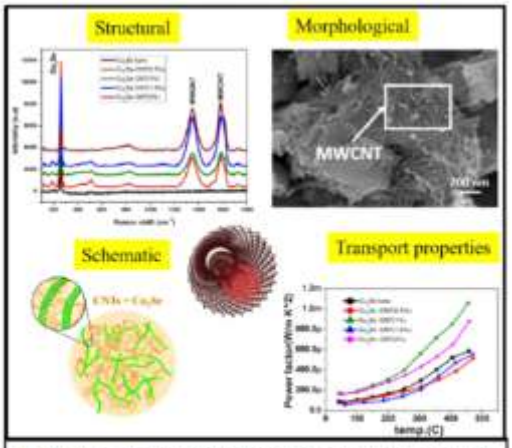

Figure1:- Graphical representation of structural, morphological, schematic, and transport properties of Cu_2Se-CNT nanocomposite

Enhancement of Thermoelectric power factor due to the inclusion of Cobalt ferrite in ZnO matrix

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Thermoelectricity has attracted a lot recently because of its ability to generate electricity from waste heat. The modern world's energy needs can be met by developing thermoelectric (TE) materials with high conversion efficiency. ZnO is a potential candidate for high temperature TE applications due to its high thermal and mechanical stability, resistance to oxidation, low cost, and lack of toxicity. In this work cobalt ferrite (CF) were synthesized using CoO and ZnO precursors through planetary ball mill followed by high temperature sintering at a temperature of 10000C for 4 hr. The CF@ZnO samples were synthesized via solid state reaction method by varying stoichiometry between CF and ZnO. The structural and optical properties of the samples were studied using XRD and UV-Vis-NIR spectroscopy. The roles of CF on the TE properties of ZnO were investigated. The effect of CF inclusion on the TE properties of ZnO matrix shows significant increase in the carrier concentration there by improved electrical conductivity and power factor. In comparison to bulk ZnO, the 15 wt% CF@ZnO sample exhibits 30.5 times greater electrical conductivity and 9.4 times greater power factor at 953 K.

Band structure modification and enhanced thermoelectric properties of Mg-N co doped $CuCrO_2$ thin films

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Defect engineering can effectively modulate the band structure of a thermoelectric (TE) material, thereby enhancing its power factor $S^2\sigma$. Here we used Magnesium along with N as a dopant in Cr site of $CuCrO_2$ thin film since it is a good candidate for creating point defect in the lattice and for improving band gap. XRD analysis was used for phase confirmation and Raman and SEM investigations have revealed the structural and morphological modifications in the lattice by Mg-N co- doping. Topographical studies were done by AFM and found roughness below 10 nm. Photoluminescence spectra were used to find the band structure modification. Carrier concentration and moblity were measured by Hall measurements techniques and found as increased with increasing gas pressure of nitrogen and with thickness. The $CuCr(MgN)O_2$ thin film of 250 nm at 40% gas pressure of nitrogen shows the enhanced carrier concentration of 5.8x1019 cm-3 and mobility of 228 cm2/Vs at 700 K. The conductivity of 2500 S/m and Seebeck coefficient of 200 μV/K leading to the power factor of 121 μW/mK2 at 300^{0}C.

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Keywords: thermoelectricity, XRD, Raman, power factor

Structural and Thermoelectric properties of burial sintered Pr doped SrTiO3 crystallites

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Structural and thermoelectric features of $SrTiO_3$ ceramics can be modified by doping at the Sr and Ti sites. Doping with Pr transforms the structural parameters and modifies the thermoelectric properties of strontium titanate. A high-temperature solid-state reaction followed by graphite burial sintering was employed and $Pr^{3}+$was introduced in the $Sr^{2}+$ site in Sr_{1-x} Pr_xTiO_3 (x=0.05, 0.075, 0.10, 0.125, 0.15, 0.20) system. Samples with x≥0.10 shows Splitting and asymmetry of the (200) and (310) peak in XRD indicates structural transformation from cubic to tetragonal phase. Morphological changes in the samples were analyzed using high-resolution FE-SEM. The electronic transport properties in $Sr_{1-x}Pr_xTiO_3$ ceramics were used to determine the optimum doping concentration. Oxygen deficiency induced by graphite burial sintering significantly enhancedcarrier concentration. The thermoelectric power factor increases with Pr concentration up to x=0.10 and the structure gets deformed at higher doping percentages reducing the electron transport and resulting in low thermoelectric performance. A maximum power factor of 1.12mW/mK2 was obtained for $Sr_{0.9}Pr_{0.1}TiO_3$ samples at 673 K.

