International Symposium on Semiconductor Materials and Devices (ISSMD-2022)

16th – 18th December 2022

School of Electronics Engineering,
KIIT (Deemed to be University),
Bhubaneswar, Odisha, India.

Organized by

School of Electronics Engineering,
KIIT-Deemed to be University
and
Semiconductor Society (India)
in co-operation with
Society of Semiconductor Devices

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International Symposium on Semiconductor Materials and Devices (ISSMD-2022)

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Society of Semiconductor Devices (SSD), India

Veeco, Singapore

NTT-AT, Japan

McGraw Hill, India

MESSAGE

Date: 02.12.2022

It gives me immense pleasure to know that "The International Symposium on Semiconductor Materials and Devices (ISSMD-2022)" is being organized by the School of Electronics Engineering, KIIT Deemed To be University, in association with the Semiconductor Society (India) and the Society for Semiconductor Devices from 16th to 18th December, 2022.

KIIT Deemed to be University has always been in the forefront of Research & Innovation with the University being recognized with consecutive top ARIIA (Atal Ranking of Institutions on Innovation Achievements) Ratings. With a strong Interdisciplinary culture & commitment to excellence in the field of pedagogy & Research, KIIT is the first destination of choice for many young researchers & students from pan India & around the globe.

I am happy that the School of Electronics Engineering, KIIT Deemed to be University true to its rich traditions & legacy has been conducting International Seminars & Symposiums which provide the students an opportunity to interact with the some of the best scientific minds in the country & world. This symposium is being organized to act as a platform for exchange of scientific know how & interchange of information about the very important & crucial field of semiconducting materials & devices. Today we are living in an era of knowledge economy with the fast moving & changing world of technological development. It is imperative that we prepare ourselves today to face the future challenges of a new world order. I am sure the participants will largely benefit from this symposium to contribute to their communities in the long run.

I congratulate all the stakeholders, faculties & my dear students for organizing the symposium & wish the publication of the Abstract Book all success.

(Achyuta Samanta)
Founder, KIIT & KISS

MESSAGE

It gives me immense pleasure to learn that School of Electronics Engineering is organizing the International Symposium on Semiconductor Materials and Devices 2022 from 16th-18th December'22.

The International Symposium aims at addressing issues pertaining to Semiconductors, its materials and emerging semiconductor devices. I am certain that the conference will open a plethora of opportunities for the participants working under the semiconductor umbrella to interact with the pioneers in the field.

I applaud the painstaking work of the organizing committee and my warm wishes to the scientific fraternity for participating in the conference. Hope the outcomes will enrich the intellect horizon to cherish.

Vice Chancellor

Vikram Kumar

FNAS, FNAE, FIETE, DSc(hc)

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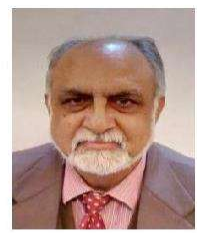
Semiconductor materials are all pervasive in modern society influencing all aspects of life. Ever since the invention of transistor in 1947, they have determined the technology growth in all fields. Be it communications, computation, entertainment, household, power, defence, aviation, medical, transportation, space or any other field, the progress is ultimately limited by advances in semiconductor technologies. With time, more and more exotic materials are joining the semiconductor family and opening new applications to meet the increasing demands of society. While scientists study the structure and property relationships and develop new materials, engineers find new applications and products. Amorphous semiconductors, organic semiconductors, TMDC, 2D materials, ultra-wide bandgap materials are all playing important roles in active devices.

Though Indians form probably the largest group of semiconductor technologists in the world, the field has been relatively weak in India. The Society for Semiconductor Devices (SSD), which organizes the biennial International Workshop on the Physics of Semiconductor Devices (IWPSD), the 22nd edition of which will be held at IIT Madras in 2023, and the Semiconductor Society (India) (SSI), formed in 1984, have been working to strengthen research in this field through conferences to provide forum to exchange ideas and information and identify research needs and opportunities.

The series International Symposium on Semiconductor Materials and Devices (ISSMD) was initiated to fill the gap year between two IWPSDs. The first ISSMD was organized at MSU Baroda in 2011. Next conferences have been held at Jammu University Jammu, Anna University Chennai, Jadavpur University Kolkata, IIT Jodhpur, VNIT Nagpur, and NIT Jallandhar. This series of symposia has provided a valuable platform for our students and researchers to learn the latest developments in the field and to interact with colleagues working in the field across the country.

Prof UP Singh and his team have done an outstanding job of putting together a very busy schedule of high-quality talks. They have done a lot of hard work with the hope that the participants will take full advantage of the deliberations at the Symposium and be benefitted with interaction with experts. I hope you will not disappoint them.

I wish you all a fruitful participation in the ISSMD 22 and success in your semiconductor journey. Please stay safe and healthy.



Vikram Kumar

President, Society for Semiconductor Devices
Past President Semiconductor Society (India)

Formerly:
Professor/Emeritus Professor, IIT Delhi (2009-2017)
Director, CSIR-NPL (2003 -2009)
Director, SSPL (DRDO) (1992 2003)
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PREFACE

I am delighted to welcome all the participants, speakers, students and well -wishers at the International Symposium on semiconductor Materials and Devices (ISSMD-22) organized by the School of Electronic Engineering, KIIT, Deemed to be University, Bhubaneswar, Odisha, India. This symposium is an international event which is held biennially at different parts of the country. The objective of this international forum is to provide a vibrant platform of deliberations on the recent advancements in the areas of Semiconductor Technology; Semiconductor based devices, recent research results and their applications in other branches of Science and Technology.

Semiconductor Materials are the backbone of most of the modern technologies and the progress in this field is so rapid that it is becoming day by day more difficult to keep track of every development even for the experts. The essence of semiconductor materials is their preponderance in the new age electronic industry. Most of the new age electronic components exploit the electronic properties of semiconductors. Semiconductors devices have replaced thermionic devices in almost every application with the added advantage of easy manipulation of electronic behaviour by doping. Semiconductor devices may be simple discrete units or a large array of tiny units interconnected into integrated circuits. The scope of this symposium is to cover both the fundamental and application aspects of semiconductors. The deliberations will be focused mainly on Thin Films, Bulk Epitaxial Growth, Amorphous and Organic Semiconductors, Semiconductors for Renewable Energy such as Photovoltaics, Theoretical Simulation and Modelling, Computational Nanotechnology, Bio-applications, Optoelectronics, Sensors, MEMS etc. Various Characterization Techniques and Emerging Novel Materials will also be discussed. The field of semiconductor research has become more vibrant and multifaceted after the advent of nanotechnology. Incorporating ideas of low dimensional nanomaterial newer properties of semiconductor materials are being invented and implemented in modern devices apart from the classical areas of application of semiconductors which is an active field of research.

It is in this context this international symposium of semiconductor materials and devices is an important event as it brings together renowned academicians, scientists, researchers, industrial personnel and young students in a same platform. The participants can listen about the latest development from the experts directly and can clarify their doubts by interacting with them. The School of Electronics Engineering has been instrumental in organizing national and international conferences, workshops and training courses in the past. We appreciate your interest and support in our events. This symposium will have three Keynote address and more than twenty invited lectures by renowned scientists across the globe. We have received overwhelming response from the researchers and more than 110 papers will be presented as posters in this symposium. I extend a cordial invitation to all of you and wish to express my sincere thanks for participating in the Symposium and for sharing your valuable ideas in the field. Organizing such an event needs financial support and I take this opportunity to express my thanks to our sponsors and various funding agencies. We hope that this International Symposium will provide an opportunity to all the participants, particularly to the students and young research scholars to exchange their ideas with the experts in the related fields.

At the end, we would like to express my gratitude and sincere thanks to all the guests, participants, speakers, sponsors and well-wishers for their valued support and co-operation. We also acknowledge the support we have received from the academic and non-academic staffs of our University. We hope your short stay in Bhubaneswar will be fruitful and pleasant with fond memories for the days to come.

Dr. Udai P. Singh,
Chairman,
International Symposium on Semiconductor Materials and Devices-2022,
School of Electronics Engineering,
KIIT-Deemed to be University,
Bhubaneswar, Odisha, India.