Thermoelectric study of manganate-based high entropy oxide

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Almost 60% of energy is wasted as heat in manufacturing companies, power plants, and automobiles. Hence recycling the waste heat is the prime concern. One of the most efficient methods for waste heat recovery can be realized through thermoelectric generators (TEGs), which can directly convert waste heat into electrical power. A basic TEG unit is comprised of n- and p-type semiconducting materials connected electrically in series and thermally in parallel. Increasing the electrical transport properties like conductivity ( ) and Seebeck coefficient (S) while reducing lattice thermal conductivity (kl) are essential to achieve a high energy conversion efficiency of TEG dictated by the thermoelectric figure of merit, ZT = S2T/(k), where T is the absolute temperature and k is thermal conductivity. State-of-the-art thermoelectric materials such as tellurides, selenides, and antimonides suffer from poor thermal stability, toxic and expensive constituting elements and difficult synthesis routes, limiting their widespread application. In that regard, oxides-based materials are viable options given their high thermal stability and low processing cost. However, oxides-based materials possess high thermal conductivity, giving rise to low thermoelectric performance. Therefore, novel strategies need to be implemented to address this key issue. Researchers have shown that high entropy oxides, constituting multivalent cations creating phonon scattering sites, can produce inherently low thermal conductivity in oxides based, significantly enhancing thermoelectric performance. This work aims to present the concept of CaMnO3-based high entropy oxide to attain low thermal conductivity for thermoelectric application.

Keywords: High entropy oxides, waste heat recovery, thermoelectricity, electrical transport, thermal transport

Enhanced thermoelectric performance of Bi2S3 by band structure modification using halide doping

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Over the past few decades, semiconducting chalcogenides compounds (A_2B_3 with A = Sb, Bi, As and B = S, Se, Te) have been receiving much attention because of their wide range of applications in various field of science and technology. One of the most promising areas is their use in thermoelectric refrigeration.

Various research work are done on metal chalcogenides TEmaterials (Bi2Te3, PbTe, AgPbmSbTem+2, In_4Se_3, Cu_2Se, $Cu_{1.97}S$ etc.). These materials become important in last few decades due to their enhanced ZT values. However aforementioned materials have the disadvantages that it contains high toxicity, high-cost elements. Therefore, incentive exists for researcher to develop alternative material. The sulphides-based metal chalcogenides (Bi_2S_3, $Cu_{2-x}S$, CdS, TiS_2, Ag_2S etc.) as TE material finds a highly interest in research field due to their low cost, low toxicity, more abundant and optimizable TE property.

Various strategies such as doping have been used for improving its TE performance. Here we report the synthesis and thermoelectric properties of SPSed Bi_2S_3 and enhanced its performance by using x-mole% of CuCl as dopant. Powder in stoichiometric compositions were mixed and synthesized by melt and grow process inside a quartz evacuated tube. The as synthesized ingot was grounded and sintered by SPS. XRD of all samples shows single phase formation. EPMA , XRF results shows stoichiometric composition maintainAll the compositions show a negative Seebeck coefficient suggesting n-type behavior. The increasing dopant concentration leads to the improvement in its electrical property and after an optimized value it decreases. As a result, a higher power factor ~1200μW/m-K_2 for CuCl as dopant. ZT values greater than 1 was achieved in these halides doped chalcogenides.

Key Words:Chalcogenides, Thermoelectric, Energy Storage, Spark Plasma Sintering

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Synthesis and Study of Annealing effects on Structural, Morphological and Optical Properties of Pure SnO2 Thin Films

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This material has outstanding electrical, optical, and electrochemical properties. Therefore it is used in many applications like solar energy conversion, electrocatalysis, antistatic coatings, transparent conductive electrodes, and electrochromic devices. We have synthesized pure Tin Oxide thin film by using thermal vacuum evaporation method on a glass substrate. We annealed our samples at 400°C for 2 hours. We characterized our samples with Scanning Electron Microscopy in which we have studied the surface morphology and Four Probe method, in which we studied the electrical properties of our samples. From the analysis we have found that resistivity decreases in thin films which are annealed at 400°C in comparison to as-prepared thin films. The variation of conductivity with temperature suggests the semiconducting nature of thin films. Due to annealing, particles became smooth and regular size like spherical shapes in surface morphology. The as-prepared thin films without annealing particles size are small in comparison which is annealed at 400°C for 2 hours.

Study of Effects of Annealing on Structural, Optical and Electrical Properties of ZTO (Zinc Tin Oxide) Thin Films

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This study shows the aftermath of annealing on structural, optical, and electrical properties on Zinc Tin Oxide Thin Films. Metal oxide nanomaterials are versatile and can be used in applications such as environmental remediation, medical technology, personal care products, with their applications projected to increase. ZTO thin films were deposited on a glass substrate using thermal vacuum evaporation technique which were then annealed using a muffle furnace and then extensively evaluated using XRD, UV-Vis-NIR spectroscopy and I-V two probe method. The deductions from the results were made as follows – enhancement in grain size and crystallinity of the films as shown by the prominence of peaks in graphs, augmentation in optical band gap as calculated from the graphs, refining of films to improve, above 85%, transmittance and an improvement in electrical properties shown by the decrease in resistance and increased conductivity.

Keywords:

ZTO, annealing, XRD, band gap, I-V two probe

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Role of Nanomaterial in Solar Cell

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The increasing global population has created a demand for energy sources that are environmentally sustainable, cost-effective, and dependable. Solar energy has emerged as one of the most promising options, and significant progress has been made in the development of photovoltaic (PV) cells that can capture photons and convert them into electricity. However, PV cell efficiency and cost-effectiveness remain a challenge. About 70% of the captured energy is lost due to factors such as spectral mismatch and electron-hole pair transfer. Numerous studies have focused on improving PV cell efficiency by minimizing electron-hole pair losses and expanding the range of solar spectra that can be absorbed. Proposed solutions include using lanthanide-based up-conversion and down-conversion materials, organometal halide perovskite devices, V-Trough concentrator systems coupled with solar modules, dye-sensitized solar cells, nanofluids in solar collectors, semiconducting nanocrystal-based solar cells, and hybrid nanocomposite solar cells. Researchers and industry professionals alike are striving to enhance the efficiency, affordability, and accessibility of solar cells for all segments of society.

Frequency Dependence Dielectric Properties of Gluten free grains at Microwave Frequency

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Values of dielectric constant (ε') and dielectric loss (ε'') of gluten free grains viz., finger millet, amaranth and buckwheat were measured at room temperature for grain size 250-300 micrometers at three different frequencies (4.70 GHz, 7.15 GHz and 9.76 GHz) in microwave region by using Two Point method and employing a specially designed dielectric cell for powder samples. Both, the dielectric constant and loss factor are found to decrease with increase in frequency. These dielectric properties are beneficial to develop microwave applications in food processing sector.

Keywords:

Dielectric constant, Dielectric loss, Gluten free grains

Study of Dielectric Properties of Pomegranate at Different Frequencies

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Pomegranate is a good source of Iron, Potassium, Vitamin C, Vitamin K, and several other nutrients. Pomegranate helps to prevent coronary heart diseases, cancer (skin, breast), inflammation, hyperlipidemia, diabetes, cardiac disorders, hypoxia, aging, brain disorders, and AIDS (Shishodia et al. 2006).Dielectric properties in term of dielectric constant (ε′) and dielectric loss factor (ε″) of fresh juice of pomegranate were measured by using the PNA network analyzer with 85070E dielectric probe at distinct frequencies between 10 MHz to 20 GHz at fixed temperature(250C). Dielectric constant of the sample is found to decrease with increasing frequency and dielectric loss increase with increase in frequency.

Keywords:

Dielectric constant, Dielectric loss, Pomegranate

Synthesis and characterization of Bismuth Telluride alloy based nanocomposites with multiwalled-CNT nanoinclusions

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The performance of thermoelectric (TE) devices depends directly on the figure-of-merit ZT of the thermoelectric material used, which is defined as ZT =T (α2σ/K) where T is the temperature, α the Seebeck coefficient, σ the electrical conductivity and K the thermal conductivity respectively.

Bismuth Telluride is a promising thermoelectric material with the highest figure of merit ZT ≈ 0.9-1 at 300K around room temperature. Current research directions involve the use of low dimensional materials to achieve improvements in ZT through the simultaneous reduction in thermal conductivity of the material and enhancement in the power factor viz (α2σ).

Nanocomposites, which consist of a nanostructured matrix embedded with suitably chosen nanoinclusions, have been suggested as one of the approaches to achieve enhancement in ZT. In optimally designed nanocomposites, reduction in K is aimed through strong phonon scattering at the nanograin boundaries while the charge transport is significantly less affected, thus leading to the overall increase in ZT.

In this work, ball milling process was used to prepare a nanostructured matrix of p type Bismuth Antimony Telluride bulk alloys & multiwalled CNTs were dispersed in this nanostructured matrix as a secondary phase, to produce nanocomposites. MWCNTs have been added in varying concentrations to prepare different nanocomposites. These nanocomposite powders were compacted using a cold press and subsequently annealed. Phase identification and crystalline structures were investigated using X-ray diffraction (XRD) method. Surface morphology was analysed by scanning electron microscopy (SEM). Thermoelectric parameters such as the Seebeck coefficient and electrical conductivity were measured by Ulvac-Riko ZEM-3 system. Thermal conductivity was determined by Xenon flash method (DXF-200). By using these thermoelectric parameters, figure of merit (ZT) was calculated for all the nanocomposites with varying concentrations of CNTs. Nanocomposites with 0.1 wt% CNT have exhibited a significant reduction in thermal conductivity in the temperature range 153-333K compared to bulk alloys which contributed to an overall enhancement in ZT.

Ananas Comosus Leaves Extract as Agent in Synthesis of Zn1-XNixO(X=0, 0.07) NP's and XRD, UV-Vis & SEM-EDX Studies

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This paper reported synthesis of Zn1-x Nix O(x= 0, 0.07) nanoparticles uses ananas comosus leaves extract as a size reduction or capping agent. The synthesized materials have been characterized by UV-Vis, XRD, SEM, and EDX . The results shown that absorbance of doped sample seen considerably less than undoped may be maximum photons were absorb due to existence of nickel in ZnO [Figure]. Tauc plot band gap analysis reported band gap of doped sample less than pure. The synthesized samples have been confirm of hexagonal phase and strong Braggs peaks seen in (101) planes, indicates Zn atom are dominate Ni atom .The EDX techniques confirm quantitative analysis of synthesized samples. Surface morphological studies by scanning electron microscopy have been reported that an increase in the agglomeration of particles with an increase in the dopent.