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CONFERENCE SCHEDULE (FINAL)

Registration

15th December 2022 - 4:30 - 6:30 PM	**Venue: Thin film Photovoltaic Lab, 3rd floor, School of Electronics Engineering (New Building)**
16th December 2022 - 8:30 - 9:20 AM	**Venue: Training and Placenent Cell, 1st floor, School of Electronics Engineering**

16th Dec. 2022

Venue: School of Electronics Engineering, Campus-12, Auditorium

Time	Presentation	Speaker	Title
9.20 - 10.30 am	**Inaugural Function**		
	Session-1	**Session Chair: Dr Ashok Sahoo**	
10.30 to 11.15 am	Plenary Talk	Dr. C. Jagadish, Australia	"Semiconductor Nanostructures for Optoelectronics Applications"
11.15 to 11.35 am	Tea Break		
11.35 to 12.15 pm	Keynote-2	Dr. V. Ramgopal Rao, IIT Delhi	"Bottom-up meets top down: An Integrated Approach for Future High Performance CMOS & Sensor Technologies"
12.15 to 12.55 pm	Keynote -3	Dr S Karmalkar , Director IIT Bhubaneswar	"Device Modeling - the Art of Making Approximations"
1.00 to 1.15 pm	Group Photo		
1.30 to 2.30 pm	LUNCH		
	Session-2	**Session Chair: Dr J K Rath**	
2.30 to 3.00	Invited-1	Dr R K Sharma, IIT Delhi	Sub-surface mechanical characterisation of semiconductors using nanoindentation.
3.00 to 3.30	Invited-2	Dr Pushpashree Mishra, SSPL, DRDO	MBE growth of III-V semiconductors
3.30 to 4.00	Invited-3	Dr Amit Munshi, Colarado State Univ, USA	Progress, Challenges and Prospects with CdTe Photovoltaics Technology
4.00 to 4.20	**Tea Break**		
4.20 to 4.50	Invited-4	Dr T Som, IOP, Bhubaneswar	Atomic force microscopy: An amazing tool for micro-to-nanoscale science
4.50 to 5.20	Invited-5 (online)	Dr. Antonio Politano, Italy	Improving the efficiency of van der Waals semiconductors for gas sensing through interfacing with their native oxides.
5.20 to 7.30 (PARALLEL SESSION)	POSTER SESSION and ORAL /ONLINE PRESENTATIONS		
	ORAL /ONLINE PRESENTATIONS PAPERS IDs-A-2001,A-2002,A-2005,A-2007,A-2009,C-3001,C-3008,C-3009,O-8007,O-8008,O-8009,O-8010,M-7003,M-7004, M-7005		
	Venue: New Building , 3rd Floor		
7.45 pm	**Founder's Dinner**		

17th Dec. 2022			
Venue: School of Electronics Engineering, Campus-12, Auditorium			
Time	**Presentation**	**Speakers**	**Title**
	Session-4	**Session Chair : Dr S K Mohapatra**	
8.00 to 10.00	ORAL/ONLINE PRESENTATIONS PAPER IDs-M-7007,M-7008,M-7010,M-7012,M-7014,M-7015,M-7017,M-7018,N-4003,N-4005, N-4006,N-4009,N-4013		
10.00 to 10.30	Invited-6	Dr Saptarshi Das, The Pennsylvania State University, USA	Bio-inspired Devices for Sensing, Computing, Storage, and Hardware Securitybased on Two-dimensional (2D) Materials
10.30 to 11.00	Invited-7	Dr D S Rawal, SSPL, DRDO	GaN HEMT Device Technology; A way forward for high frequency/high powerMMIC Applications.
11.00 to 11.20		**Tea Break**	
11.30 to 12.00	Invited- 8	Dr Anant Naik, CEO, GAETEC, Hyderabad	Monolithic Microwave Integrated Circuit (MMIC)Technology for Strategic Applications
12.00 to 12.30	Invited- 9	Dr Mukesh, IIT Ropar	Gallium oxide thin films based solar blind photodetectors
12.45 to 1.45	ORAL/ONLINE PRESENTATIONS PAPER IDs-N-4017,N-4020,N-4028, N-4029,N-4032,N-4034,N-4035	**KISS VISIT(OPTIONAL)**	
1.45 to 2.30		**LUNCH**	
	Session-5	**Dr. S. K. Sabat**	
2.30 to 3.00	Invited- 10	Dr Jawar Singh, IIT Patna	Devices and Circuits for In-memory and Brain Inspired Computing
3.00 to 3.30	Invited-11	Dr Ankur Goswami, IIT Delhi	Manipulation of Metal Insulator Transition in epitaxial VO2 by engineered interfaces and its application in MEMS resonators
3.30 to 4.00	Invited- 12	Dr. Sudhiranjan Tripathy, Institute of Materials Research and Engineering, Singapore	Wide Bandgap Semiconductors toward Energy and Sustainability
4.00 to 4.30 (PARALLEL SESSION)	Industry Talk 1 (15 min)	Dr Vinod Navin Merai, Vecco Instruments, USA	Products for Semiconductor Technology
	Industry Talk 2 (15 min)	Dr D Krishnamurthy, Scientific and Technical Adviser, NTT-AT, Japan	NTT-AT's GaN Epitaxial Wafers for Power and RF applications
	ORAL/ONLINE PRESENTATIONS PAPER IDs- N-4036,N-4041,N-4042		
4.30 to 4.50		**Tea Break**	
4.50 to 5.20	Invited-13	Dr Sankar Mukhopadhyay, IIT, Kolkata	Growing need and opportunities in Indian Power Sector
5.20 to 5.50	Invited-14 (Online)	Dr.Helge Weman, Norway	III-V nanowire/graphene hybrid structures for applications in solar cells and UV LEDs
5.50 to 7.30	POSTER SESSION and ORAL /ONLINE PRESENTATIONS		
(PARALLEL SESSION)	ORAL /ONLINE PRESENTATIONS PAPER IDs:- N-4046,N-4047,N-4048,N-4049,N-4051,N-4053,N-4054,P-5001,P-5006,P-5011,P-5014		

18th Dec. 2022

School of Electronics Engineering(Campus-12), Auditorium

Time	Talk	Speaker	Title
	Session-8	Session Chair : Dr Arindam Basak	
8.00 to 10.00	ORAL/ONLINE PRESENTATIONS PAPER IDs-P-5028,P-5032,P-5035,P-5037,P-5038,P-5040, W-1003,W-1013,W-1014,W-1016,W-1018,W-1019,W-1020,W-1023		
10.00 to 10.30	Invited 15	Dr Satyabrat Jit, IIT BHU	Organic thin film solar Cells: An Overview with Some Case Studies
10.30 to 11.00	Invited 16 (ONLINE)	Dr Sanjay Behura,San Diego State University, USA	'Light-Matter Interactions in van der Waals Heterostructures'
11.00 to 11.20		Tea Break	
11.20 to 11.50	Invited- 17	Dr J K Rath, IIT Madra	Prospect of carrier selective contact silicon heterojunction solar cells
11.50 to 12.20	Invited- 18	Dr Mrinal Pal, CGCRI, Kolkata	Defect mediated Multi-coloured emission from pristine ZnO nanostructure: A potential singlesource white LED
12.20 to 12.50	Invited- 19	Dr Chetan Panchal,MS University, Baroda	Monolithically integrated 2 square inches CIGS thin-film solar cell module
1.20 to 1.50		CLOSING	
1.50 to 2.45		LUNCH	
3.00 pm		TRIP To PURI (optional)	

Plenary/ Keynote/ Invited Talk

Semiconductor Nanostructures for Optoelectronics Applications

Chennupati Jagadish

Australian Research Council Centre of Excellence on Transformative Meta-Optical Systems, Research School of Physics, The Australian National University, Canberra, ACT 2600, Australia

Email: c.jagadish@ieee.org

Semiconductors have played an important role in the development of information and communications technology, solar cells, solid state lighting. Nanowires are considered as building blocks for the next generation electronics and optoelectronics. In this talk, I will present the results on growth of nanowires, nanomembranes and microrings and their optical properties. Then I will discuss theoretical design and experimental results on optoelectronic devices. In particular, I will discuss nanowire and micro-ring lasers and integration of nanowires and microrings. I will also present the results on polarization sensitive, broad bandwidth THz detectors operating at room temperature. Nanowire based energy devices such as solar cells and photoelectrochemical (PEC) water splitting will be discussed. I will discuss about Neuro-electrodes to study brain signaling to understand dementia. Future prospects of the semiconductor nanostructures will be discussed.

Sensor Platforms & Affordable IoT Solutions for the Developing World

Prof. V. Ramgopal Rao

Fellow IEEE, FNAE, FASc, FNA, FNASc

Pillay Chair Professor, Dept of Electrical Engineering, IIT Delhi

IoT based sensor networks are seeing a massive growth the world over. However, the poor infrastructure facilities available in many of the developing countries and the extreme low-cost requirements pose a challenge for an increased penetration of these technologies in such environments. This calls for an innovation on the technology front in addition to developing a novel business model for their penetration. The requirement for IoT sensor platforms in these economies is however very critical in solving the needs of security, healthcare, agriculture, water, air quality monitoring etc.

In this talk, we will discuss some of these challenges and opportunities for development of IoT based sensor solutions for resource-constrained environments. We will show the need for a massive deployment of such technologies, their calibration, power supply and network challenges as well as the user interface requirements keeping in mind the socio-economic conditions of the end users. In order to achieve some of these goals, we demonstrate novel sensor integration methodologies where completely diverse platforms, materials and approaches are brought together in order to realize the desired system functionality at the targeted price points. The talk also discusses how nano-scale materials and phenomena can help improve the sensitivity of sensor platforms for detection of sub ppb levels of analytes for specific sensing applications.

Device Modeling - the Art of Making Approximations

Dr. Shreepad Karmalkar, Director

IIT Bhubaneswar

Professor, School of Electrical Sciences, IIT Bhubaneswar

Modeling of a device proceeds through the following nine steps, abbreviated as SQEBASTIP: 1) Description of the device Structure and measured characteristics to scale. 2) Qualitative understanding of the carrier, current and potential distributions causing the characteristics. 3) Translation of the qualitative understanding into differential Equations which describe these distributions. 4) Translation of the information about the device structure into Boundary conditions on the carrier, current and potential. 5) Summarizing the Approximations made in each of the four previous steps. 6) Solving the approximated equations to get the carrier, current and potential distributions, and the characteristics of interest. 7) Testing the solution against measured data or, at least, accurate numerical simulations. 8) Improving the solution by adding some terms, if possible. 9) Parameter extraction, i.e. deciding values of solution parameters to fit the solution into measured data or accurate numerical simulation results. In this procedure, approximations play a central role in derivation of a model. With the help of examples of approximations in each of the steps 1)-4), this talk will illustrate how ‒Modeling is the art of making approximations.‖

Subsurface Mechanical Characterization of Semiconductors Using Nanoindentation

Rajesh K Sharma* and Hemant Sharma**

*Defence Institute of Scientists and Technologists, Delhi-110054, India
**Solid State Physics Laboratory, Delhi -110054, India

ABSTRACT

Surfaces play vital roles in influencing the performance/characteristics of semiconductor electronic/optoelectronic devices in general. Therefore, the surface preparation of semiconductor wafers is an intricate process and generally chemo-mechanical polishing (CMP) is employed for the final surface preparation of semiconductor wafers. A knowledge of mechanical behaviour of the subsurface region in terms of its elastoplastic deformation can be used as a guide for establishing the limits of polishing parameters. During last few decades, the nanoindentation has evolved a powerful technique for studying the subsurface mechanical properties of materials, such as stiffness, hardness and elastic modulus. Nanoindentation studies on a variety of semiconductors has been done during these years. However, we have observed a number of issues related with the interpretation of nanoindentation data which could lead to misleading information. We would review the nanoindentation studies on semiconductors and some related concerns therein. The importance of anelsatic deformation/recovery has been highlighted for understanding the load-displacement characteristics in crystalline semiconductor materials. Some important applications of nanoindentation studies for semiconductor technology have been underlined.

Bio-inspired Devices for Sensing, Computing, Storage, and Hardware Security based on Two-dimensional (2D) Materials

Saptarshi Das, PhD.

Associate Professor, Engineering Science and Mechanics, Electrical Engineering and Computer Science, Materials Science and Engineering, Materials Research Institute, Pennsylvania State University, University Park, PA, USA

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My group is developing a new paradigm of sensing, computing, storage, and hardware security inspired by the neurobiological architectures and neural algorithms found inside various animal brains that allow evolutionary success in resource constrained environments. Towards the realization of our vision, we exploit unique electronic and optoelectronic properties of layered two dimensional (2D) materials such as graphene, MoS_2, WSe_2, black phosphorous etc., to design high performance, ultra-low-power, artificially intelligent, and inherently secure solid state devices inspired by natural intelligence. For example, we have mimicked auditory information processing in barn owl (Nature Communications, 10, 3450, 2019), collision avoidance by locust (Nature Electronics, 3, 646–655, 2020), and subthreshold signal detection by paddlefish and cricket using stochastic resonance (Nature Communications, 2020). We have also mimicked probabilistic computing in animal brains using low-power Gaussian synapses (Nature Communications, 10, 4199, 2019), and memristive graphene synapses (Nature Communications, 11, 5474, 2020) and realized biomimetic devices that can emulate neurotransmitter release in chemical synapses (ACS Nano, 11, 3, 2017) and neural encoding in afferent neurons (Nature Communications, 12, 2143, 2021). We have also made these device secure through SAT-attack resistant hardware obfuscation using camouflaged 2D heterostructures (ACS Nano, 15, 2, 2021) and by realizing machine learning resilient and reconfigurable physically unclonable functions (Nature Electronics 4, 364-374, 2021).

GaN HEMT Device Technology; A way forward for high frequency/high power MMIC Applications

D. S. Rawal
Solid State Physics Laboratory,
Delhi, India

AlGaN/GaN based HEMTs (High Electron Mobility Transistors) with improved performance are being developed worldwide for high frequency, high power, and broadband civil/military systems. Indigenous HEMT Device Technology for MMIC (Monolithic Microwave Integrated Circuit) applications has been developed in-house on 100µm thick, 75mm diameter SiC semi-insulating substrate, to deliver RF power output ~ 5W/mm @28V for up to X-band applications. The main technology breakthrough has taken place in HEMT device design, epi-layer structure, improved S/D contacts and slit gate through SiN with gate length (~ 0.25µm) with reduced gate capacitance. Devices have been developed with innovative multi-finger field plate design and low parasitic interconnection techniques using air-bridge metal cross overs/through SiC substrate via-hole source grounds. The fabricated HEMT devices have resulted in excellent RF power and noise performance with desired cut-off frequency ~ 34 GHz.

The talk will mainly cover all the important aspects of GaN HEMT device technology right from HEMT material structure optimization, device design to unit process development on front side/backside of 3-inch wafer to fabricate active/passive component, characterization and their integration including ADS compatible Process Design Kit (PDK) development essential for X-band MMIC development.

Solar-Blind Photodetectors

Dr. Mukesh Kumar, Email- Mkumar@iitrpr.ac.in

Functional and Renewable Energy Materials Laboratory (www.fremgroup.in)
Department of Physics, Indian Institute of Technology Ropar, Punjab, India – 140 001

Solar-blind photodetectors are an emerging technology for forest fires, territory intrusions, ozone hole monitoring, deep space exploration, satellites, and security communication [1-2]. A photodetector working in the <280 nm, solar-blind region, could minimize the chances of false radiation detection even under intense sun interference on the earth‘s surface by detecting ozone layer filtered deep UV (UV-C) terrestrial signatures.

Here, we demonstrated an ultrahigh-performance and self-powered β-Ga_2O_3 thin film solar-blind photodetector fabricated on a cost-effective Si substrate using a high-temperature seed layer (HSL) [3-4]. Also, Ag nanoparticle decorated β-Ga_2O_3 photodetector exhibits a change in the polarity of the photocurrent for different UV bands. The photodetector shows a record responsivity of 250 A W^{-1}, which significantly outperforms bare GO planar photodetectors along with opposite response with UVA and UVC bands [5-6]. The current reversal is rationalized by considering the charge dynamics stemming from hot electrons generated when the incident light excites a local surface plasmon resonance in the Ag nanoparticles. Paper based super-flexible, non-wettable, self-powered and high-voltage stable amorphous gallium-oxide photodetector is also fabricated and investigated in details.

The gallium oxide thin films and grown photodetector is also investigated against extreme environment conditions for their space applications.

References

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Defect mediated Multi-coloured emission from pristine ZnO nanostructure: A potential single source white LED

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Abstract

Wideband gap semiconductor based light emitting diodes (LED) have drawn much attention due to its potential applications. We have tried with success to generate for the first-time multiple emission having tuneable PL intensity, shade, and color temperature in pristine zinc oxide. The ZnO nanopowder was prepared by a facile and cost-effective aqueous solution-precipitation method. The as-synthesized nanopowder was annealed at different temperatures ranging from 150 ^{o}C to 850 ^{o}C and all these samples were characterized by XRD, FESEM, EDX, BET, Raman spectroscopy, and UV-Vis spectroscopy to have insight into their microstructural, compositional, and band-structure details. Optical studies of the samples were conducted using PL and s-PL spectroscopy. Color coordinates of the samples were obtained from the CIE plots derived from the PL spectra. The CIE coordinates were further used to calculate the CCT values of the samples and they are found to be suitable in cold light applications. These nanostructured zinc oxide particles being sufficiently large in size are extremely stable and expected to show photoluminescence for a longer period of time than nanorods and quantum dots. PL studies of the samples revealed that various emission is originating from crystalline point defects, viz. zinc interstitial (Zn_i), and oxygen interstitial (O_i). Annealing at different temperatures triggered changes in the defect concentrations leading to the corresponding changes in the intensity, shade, and color temperature of the blue phosphorescence.