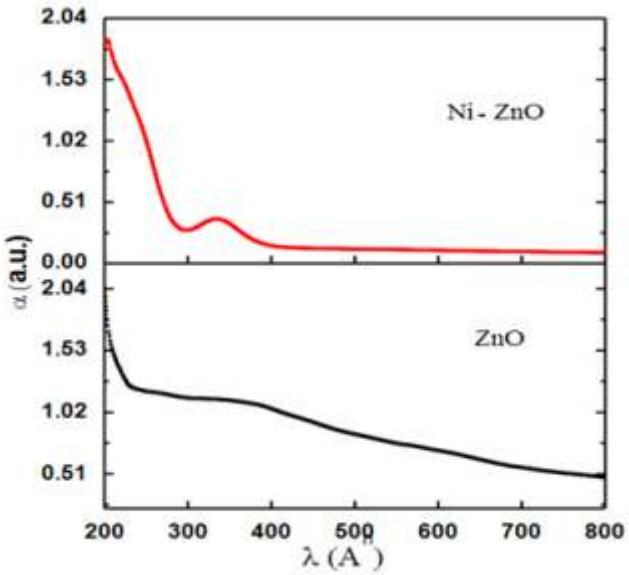

Figure : Absorbance (α) verses wavelength (Å)of $Zn_{1-x}\ Ni_x\ O(x= 0, 0.07)$

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Mxene reinforcement in perovskite oxide for thermoelectric power generation

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Thermoelectric materials hold great promise for producing power from waste heat without causing carbon emissions. However, we cannot deny that their efficiency is not remarkably good. Researchers have found a variety of methods to improve its efficiency. In the current work, a nanocomposite of perovskite oxide is made with a new generation 2D material called (Ti3C2Tx, where Tx: -O, -OH, -F) MXene as reinforcement. MXene has been synthesized by selectively etching out Al from the one-pot synthesized MAX phase. Layered structure MXene and SrTi0.85Nb0.15O3 (STN) powder have been sintered by spark plasma sintering (SPS) route. Thermoelectric properties such as electrical conductivity, Seebeck coefficient, and thermal conductivity have been measured in the temperature range from 323 K to 921 K. MXene incorporation has shown significant improvement in the power factor and thermoelectric figure of merit of these nanocomposites. The maximum power output obtained for this nanocomposite is 38 mW. Transport properties of these composites have been analyzed in correlation with XRD, XPS, SEM, TEM, and Raman spectra.

Transition Metal Chalcogenide Perovskites for Energy Applications

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Transition Metal Chalcogenide Perovskites (TMPCs) have gained increased attention in the scientific community for optoelectronics and energy applications. These perovskites form in the ABX3 configuration, where A is alkaline earth metal or alkali metals (Ba, Sr, Ca), B is transition metals (Ti, Zr, Hf) and X is mainly S or Se. As these elements are low cost, less toxic and earth abundant as compared to the state of art thermoelectric materials (tellurides = PbTe, Bi2Te3 and Selenides= SnSe, which show high figure of merit ZT= 2.4) they can be considered as a potential candidate for thermoelectric applications. It has been already reported that perovskite oxides are excellent n type thermoelectric material, compared to their oxide counterparts, TMPCs possess more favorable properties such as low lattice thermal conductivity and lower band gap making them promising candidate for high temperature thermoelectric. Although there are not many reports available in literature about their structural and transport properties, there are still various aspects of these materials yet to be discovered. Though a lot of computational and theoretical work has been carried out on these novel materials predicting their feasibility for thermoelectric and optoelectronic applications but they require experimental validation. Furthermore, we believe that rich tunability from the structural diversity and vast chemical composition in these TMPCs offer an exciting platform to realize innovative and desired functionalities for energy and optoelectronic applications in general.Objective of the current work is to develop novel low-cost sulphide based TMPCs for thermoelectric applications and elucidate its structural and functional properties by various characterization methods.

Design and Fabrication of Sb_2S_3 for the Opto-thermoelectric Applications

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Opto-thermoelectric materials are materials that can convert changes in temperature and light exposure into electrical energy. They are a promising solution for developing low-cost and highly efficient wearable devices for health monitoring and weather protection, as they can improve harvesting outcomes and are less affected by electromagnetic waves. Sb_2S_3 is one such material that has a range of ZT and is being explored for its potential. In order to examine how temperature and light exposure affect the properties of Sb_2S_3 thin films developed using an Engineered Fluid Dispenser (EFD), various characterization techniques such as Scanning Electron Microscopy (SEM), X-ray Diffractometer (XRD), X-ray Photoelectron Spectroscopy (XPS), UV-Vis Spectroscopy, and the determination of the Seebeck and Hall coefficients were taken. The results show that increasing the substrate temperature and exposing it to light improved the crystallinity of the films on a range of substrates. Furthermore, the direct band gap calculated was 1.54 eV, and the Hall coefficient was found to be 1.59 cm^3/C. Finally, the integration of Sb_2S_3 thin films into a device intended for opto-thermoelectric purposes was achieved successfully.