Suggested references:

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Organic thin film solar Cells: An Overview with Some Case Studies

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Abstract

An organic solar cell (OSC) is a type of photovoltaic device using conductive organic polymers or small organic molecules as its photoactive material. Like a conventional inorganic (e.g. silicon) solar cell, it produces an electrical output voltage by absorption of the sunlight by the photovoltaic effect. OSCs have drawn considerable attentions due to their inexpensive solution-processed fabrication method at low temperatures, light weight, flexibility, potentially disposable nature and possibility of changing light absorption coefficient by electronic bandgap tuning via molecular engineering. However, the OSCs largely suffer from low efficiency, low stability and low mechanical strength compared to the inorganic photovoltaic cells such as silicon solar cells.

The lecture will focus on an overview of the organic thin film solar cells. After introducing various generations of solar cell technologies along with their merits and demerits, organic semiconductor based 3rd generation solar cells will be introduced. Bulk heterojunction (BHJ) OSCs using blended donor and acceptor polymers as photoactive layer will be discussed. BHJ OSCs using poly[N-9′-hep-tadecanyl-2,7-carbazole-alt-5,5-(4′,7′-di-2-thienyl-2′,1′,3′-ben- zothiadiazole)] (PCDTBT) as donor polymer and $PC_{61}BM$ as acceptor polymer will be introduced. The effect of electron transport layer (ETL) and hole transport layer thicknesses on the performance parameters of the BHJ OSCs will be presented. BHJ OSCs using PCDTBT:$PC_{61}BM$:CdSe QDs as photoactive layer will also be introduced. Finally, the organic-inorganic hybrid perovskite based 4th generation OSCs will be introduced. Some results on $CH_3NH_3PbI_3$ hybrid perovskite based solar cells will be discussed. The effect of TiO_2 nanorods ETL engineering on the $CH_3NH_3PbI_3$ based solar cell performance will be considered.

Progress, Challenges and Prospects with CdTe Photovoltaics Technology

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Abstract:

Cadmium Telluride (CdTe)-based photovoltaics (CdTe PV) has been at the forefront of next generation commercial solar energy industry and research. In the past two decades, the power conversion efficiency (PCE) using thin film CdTe has improved from ~10% to over 20% and the cost of commercial solar panels has reduced from $4/Wp to under ¢50/Wp. These are great strides forward and have been accomplished through a combination of scientific and engineering innovations as well as novel business strategies and sound approach towards vision for future advances. In this talk, the key innovations that led to the improvements in efficiencies over the years will be discussed. This includes understanding the role and advantages of transparent buffer/window layers, p-type absorber and relevant bandgap engineering, charge carrier transport layers, electrical contacts/electrodes, doping, defect passivation and manufacturing processes. While the journey so far in improvement in PCE and field longevity of CdTe have been exceptional, further advances have been challenging. Within this discussion, we will also touch upon several efforts made towards further improving the PCE using CdTe PV and the associated challenges. While the limitations to further advances are speculative to a large extent, through a combination of experimental analytics and computational simulations, some of these limitations will be explored. Furthermore, the prospects for future advances and potential approaches will also be briefly touched upon. The talk will also briefly talk about key advantages of CdTe PV technology and how it holds a unique position in the world of materials engineering where it can complement advanced device development with other PV technologies.

Manipulation of Metal Insulator Transition in epitaxial VO_2 by engineered interfaces and its application in MEMS resonators

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Abstract:
Modulation of Metal-Insulator Transition (MIT) in vanadium dioxide (VO_2) offers wide scale of applications in electronic and electromechanical devices. Although the physics of the transition still remain elusive the promise of this material still drives the scientist and engineers to investigate further on this material. VO_2, is a class of transition oxide which has metal insulator transition at 68 °C at its single crystal form where the material changes it electrical resistance three to four orders of magnitude which is reversible in nature and show a hysteresis under a heat-cool cycle. Along with the physical property it also changes its structure from monoclinic (M1- low temperature) to tetragonal form (R-high temperature). Except these two equilibrium structures VO_2 also possess few numbers of metastable phases such as triclinic, monoclinic (M2) etc. Transition temperature in VO_2 and the stability of these metastable phases can be manipulated by doping, incorporating strain by interface modification. In this talk I will discuss how epitaxial VO_2 thin film on sapphire grown by pulsed laser deposition (PLD) technique one can modulate the wide range of transition temperature by interface modification through TiO2 interface. Such modifications are indeed required for the application in thermal switches, IR detectors and memory devices. Further, I will also discuss the study of the dynamic characteristic of MEMS based doubly clamped microstring resonators by incorporating VO_2 as a layer along with TiO_2 interface. Frequency modulation of these resonators can be possible by external stimulus such as light and electric field at room temperature which have possible applications in neuromorphic devices.

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MBE growth of III-V semiconductors

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DRDO, New Delhi

III- V semiconductors form the backbone of most of the opto-electronic and electronic devices such as High Electron Mobility Transistors (HEMTs), Lasers and Detectors etc. Molecular Beam Epitaxy (MBE) is one of the most important techniques in semiconducting industry for epitaxial growth of III-V materials with precise control of composition, doping and thickness with atomic level resolution. Various low dimensional structures such as Quantum wells, Superlattices, Quantum Dots and Wires can be grown using this technique.

This talk will focus on the MBE growth and characterization of various III-V semiconductors carried out recently in SSPL. One of the key materials, which has been developed is type II strained layer superlattice (T2SL) based structures. The current third generation infrared photon detectors, which provide enhanced capabilities like large number of pixels, higher frame rates, better thermal resolution as well as multi-colour functionality and other on-chip functions have been based on HgCdTe, Quantum Well (QWIPs) or Quantum Dot (QDIP) based structures. Infra-red (IR) sensors based on type II strained layer superlattice (T2SL) structures are predicted to overcome several difficulties posed by these materials and demonstrate better performance. These are artificially engineered materials consisting of hundreds of alternate thin layers of InAs and GaInSb/GaSb with perfect interfaces and a unique type-II band alignment, which allows the band gap to be controlled entirely by the thickness of the constituent layers. Growth of high-quality layers is extremely challenging due to lattice mismatch between InAs and GaSb , In and Sb segregation, interdiffusion of constituent atoms etc. The optimized growth process for T2SL based detector structures will be presented. Extensive characterization of the grown epilayers has been carried out and will be discussed. GaAs is often explored as an alternate substrate for growth of Sb based detectors and lasers since it is less expensive and is transparent in the IR region. Successful growth of lattice mismatched GaSb buffer layers on GaAs substrates using a novel interfacial misfit array method will be presented. In addition, the growth mechanism of self-assembled Stranski-Krastanov (S-K) GaSb and InAs QDs for novel optoelectronic devices will be discussed. Finally, the growth of catalyst free InAs nanowires on Si substrates and some applications will also be highlighted in the presentation.

Wide Bandgap Semiconductors toward Energy and Sustainability

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There is a growing need for transition from current silicon incumbents to SiC and GaN electronics for sustainable development providing highly efficient electric energy conversion. Wide bandgap technology provides faster power switching in renewables and transport, with added intrinsic advantages allowing devices to operate at higher voltages and temperatures. The large-scale deployment of these wide bandgap materials is not fully realized mainly due to high cost, low yield from small diameter wafers, and reliability concerns. Larger chip area in high current rating devices need significant improvement of crystal quality of SiC and GaN epitaxial wafers. The wafer diameter increase to 200 mm would reduce the cost of SiC and GaN power devices to be competitive with Si devices for 600-3300 V applications. Larger wafer area epitaxial growth with overall defect density reduction would then focus on device specific trade-offs for $/Ampere cost parity for power switching deployment. In this talk, we shall address the growth and characterization of AlGaN/GaN high electron mobility transistor (HEMT) structures on 200 mm diameter Si(111) substrates. It is desirable to realize stable and repeatable growth technologies for nitride heterostructures, where the interface abruptness of the buffer-intermediate layers, smoothness of surface morphology, and high crystalline quality GaN layers are crucial for the reduction of leakage currents for 200 - 1200 V applications. To further demonstrate Si-foundry compatibility of such large diameter GaN on Si wafers, Au-free device processing schemes are employed for normally OFF devices for >650 V applications. In addition, GaN HEMT for sensing devices are explored using low-cost GaN-on-Si epiwafers.

We shall also address our research efforts to realize high crystalline quality SiC wafers for high power electronics. When compared to conventional Si based technology, it is now well known that SiC power modules offer improved efficiencies, reduced size and reduced weight, for 1200-3000 V application potentials. Defects such as micropipes, dislocations, stacking faults, and polytype inclusions have to be minimized for high volume production of SiC-based metal oxide semiconductor field effect transistors (MOSFETs). Optimization of processes to reduce defects in 4H-SiC and implementation of defect inspection technique for SiC wafers will be presented to address yield improvement of SiC power device manufacturing.

Area: Semiconductor Materials and Devices

Next Generation Semiconductor Photonic Chips for Communication and Sensing

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A semiconductor laser emits that emits light either in horizontal or vertical direction at a given wavelength with a controlled speed, power or beam divergence can be called a Photonic Chip. A *vertical-cavity surface-emitting laser* (VCSEL, pronounced as *vikcell*) invented in 1977 from Tokyo Institute of Technology, Japan act as a building block of a Photonic Chip. As shown in Fig 1(a), currently VCSEL chips are transitioned from a rapid growth to full digital maturity, attracting over US$ 12 Billion markets by 2030 [1]. In particular, NIR/SWIR wavelength (0.7-1.3 μm) GaAs based VCSELs have attracted high attention for mass manufacturing at 6"(150mm)-wafer level and quickly catching up 8"(200mm) CMOS platforms due to well established epi-growth and wafer-fab foundry standards. As shown in Fig 1(b), standard 1D or 2D arrays of VCSEL emitters integrated with new functions as advanced photonic chips find next-generation applications in numerous core and edge industries ranging from high-speed data communications in datacenters & hyper-scale networks to high power sensing & imaging in consumer electronics (smart phone face ID, proximity sensing, flood illumination etc), addressable e-scan and flash LiDARs in Automotive/Intelligence transport), optical sensors in IoT (drones & robotics), industrial heating (kW level power densities) for digital heating and so on. Prominent security and surveillance applications in defense sector includes NIR/SWIR night vision illumination and directed energy systems (power densities over 1kW/mm^2) up to few km.

However, recent global supply-chain woes and chip shortages from COVID-19 fallouts grapples the global semiconductor industry that forced most of the technologically advanced nations to make steps towards self-reliance, long-term strategic and trusted partnerships. With the rise of start-up eco-system through indigenous efforts from various government agencies, there are potential opportunities for Semiconductor Photonic Chip development and their commercialisations in India. In this talk authors will discuss the recent progress made in next-generation VCSEL photonic chips for each of the above fields with an example from UV to mid-IR regions of EM spectrum. With the long-term strategic support, technology protection through IPs & wide networking with academia and industry; the dream of an indigenous semiconductor photonic chip manufacturing in INDIA is not far-away!

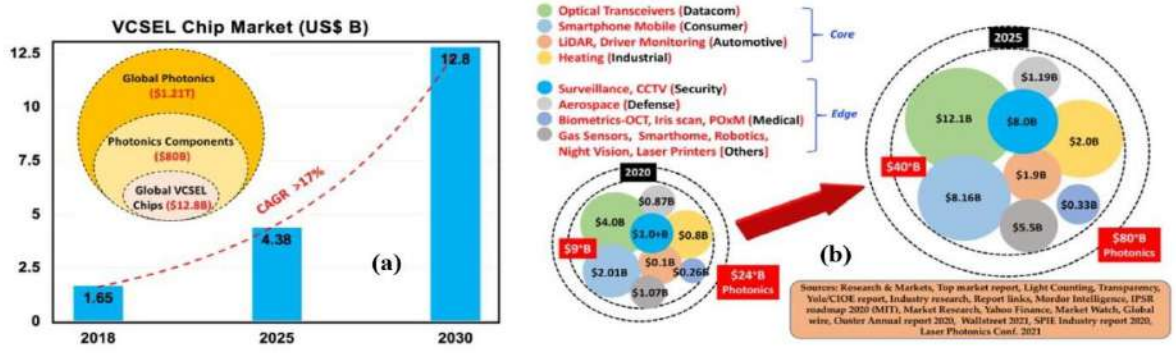

Figure 1: (a) Chip level and (b) total addressable market of VCSELs in numerous industries

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Atomic force microscopy: An amazing tool for micro-to-nanoscale science

Tapobrata Som

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Atomic force microscopy (AFM) is an amazing tool to study various aspects of materials from micro-to-nanoscale.

For instance, it offers several different modes to study surface morphology, work function, nanoscale current-voltage characteristics, field-induced doping of materials, resistive switching, cold cathode electron emission sites on nanostructures, and emulation of bio-synaptic behaviour of electronic synapses for in-memory computation, self-organized pattern formation and their nanoscale functionalization, chemically textured semiconductor surfaces for photovoltaic applications, and so on. In addition, electrostatic force microscopy and piezo force microscopy can also help addressing various interesting aspects of materials. This talk will provide an overview of all these aspects through a gamut of examples.

Monolithically integrated 2 square inches CIGS thin-film solar cell module

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For the mass production of the thin film Photovoltaic modules, the monolithic integration of modules is one of the key technologies because of an opportunity for cost advantage upon its simplified production steps compared with the Si wafer-based and the equivalent structure PV modules [1, 2]. Monolithic integration of the CIGS solar cell module into a series of cells has been carried out using the Laser patterning process. The laser patterning (P1, P2, and P3) has been processed at three different levels uring the deposition sequence. This atterning process connects the adequate region of front and back contact of adjacent cells; thus, it reduces the contact resistance and dead zone area. This patterning merits the dispensable use of wires, tabs, metal grids, and ribbons which reduces the effect of shading and hinders

the module performance. Laser Pattering P1 was carried out after deposition of ohmic back contact Mo layer using Nd: YAG 1064 nm laser. An effort was made for P2 laser patterning using a 532 nm laser after the deposition buffer CdS layer. The clean P2 patterning still has challenges over the module area. The possible reason may be the compatibility of laser features for the Lift-off process during the P2 process or there may be inhomogeneity and non-uniformity of the deposited layers. So, the alternative conventional method i. e. mechanical scribing was adopted for P2 patterning. A fine needle was used for P2 patterning. P3 patterning of top window contact available at our laboratory. So, for P3 patterning, a mechanical scribing technique was used. The latest results will be highlighted during the presentation.

Improving the efficiency of van der Waals semiconductors for gas sensing through interfacing with their native oxides.

Dr. Antonio Politano,

Italy

Monolithic Microwave Integrated Circuit (MMIC)Technology for Strategic Applications

Dr Anant Naik, CEO,

GAETEC, Hyderabad

Devices and Circuits for In-memory and Brain Inspired Computing

Dr Jawar Singh,
IIT Patna

Products for Semiconductor Technology

Dr Vinod Navin Merai,
Vecco Instruments, USA

NTT-AT's GaN Epitaxial Wafers for Power and RF applications

Dr D Krishnamurthy,
Scientific and Technical
Adviser, NTT-AT, Japan

Growing need and opportunities in Indian Power Sector

Dr Sankar Mukhopadhyay,
IET, Kolkata

III-V nanowire/graphene hybrid structures for applications in solar cells and UV LEDs

Dr.Helge Weman, Norway

Light-Matter Interactions in van der Waals Heterostructures

Dr Sanjay Behura,
San Diego State University, USA

Prospect of carrier selective contact silicon heterojunction solar cells

Dr J K Rath,
IIT Madras

Oral/Online Presentation
and
Poster Presentation

Paper ID: A-2001

Area: Organics and amorphous semiconductor

Temperature dependent Raman Spectro-microscopy to Investigate Fermi Level Position in Degenerate Silicon

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Abstract: Temperature dependent Raman spectro-microscopy[1,2] has been performed here to investigate the information about temperature dependent Fermi level position in heavily doped Silicon e.g., p and n type[3]. Information about the position of Fermi-energy in an extrinsic semiconductor and its relative position with respect to the intrinsic counterpart is of great interest. Typical asymmetrically broadened Raman spectral line-shape from sufficiently doped n- and p-type silicon has been analyzed here to get the associated latent information about the Fermi level position. Consequently, a simple formula, developed based on existing established theoretical frameworks, has been proposed that can be used to calculate the position of Fermi level in doped silicon. This proposed Raman spectro-microscopy based formulation was found suitable for n- and p-type silicon. Calculated Fermi level position and its temperature dependent variation are consistent with the existing reports. In brief, temperature dependent Raman spectro-microscopy proves to be a simpler yet powerful tool for estimating Fermi-energy.