Human Testing of the Sb_2S_3 Thermoelectric Device

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Cellulose fabric with Boron doped Al_2 Fe_3 nanostructure by Hydrothermal process for wearable applications

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One of the greatest issues facing humanity today is securing reliable, sustainable energy.As the energy production and environmental issues are directly connected with technological development of mankind, flexible thermoelectric films which can be used to fabricate flexible thermoelectric generators that have the potential to convert human body heat directly into electricity are gaining a lot of attention recently. In the last decade, many efforts were devoted to study Al_2 Fe_3 nanocomposites because of their environmental friendly nature and potential in magnetocaloric applications . Herein, an attempt was done to design and fabricate boron-doped Al_2 Fe_3 flexible films on cotton fabric. Nanocomposite films of Al_2 Fe_3 and boron-doped Al_2 Fe_3 were uniformly coated on cellulose fabric using the hydrothermal method at 100 C. The morphological features on the fabric was studied X-Ray Diffraction (XRD), where the highest intensity peak was observed at 22.96 which is in good agreement with earlier data corresponding to cellulose fabric (JCPDS card no. 50-1364). Seed and growth samples of as-synthesized fabric show diffraction peaks corresponding to aluminium and iron, indicating the formation of nanostructures on the fabric.The synthesized films' structural, electrical and thermal properties were also studied from Scanning Electron Microscopy (SEM), Fourier Transform Infra-Red spectroscopy, I-V measurements, and the thermoelectric performance of the coated fabric was evaluated.

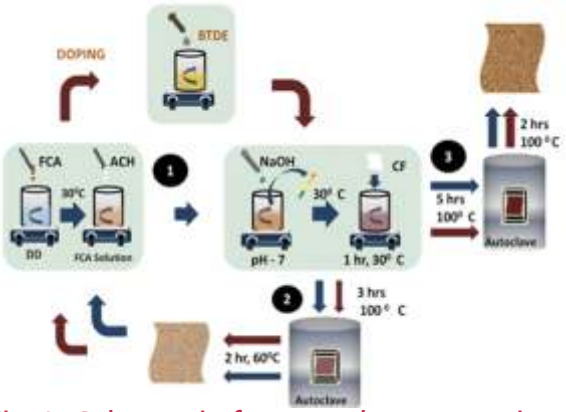

Fig.1. Schematic for sample preparation

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Hybrid photothermal power generation using fabric-based photon capture

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Research into 1-dimensional and 2-dimensional materials is gaining popularity in the quest to improve power generation in miniature devices. Achieving optimal parameters requires careful consideration of the substrate used to manufacture these devices. In this study, we utilized 2-dimensional structures on conductive fabrics to create an intrinsic layer of PIN configuration using the popular Bi_2Te_3 thermoelectric material. Our manufactured PIN device generated an output voltage of 31.3mV in response to a temperature change of 2.7^{0}C between the body and the environment. We evaluated the structural configurations of the PN, PIE, and PIN devices to determine their effectiveness in different environmental conditions. The I-V characteristics displayed an ohmic behavior, with a steep curve in the presence of temperature differences and sunshine. Meeting the demand for convenient energy resources has become a significant challenge, particularly for powering sensors and wearable applications. Simultaneously harnessing both light and thermal energies offers a promising solution to the battery-free operation of various gadgets.

Keywords:

Thin films; Bi_2Te_3; Conducting fabric; PIN; PN

Effect of Mechanical and Durability Properties of Recycled Aggregate Concrete by using of Supplementary Cementitious Materials and Steel Fiber

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The utilization of industrial solid waste to replacement cement and recycled concrete aggregate (RCA) to substitute natural aggregate (NA) in concrete is deemed an efficient approach to manage global warming and keep resources in construction and building engineering. This paper investigate the consequence of RCA, fly ash (FA), ground granulated blast furnace slag (GGBS), rice hush ash (RHA) (GGBS), and steel fiber (SF) within on the mechanical and durability properties of recycled aggregate concrete (RAC). Three FA by weight of cement of 10%, 15%, and 20%, and four RCA replacement levels of 100% are measured. Three GGBS by weight of cement of 15%, 20%, and 25%, and four RA replacement levels of 100% are measured. Three RHA by weight of cement of 10%, 15%, and 20% and four RA replacement levels of 100% are considered. To increase the concern over RAC, its presentation in terms of strength and durability needs to be optimized. This research work presents the effects of the combined incorporation of supplementary cementitious materials (SCMs) and hook-ended steel fibers (HSF) on the strength and durability behavior of RAC. Different types of properties take in compressive strength, splitting tensile strength (STS), flexural strength, water absorption (WA), chloride penetration, and acid attack resistance (AAR). The results of the testing designate that the mechanical strength and durability of RAC can be considerably improved by the combined incorporation of SCMs and HSF reinforcement. SCMs show a greater contribution to the development of the durability properties of RAC, whereas, HSF shows a greater contribution towards the development of mechanical properties and AAR. The profit of the combined addition of HSF and SCMs are chiefly higher than the sum of the benefits achieve through individual inclusion of HSF and SCMs.