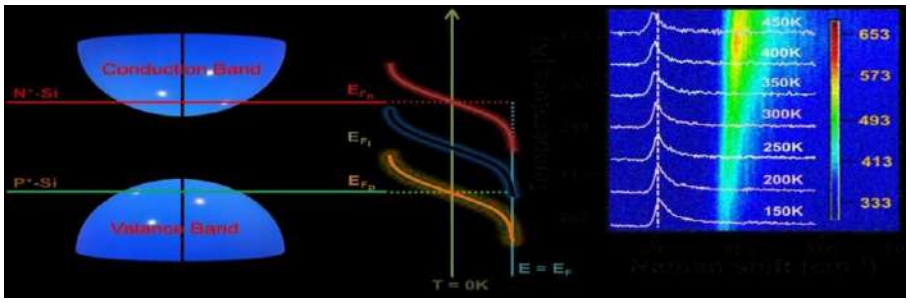

Figure 1: Schematic diagram for Fermi level position in differently doped semiconductors i.e., heavily doped n-type, intrinsic and p-type semiconductor

Keywords: *Temperature dependent Raman spectromicroscopy, Fano interaction, Fermi level position, Heavily doped semiconductor*

Paper ID: A-33

Area: Organics and amorphous semiconductor

Thermally colour tuned $LaVO_4:Tm^{3+}/Yb^{3+}$ upconverting phosphor for higher optical thermometry

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$LaVO_4$ phosphor codoped with 0.3mol% Tm^{3+}/5mol% Yb^{3+} ions was synthesized via high temperature solid state reaction method. The X-ray diffraction (XRD) analysis reveals the formation of pure monoclinic phase of $LaVO_4$. The upconversion (UC) emission study upon 980 nm laser diode excitation shows bands at blue (475 nm) and red (647 nm, 700 nm) regions attributed to the $^1G_4 \rightarrow {}^3H_6$, $^1G_4 \rightarrow {}^3F_4$ and $^3F_3 \rightarrow {}^3H_6$ transitions of Tm^{3+} ion respectively. The temperature dependent UC spectra show that the intensity of bands at 475 and 647 nm decreases upon increasing temperature whereas band at 700 nm shows opposite property as shown in Figure 1. Due to this colour tuning is observed from blue to red region at increasing temperature and the corresponding mechanism is proposed. Moreover, the temperature sensing behaviour was studied on the basis of fluorescent intensity ratio (FIR) technique. The temperature sensing study was conducted through non-thermally coupled levels (NTCL) $^3F_3$ and $^1G_4$ of Tm^{3+} ion. The higher absolute sensitivity of 94.7 $\times 10^{-3}$ K^{-1} is observed at 653 K. Furthermore, some anti-counter fitting applications were also demonstrated using the prepared phosphor. Therefore, prepared phosphor has potential use in optical thermometry, safety sign at higher temperature and anti-counterfeiting applications.

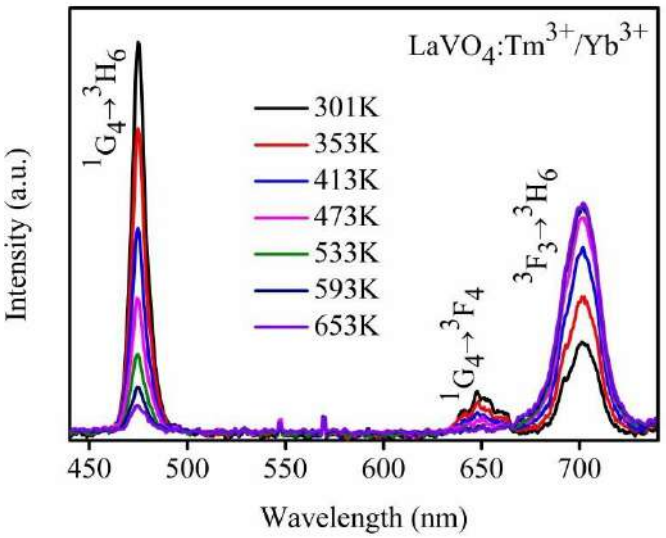

Figure 1: UC emission spectra of 0.3mol% Tm^{3+}/5mol% Yb^{3+} codoped $LaVO_4$ phosphor recorded in temperature range 301-653K with 980 nm laser diode excitation having pump power of 63 mW.

Paper ID: A-34

Area: Organics and amorphous semiconductor

GO doped $CsTiBr_3$ perovskite nanorods by solvothermal method

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Abstract. The perovskites with ABX_3 structure is commonly known as halide perovskites if X anion is a halide(X=Cl,Br,I).The halide perovskites are semiconductors having unique electrical and optical properties. Mostly studied are lead based all-inorganic halide perovskites but the lead toxicity limits its usage in commercial applications. The lead free halide perovskite of $CsTiBr_3$ is a stable and wide bandgap semiconductor. The all-inorganic lead free perovskite of pure and graphene oxide (GO) doped $CsTiBr_3$ is synthesized by solvothermal method and the GO powder by modified hummers method. The XRD analysis confirms the formation of $CsTiBr_3$. The incorporation of GO into the $CsTiBr_3$ crystal is evident from the EDAX analysis. The intensity of both XRD peaks and Raman peaks get reduced by doping. The Raman spectrum shows that the doping agent GO exist as reduced graphene oxide (RGO) in the doped sample. The two dimensional sheet like structure and the semiconducting nature of RGO enhances the electrical properties of $CsTiBr_3$. Each grains of the powder sample are formed by spherical balls of closely packed nanorods. The scattered nanorods of $CsTiBr_3$ which are not participating in spherical ball formation are wrapped up by the sheets of reduced graphene oxide (RGO) in the doped sample. The conductance of pure $CsTiBr_3$ is improved by the much conducting RGO. A better semiconducting property is achieved through GO doping. The GO doped $CsTiBr_3$ nanorods finds applications in various optoelectronic devices.

Paper ID: A-35

Area: Organics and amorphous semiconductor

Dielectric permittivity, modulus, and ac conductivity of regioregular poly(3-hexylthiophene) at various doping

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We have studied the capacitance, dielectric permittivity, dielectric modulus, and ac conductivity at varying frequencies (40 *Hz* to 110 *MHz*) in regioregular poly (3-hexylthiophene) prepared using solution casting method. This study is carried out for undoped and at two different doping concentrations. The dielectric permittivity value decreases at lower frequencies, tends to merge and becomes constant at higher frequencies. The relaxation peaks appears at lower frequencies for undoped sample shifts towards higher frequencies with increasing doping level. At fixed frequency the dielectric constant value is more for doped sample as more dipoles are oriented with the electric field. Electric modulus analysis shows the bulk dielectric relaxation peak at higher frequencies, and it suppress the interfacial relaxation. The relaxation time constant values are calculated; the value reduces with doping as more charge carriers are created, and this reduces the variation of charge carrier densities within the sample. The ac conductivity value shows increasing trend with the doping concentrations. At lower frequencies, the conductivity value increases with doping. The behavior of ac conductivity with frequency is analyzed using JonscherPower-law model.

References:

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Paper ID: A-36

Area: Organics and amorphous semiconductor

Amorphous-crystalline phase transformation induced changes in linear and nonlinear optical properties of Te/As_2Se_3 bilayer thin films

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The present work reports the amorphous-crystalline phase transformation upon diffusion of the top Te layer into the bottom As_2Se_3 thin film at various annealing temperatures (100, 150, 200, and 250 ºC). The Te/As_2Se_3 bilayer thin films have been prepared by electron beam (e-beam) evaporation technique under high vacuum conditions. The X-ray diffraction study shows the amorphous nature of the As_2Se_3 thin film whereas small peaks have been observed in Te/As_2Se_3 thin film. Further thermal annealing of the bilayer thin films led to the formation of crystalline peaks at 17.75º (-1, 2, 1), 22.54º (0, 2, 2) for As_4Te_4 (monoclinic) phase and at 27.12º (4, 0, 1), 39.94º (-6, 0, 2) for As_2Te_3 phases (monoclinic) respectively. The peak at 17.75º has shown significant growth at 250 ºC as compared to 200 ºC annealing. The XRD study confirms the amorphous to crystalline phase transformation upon thermal annealing. The surface morphology has been checked by FESEM and further structural change has been noticed from Raman spectroscopy. The UV- Visible spectroscopy data shows significant changes in both linear and nonlinear optical properties due to diffusion of Te into $As_{40}Se_{60}$ upon thermal annealing. Annealing temperature led to the shifting of absorption edge towards a higher wavelength. The absorption coefficient and extinction values increased with the decrease in transmittance. The change in Eg values upon annealing is due to the changes in defect states and the degree of disorder. The increase in E_u represents the increase of disorder which increased the band tailing and consequently decreased the band gap. The linear refractive index values increased with annealing temperature thus agrees well with the Moss's rule, $E_g n^4 \sim$ constant. The dispersion parameters, dielectric parameters, high-frequency dielectric constant, carrier concentration, etc. have shown significant variation due to the phase transformation. The 3rd order nonlinear susceptibility (χ^3) and nonlinear refractive index (n_2) have been increased with annealing which is useful for stable optical devices. The tuning of linear and nonlinear optical properties by annealing can be used in various optoelectronic applications. Specifically, the phase transformation behaviour of the Te/As_2Se_3 bilayer thin films can be utilized in phase change material-based optoelectronic devices.

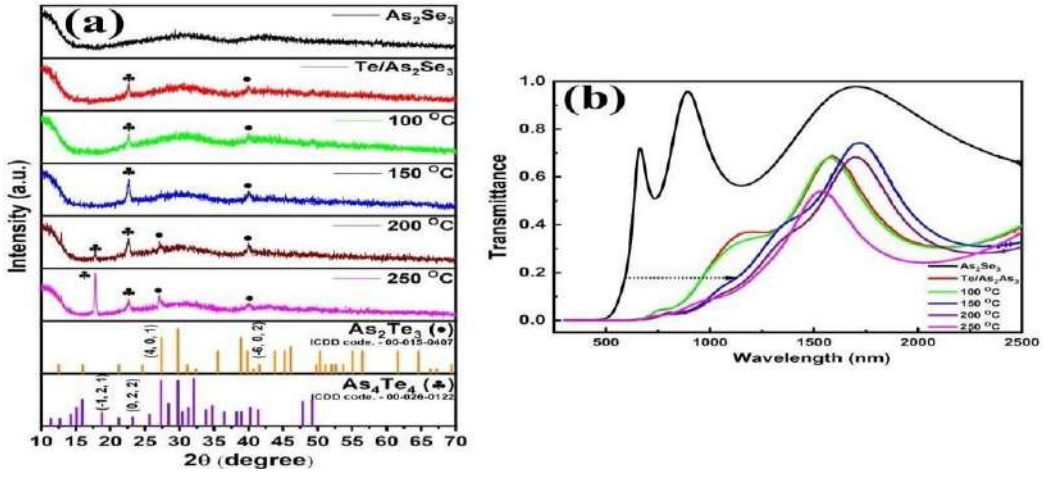

Figure 1: (a) XRD pattern and (b) transmittance spectra of As_2Se_3, Te/As_2Se_3, and 100 ºC, 150 ºC, 200 ºC, 250 ºC annealed thin films.

Paper ID: A-37

Area: Organics and amorphous semiconductor.

Novel air-stable p-type dopants: green synthesis, characterization, and determination of HOMO-LUMO for the applications of organic electronics.

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Abstract: Molecular doping approach in an organic semiconductor is recently emerged as a thrust area of research in the field of organic electronics such as organic light-emitting diodes (OLEDs), organic field effect transistors (OFETs), and organic photovoltaic (OPVs). Larger molecular dopants are more desirable since they are less reactive, restrict dopant ion diffusion, and minimize the electrostatic interactions between dopants ions and charge carriers. Recently several approaches of doping have been developed to yield an efficient dopant, yet easily handled, for example, where an electron transfer is coupled with additional chemistry. Among a wide variety of molecular p-type dopants, F4-TCNQ is one of the most widely used p-type dopant and is strong enough (EA = 5.2 eV) to oxidize a range of hole transport materials [1]. However, its volatile nature, instability vs diffusion, and poor solubility are undesirable features. We are recently working on a range of sulfur-based dimeric compounds, where the electron can take place via the cleavage of the S−S bond or via an adduct formation.[2]. Our study involves the synthesis of disulfide, and sulfonyl-based organic dimeric compounds (Figure 1). The sulfur-based dimeric compounds (such as 2,2'-disulfanediyldianiline, 1,2-bis(perfluorophenyl)disulfane, etc.) are synthesized via a green approach, using ball-milling over aluminium oxide (grinding auxiliary) without any catalysis and organic solvent [3]. These organic dimers are characterized by NMR, FT-IR, GC-MS and their redox potentials are measured by cyclic voltammetry. Utilizing cyclic voltammetry, UV-Visible spectroscopy, and comparisons with density functional theory (DFT) investigations, the energy gap of the synthesized new air-stable p-type dopants was determined.

Keywords: organic semiconductor, doping, green synthesis, p-type dopants, dimeric compounds

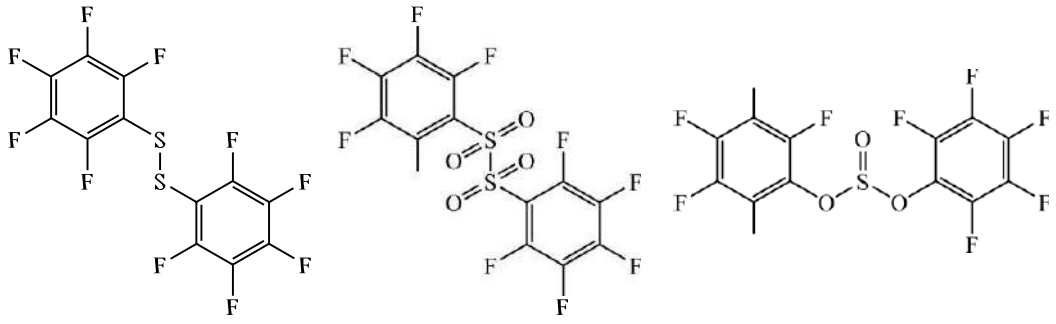

Figure 1: Disulfide and sulfonyl-based organic dimeric compounds.

References: [1] K. Walzer, et. al., Chem. Rev. 107, 1233 (2012). [2] N. Sakai, et al., Nat. Mater., 20, 1248 (2012). [3] T. Chatterjee & B. Ranu, RSC Adv., 3, 10680-10686 (2013).

Paper ID: A-2007

Area: Organics and amorphous semiconductors

Effect of annealing temperature on optoelectronic properties of Ag_2S-$As_{40}Se_{60}$ thin films

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Amorphous chalcogenide semiconducting materials show many peculiar changes in their optical, electrical, and structural properties upon exposure to numerous external stimuli like laser irradiation, thermal annealing, low-energy and high-energy ion irradiation, etc. Among these, thermal annealing is one of the important external stimuli for creating major structural and optical transformations in the films. The present investigation is based on the annealing induced changes in the Ag_2S-$As_{40}Se_{60}$ film at different annealing temperatures like 100 ^{0}C,150 ^{0}C and 200 ^{0}C. The Ag_2S/$As_{40}Se_{60}$ bilayer chalcogenide thin films has been prepared by thermal evaporation method at high vacuum condition. The Ag_2S film of 35 nm is diffused into $As_{40}Se_{60}$ film of thickness 65 nm by annealing to form the Ag_2S-$As_{40}Se_{60}$ solid solution. The comparative study of $As_{40}Se_{60}$, Ag_2S/$As_{40}Se_{60}$ and annealed Ag_2S/$As_{40}Se_{60}$ films shows the changes in structural as well as optical properties of the films. The X- ray diffraction analysis probes the amorphous phase of Ag_2S/$As_{40}Se_{60}$ thin film and also for the 100 ^{0}C annealed film. However, the minor peak is found for the 150 ^{o}C annealed film which represents the phase change of selenium from rhombohedral to hexagonal and formation of orthorhombic $AgAsSe_2$ phase at 200 ^{o}C annealing (Fig.1a). The transmission power change with shift of absorption edge has been noticed from the UV-Vis-NIR data (Fig.1b). The transmittance decreased with annealing at lower wavelength regime whereas it increased at higher wavelength region. The reduction in optical bandgap upon Ag_2S mixing in $As_{40}Se_{60}$ film and subsequent annealing is due to the formation of localized states in the bandgap region. The change in Tauc parameter and Urbach energy infers the change in degree of disorder in the film upon annealing. The increase in refractive index increased the nonlinear parameters such as 3rd order nonlinear susceptibility, nonlinear refractive index. The evolutions in optical parameters make ‗the annealing temperature' as an important factor for controlling the optoelectronic properties of Ag_2S/$As_{40}Se_{60}$ thin films. Furthermore, the surface morphology and composition of the films has been characterized by FESEM and EDX whereas the vibrational mode change is noticed from the Raman Spectroscopy.

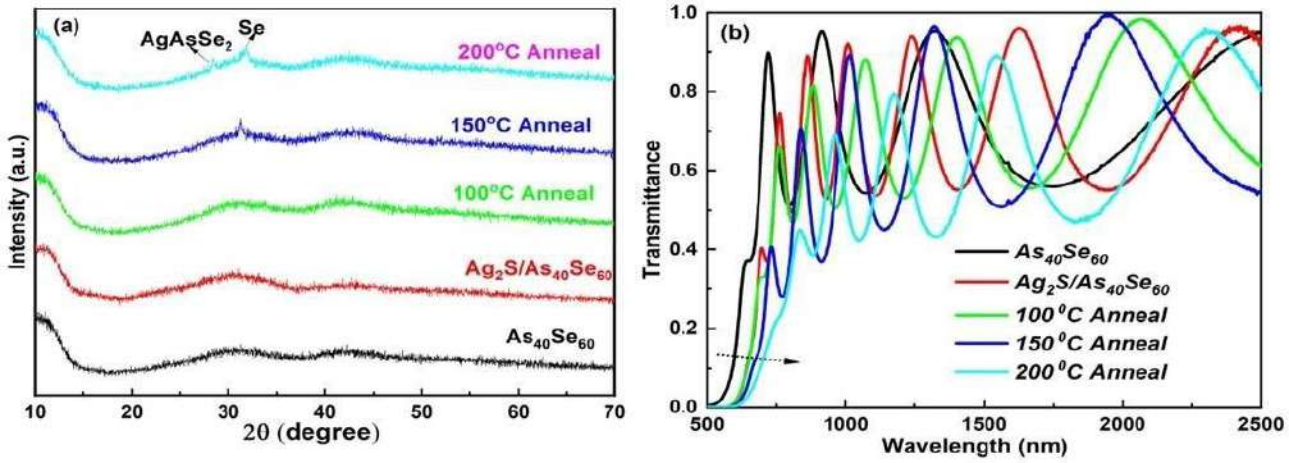

Figure 1: (a) XRD pattern and (b) Transmittance spectra of $As_{40}Se_{60}$, Ag_2S/$As_{40}Se_{60}$, and 100 ^{o}C, 150 ^{o}C, 200 ^{o}C,annealed thin films.