Keywords: Compressive strength; split tensile strength; flexural strength; steel fiber, recycled aggregate; mechanical properties; supplementary cementitious material

P-N Junction Thermoelectric Generator with Ultrahigh Output Power for Wearable Devices

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A bid to realize the wearable thermoelectric devices (WTED) to convert human body heat into electricity for powering devices has sparked a lot of research. The device's compliance is required by introducing stretchable structures or materials to reduce device resistance and improve the effectiveness of the energy harvesting process. As a result, we demonstrate a unique p-n junction wearable thermoelectric device with four pairs of thermoelectric legs joined by modified conducting electrodes. The device was fabricated using two forms of an electrode to harvest the human body heat to meet the energy requirements of the wearable device. The p-n WTED are fabricated using Bi2Te3, Copper, and Nickle- Copper Coated conductive fabric used as an electrode. The proposed p-n intersection WTED has good flexibility to wear on the human wrist. The performance of the fabricated devices was compared with the traditional WTED using the same material and electrodes. While compared with the conventional WTED and p-n WTED (Ni-Cu), the p-n junction WTED with copper electrode produces a more reliable performance. The p-n WTED (Cu) has harvested 145nW power on the human wrist application for a 1K temperature difference. Our findings show that the proposed p-n WTED design has a higher output performance and can be used in wearable electronics applications.

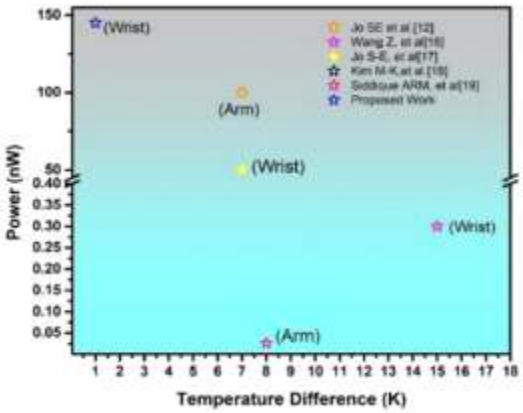

Fig. 1. Performance Analysis of the Present Work with Published in the Literature

Keywords:
Thermoelectric generator; p-n junction; Conductive fabric; Wearable Devices

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Study Of Structural Properties of Bi2Te3 /Sb2Te3 Multilayer periodic Thin films for Thermoelectric Efficiency Improvement.

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Thermoelectric (TE) materials have high potential to convert waste heat into electricity. But the devices made from these materials have low efficiency. Telluride based nanomaterials have large thermoelectric efficiency at room temperature. It has been investigated that multilayer arrangement of alternate layers of thin films have high TE efficiency as compared to single layer thin film. Present work has been reported multilayers of Bi2Te3/Sb2Te3 of (300 – 500 layers) having thickness of individual layers from 20 nm – 200 nm by thermal evaporation method and e-beam technique. The films were characterized by XRD, AFM, TEM and EDAX.

Keywords:Bi2Te3(Bismuth Telluride),Sb2Te3(Antimony Telluride), XRD (X-Ray diffraction), AFM (Atomic force Microscopy), TEM (Transmission electron Microscopy), EDAX (Energy Dispersive X-Ray Analysis).

Experimental study on mechanical strength and slump properties of concrete by partial replacement of cement by rice husk ash

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Concrete being the second-largest consumed material after water requires alternate sustainable materials to be used, especially those generated from waste. India stands in second place for rice production among several countries in the world, as it is one of the most important staple foods. The disposal of this rice husk is causing an environmental problem, and hence its reuse is emphasized. The rice husk ash (RHA) is the outer shell of a rice grain, which is separated from the grain during the milling process. The present study, based on an extensive review, highlights the possibility of utilizing RHA as a conventional binder in concrete. The physical, chemical and mechanical properties of different concrete with RHA will be reviewed. This study uses an unfired, compressed dirt block stabilized by solid waste as the test subject. Tests here on cubes were carried out to assess their compression characteristics & mechanical characteristics. Two types of samples are prepared: one with regulated RHA temperature burn and another with unregulated rice husk temperature burn. The sample is organized with special amount of R-h replacement. The 10 percent, 15 percent, 20 percent & 30 percent; R-H Ash with 20 percent replacement of in time one has enhanced mechanical properties. The mechanical properties of a block contain R-H ash are improved. The RHA which is obtain by burning the rice husk between 600 and 700°C for 2 h contains a huge amount of non-crystalline silica dioxide with a high specific surface area, high pozzolanic reactivity, and therefore can be utilize as a supplementary material to cement in the manufacture of concrete. The mechanical properties similar to compressive strength, flexural strength, and splitting tensile strength of concrete blended with RHA increase for smaller replacements. Concrete with RHA shows enhanced bond strength as compare to conventional mix; reduce chloride diffusion, and efflorescence, and increases conflict to sulphate and chemical attacks.

Keywords: Rice husk ash, ordinary Portland cement, compressive strength, flexural strength, splitting tensile strength

Experimental investigation and optimization of electrocatalyst performance of Platinum-Ruthenium/MXene for Direct Methanol Fuel Cell.

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People all across the world now agree on the importance of sustainable development. High-performance energy devices, such as fuel cell, are greatly desired for big power applications due to the enormous demand for heavy-duty energy conversion systems. Technologies for energy storage, such as Li-ion batteries or supercapacitors, have two fundamental, long-term problems: (1) For specialised devices, it is particularly difficult to simultaneously attain high energy density and high-power density; (2) recent rechargeable technologies require attention due to their high cost and limited resource availability. Alternatively, a new material has been derived in this field, namely MXene. Composites of these material can be employed in fuel cell.Fuel cells generate clean energy, and the electrocatalysis performance in a fuel cell system can be increased by using MXene hybrids.This study will experimentally investigate the electrocatalyst performance of Platinum-Ruthenium/MXene and optimize them for improved energy conversion capabilities of Direct methanol fuel cell (DMFC).

Dye compound removal from wastewater using advanced oxidation process: An overview

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In current years, wastewater containing dyes has become the main environmental issue for textile-based industries. The wastewater coming from these industries may cause various serious problems like skin irritation, allergic reaction in the eyes, and respiratory diseases. Therefore, it is required to treat such type of wastewater before discharging it into aquatic environments. Various methods such as adsorption, photocatalysis, Fenton's reagent, cavitation, etc. are available for the treatment of wastewater. Among all the above methods, hydrodynamic cavitation (HC) has been found to be a very effective method for the treatment of wastewater. In this method, hydroxyl radicals (˙OH) with other reactive oxygen species are generated and oxidize the organic pollutants present in the wastewater. Cavitation involves collapsing of cavities which createlocalized 'hot spots' with very high transient temperature and pressure resulting in theformation of ˙OH, ˙H, ˙ and . This review gives an overview of the effect of various process parameters such as pH, inlet pressure, and initial concentration on the degradation efficiency of dye. It was found that these parameters affect the efficiency of the process. It has also been reported that hybrid approaches (HC+ , HC+Fenton's reagent and HC+ozone) are found to be effective in degrading the dye from wastewater. Overall, it can be said that based on the literature, hybrid strategies can be a better tool for the treatment of industrial dyewastewater.

Keywords: Dye wastewater; Advanced Oxidation processes (AOPs); Hydrodynamic cavitation; Hydroxyl radicals

Extraction of Calcium Carbonate Compound from Waste Eggshell: A laboratory Based Investigation for Jaipur City

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Growth in poultry population in the Indian poultry sector has been reported at 7.3%, one of the fastest annual growth of about 6% in eggs, 10% in meat production, and 8.35% in broiler production over the last decade amongst all animal-based sectors.Eggshells are composed mainly of calcium carbonate (CaCO3), which makes up around94% of the shell's dry weight. The remaining 6% is made up of various organic andinorganic compounds, including proteins, lipids, and trace elements such asmagnesium, potassium, and sodium.Calcium carbonate was extracted in the laboratory through a simple chemicalreaction using calcium chloride and sodium carbonate. The resulting product wascalcium carbonate precipitate, which was collected through filtration, and concluded that the extraction of calcium carbonate from eggshells using hydrochloric acid and sodium hydroxide was successful,and the yield obtained was 38 %. However, the yield can vary depending on the quality and quantity of the eggshells used and the experimental conditions. At large, scale fluidized bed reactors may be one of the feasible choices for technical and economicreasons.

Keywords: Calcium carbonate, Calcium chloride, Eggshell, Filtration

Electricity generation using Solar Cell with higher efficacy using various Structure of Cell Material: A Review

Lokesh Lodha, Harsh Shrivastava, Anil Agarwal

Sunlight is a vast source of energy that is available at no cost. Sunlight can easily compensate the energy drawn from non-renewable sources of energy such as fossil fuels and petroleum availablein the deep area of the earth.There is a requirement to accelerate the development of advanced technologies for the production of clean energy.

In order to address the worldwide challenges of energy security, protection from climate change and sustainabledevelopment, Solar Photovoltaic is a key technology option to realize the shift to decarbonized energy supply and is projected to emerge as an attractive alternate electricitysource in the future. Globally, the solar PV grid-connected capacity has increased from 7.6GW to 21 GW in the last four years Similarly, annual solarPV production also jumped from 3.7 GW to 10.7 GW in the last four years.

India is located in the equatorial sun belt of the earth, thereby receiving abundant radiantenergy from the sun. The India Meteorological Department (IMD) maintains a nationwidenetwork of radiation stations that measure solar radiation and also the daily duration ofsunshine.The highest annual global radiation is receivedin Rajasthan and northern Gujarat.

Silicon-based (Si) solar cells were the first-generation solar cells grown on Si wafers, mainly single crystals. Further development to thin filmssolar cells and organic solar cells with different materials like CIGS, CdTeetc. enhanced the cell efficiency and higher production.

Keywords: Solar energy, Copper Indium diselenide, Silicon Wafers, Solar Cells, Multi crystalline Silicon.

A review on the recent developments on piezoelectric medical devices

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Long employed in medical equipment, piezoelectric materials now have new opportunities to be used in a wider variety of applications thanks to recent technological breakthroughs. High sensitivity, low power consumption, and the capacity to produce and detect mechanical vibrations and pressure changes are just a few of the benefits that piezoelectric materials offer over conventional materials. They are ideal for use in medical applications where accuracy and sensitivity are crucial due to these characteristics.

A number of piezoelectric medical device examples, including ultrasound machines, surgical equipment, and prostheses, are discussed in the article. It goes through the special benefits these gadgets have over conventional ones, such their capacity for real-time imaging, increased surgical accuracy, and improved prosthesis functionality.The paper also looks at recent developments in piezoelectric technology, including the use of nanomaterials and microelectromechanical systems (MEMS), and how these can help piezoelectric medical devices perform even better.

Overall, this research study emphasises the enormous influence piezoelectric materials may have on the medical industry and their ability to spur innovation in the design and development of medical devices. Researchers and developers can produce medical devices that are more precise, efficient, and effective than conventional devices by utilising the special characteristics of piezoelectric materials, eventually improving patient outcomes.

Advances in Molecular Engineering of Organic Thermoelectric (OTE) Resources

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Countless individuals are keen in organic thermoelectric (OTE) resources due to it's affinity for usage as mobile power producers besides solid cooling components. However, due to the scarcity of molecular engineering techniques, the production of state-of-the-art OTE resources continue to experiencelack of molecular categories, which restricts the continued advancement of this developing subject. The concept of creating of molecular engineeringin order to perform well OTE resources have drawn a lot of interestlately. This paper brieflyprovides a quick introduction of molecular structure of conjugated backbones besides side chains, providing the influence ofheteroatomic on the molecular framework substitution, side chain length as well as polarity among other factors that enable effective thermoelectric conversion. In the final part, emphasis is given on the emerging trend in molecular engineering toward OTE resources with excellent performance and functionality.

A Review on Recent Developments in Mechanical Characterization of Luffa Acutangula Reinforcement Polymer Composites

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This paper presents the recent developments in the mechanical characterization of Luffa Acutangula fiber and banana reinforced epoxy resin matrix composites. The Luffa and banana fiber is used here due to its properties of being light weight, high strength, resistance quality, moisture absorption quality and many other potentialities. According to the key objective of investigating on the fiber length, filler content of Aluminum oxide and fiber loading on the mechanical properties and analyzing the behavior of erosion, the results could be optimized which showed better results and in a specified way.

To get optimum results from the erosion test done through the erosion test rig under significant conditions, it could be optimized that Luffa and banana fiberhave a higher resistant quality and which are the proper angles of impingement that can help in getting a proper result to continue the whole experimental process.

The experimental results for behavior of erosion of the polymer composite matrix were tested on the Taguchi method, ANOVA analysis and Grey analysis. The objective of this paper analysis is performed to yield better information results about the experiments done.

Keywords: Luffa and banana fiber, Mechanical properties, Taguchi method, ANOVA analysis and Grey analysis

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A review in superconducting materials for renewable energy applications, including wind turbines and energy storage systems

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This review article examines the most recent findings on superconducting materials for renewable energy applications using wind turbines and energy storage devices as the primary examples. In the field of renewable energy, the usage of superconducting materials offers the potential to increase efficiency and lower prices.

When compared to conventional generators, the usage of superconducting generators can significantly increase efficiency and reliability in wind turbines. Lower installation and maintenance costs can be achieved by decreasing the weight of the generator, which also reduces the wind turbine's total size and weight. Moreover, superconducting generators may run at lower speeds, which lessens system wear and tear and lengthens system longevity.

Another application for superconducting materials is energy storage.Systems using superconducting magnetic energy storage (SMES) can store a lot of energy efficiently and with little losses. The frequency control of power grids is one area where these systems excel that calls for quick responses. It has also been suggested that superconducting-based cryogenic energy storage devices might be used to store huge amounts of energy for a long time.

The study report also looks at additional renewable energy applications where superconducting materials might boost efficiency and cut costs, such solar power systems and wave energy converters. In wave energy converters, superconducting generators can provide more efficiency and dependability, while high-efficiency solar cells can absorb more solar energy since they can work at higher temperatures.

Superconducting materials may provide advantages, but there are still problems that need to be solved. The price of these materials and the related cryogenic cooling systems necessary to preserve their superconducting capabilities is one of the largest obstacles. Superconducting material production processes are also still rather costly and time-consuming.

The promise of superconducting materials in the field of renewable energy is highlighted in this review article, which also indicates areas that need more investigation to remove remaining technical and financial obstacles to the wide-scale implementation of these technologies.

Keywords: Superconducting magnetic energy storage (SMES), Cryogenic, Superconducting material

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Analysis of Dynamic exponential model of ferromagnetic hysteresis of $Zn_{0.97}Fe_{0.03}O$ specimen

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The present study focuses on the implications of an analysis of the dynamic exponential model of ferromagnetic hysteresis of $Zn_{0.97}Fe_{0.03}$ specimen, which combine the cooperative exponential model with the Neel fluctuating field, the Jiles-Atherton methodology to the anhysteretic, and a Preisach convolution inherent across the field distribution function.The specimen is prepared through solid-state reaction technique and then vacuum annealed at ~1000 °C approximately for 48 hours.The model is applied on M-H data of Zn0.97Fe0.03O specimen obtained through Vibrating Sample Magnetometer (VSM) experimental setup. Various parameters like saturation magnetic moment (Ms), coercivity and Remanence(Mr) are studied in detail.

Keywords - Diluted magnetic semiconductors,saturation magnetic moment (Ms), coercivity and Remanence (Mr).

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