Key words: Chalcogenides; Thin films; Optical properties; Band gap; Nonlinear refractive index.

Paper ID: A-2008

Area: Organics and amorphous semiconductor

Interface engineering of semiconducting polymer thin films for organic electronic applications

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Charge transport within the crystalline domains of organic semiconducting polymer (OSP) thin films occurs through the conjugated polymer backbone assisted by interchain hopping through overlapped π-electron clouds between adjacent polymeric molecules.[1] Thus, besides synthesizing high-mobility OSPs, efforts have been made to use process advantages to fabricate high-performance organic electronic devices. One of the most effective way-outs to enhance in-plane carrier mobility is the uniaxial orientation of these quasi-one-dimensional OSPs.[2] In this context, our group has developed a facile thin film deposition technique named –***Floating Film Transfer Method (FTM)***,‖ which provides a large area (~40 cm^2), highly oriented, crystalline, smooth polymer film and minimizes significant production costs by reducing material waste up to ~95%. *FTM* is based on the controlled dispersion of organic molecules at Air/Liquid interface by controlling surface tension, π-π interaction, and viscosity. However, major polythiophene derivatives were found to form ‗edge-on' type molecular stacking while processed through *FTM*,[1] which will benefit OFETs but not SBDs. Thus, harnessing the key advantages of *FTM* and an interfacial engineering approach, a novel subphase modified *FTM* has been developed for controlling the molecular arrangement in polymer thin films, which yields a dramatic enhancement of rectification ratio up to 0.82×10^7 at ±6V in an ITO/P3HT/AlOx/Al sandwiched structure (Fig 1 (c)). We also gain control over the effective coherence length by manipulating the evaporation flux (in-plane mobility enhanced five times). We further demonstrated the dynamics of polymer solution spreading over an air-liquid interface through a simple model based on lubrication theory and thin-liquid film flow kinetics. Thus, *FTM* opens a new paradigm of material processing to engineer high- performing organic electronic devices to meet the growing technological appeal.

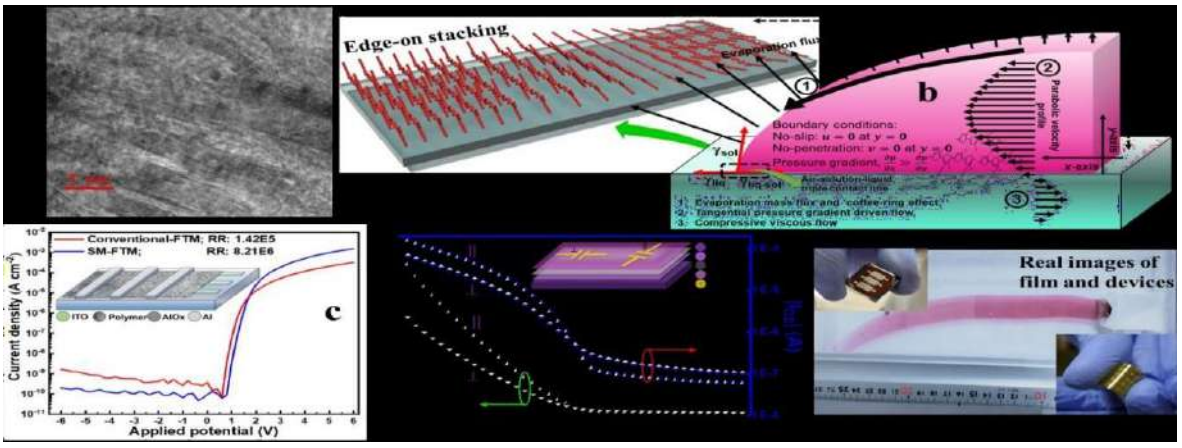

Figure 1: (a) HR-TEM image of oriented PBTTT film, (b) *FTM* film formation mechanism, (c) Highly rectifying P3HT Schottky barrier diode, (d) Anisotropic charge transport in oriented PBTTT *FTM* film.

Keywords: *Organic semiconducting polymer; Interface engineering; Self-assembly; Floating-film transfer method; Organic electronics.*

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Paper ID: A-2009

Area: Organics and amorphous semiconductor

Study of AC Conductivity and Dielectric Relaxation in Li2O·PbO·Bi2O3·B2O3 Glasses

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Abstract: In the present work, we have prepared lithium lead bismuth borate glasses with different concentrations of bismuth having the composition 30Li2O·20PbO·xBi2O3·(50-x)B2O3 (where, x=0, 10, 20, 30, and 40 mol%) by following the melt quenching technique. The prepared samples are investigated by electrical and electric modulus formalism properties in the range of frequency from 10^{-1} to 10^{7} Hz and temperature from 473 to 613K. To check the applicability of various charge transport mechanisms in the prepared samples, the experimental data of ac conductivity has been fitted with Johnscher's power law. It was found that to be satisfied in the studied frequency and temperature range and helps to calculate all the parameters viz., dc conductivity (□dc), cross-over frequency (ωH), and frequency exponent (s). The value of ac conductivity found to be dependent on bismuth concentration. The value of frequency exponent parameter decreases with increase in temperature. The CBH model is found to be suitable for explaining the ac conduction mechanism. Almost similar values of thermal activation energy for conduction and relaxation suggest the single mechanism for the dynamic processes occurring in the present glasses.

Keywords: Bismuthate glasses, Jonscher's Power Law, Electric Modulus Formalism, Relaxation Time.

Paper ID: C-3001

Area: Crystal Growth

Structural and optical properties of zinc stannate bulk samples

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$ZnSnO_3$ is one of the promising candidates as transparent conducting oxide (TCO) having perovskite structure. In this work we have doped $ZnSnO_3$ with Sb ions to introduce electrical conductivity while keeping it optically transparent. The powder samples of Sb-doped zinc-stannate ($ZnSn_{1-x}Sb_xO_3$, x = 0, 1, 3 and 5) were prepared using the solid-state reaction method. These powders were characterized for their structural, electrical and optical properties. Two phases of SnO_2 and Zn_2SnO_4 were observed in the X-ray diffraction spectra. On increasing the concentration of Sb doping the Sn-O bond length decreased which was found responsible for the observed shifting in Raman modes. UV-Visible studies showed that the optical band gap decreased with increase in doping concentration and lies between 3.08 to 3.45 eV. These samples showed over 80% average transmittance in the visible region which showed their promise as a possible TCO material.

Paper ID: C-42

Area: Crystal Growth

High-quality, uniform growth of MoSe2 on Si (111) substrate by molecular beam epitaxy

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Molecular beam epitaxy (MBE) growth of 2D-TMDCs is getting more research interest due to control over thickness, lower growth temperature and high-quality film. Outstanding electrical and optoelectrical properties of atomically thin 2D-TMDCs promising future applications in a wide number of fields. Here we are going to present the growth of $MoSe_2$ on Si (111) by optimizing the growth temperature and flux. The growth of $MoSe_2$ has been performed in four different conditions by varying the growth temperatures, flux rate and flux ratio. It has been observed that the best growth achieved at 580 ˚C substrate temperature and 1:50 molybdenum to selenium flux ratio. Phase pure, uniform, and smooth MoSe2 film is obtained, evidenced by Raman spectroscopy and atomic force microscopy. X-ray diffraction peak comes only from family of (002) planes, which confirms the van der Waals growth along c-axis of the substrate. Atomic force microscopy shows the grain size of $MoSe_2$ for the four samples are varying between 25 nm to 50 nm. Also, the thickness of the samples is in between 3 nm to 4 nm, which are 4 to 5 layers of $MoSe_2$.

Paper ID: C-43

Area: Crystal Growth

Dielectric behaviour and conductivity studies of YBaYbSiO ceramic

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In this paper, we study the dielectric behaviour of YBaYbSiO ceramic. The samples were prepared by combustion route. The morphological analysis was done by scanning electron microscopy which shows both spheroidal and ellipsoidal shape of grains as shown in figure 1 below. The Fourier Transform Infrared (FTIR) Spectroscopy has been performed and the obtained spectra confirms the presence of functional groups and bond formations in the synthesized samples. The frequency dependent dielectric studies of the ceramic were done with temperature ranging from 50 °C – 500 °C. The dielectric constant and dielectric loss decrease with increasing values of frequency due to reduction of polarization effects. The a.c. conductivity analysis followed universal power law suggesting it‘s utilization in electrical devices, capacitors etc.

Keywords: *Dielectric, Conductivity, Morphological, Ceramic*

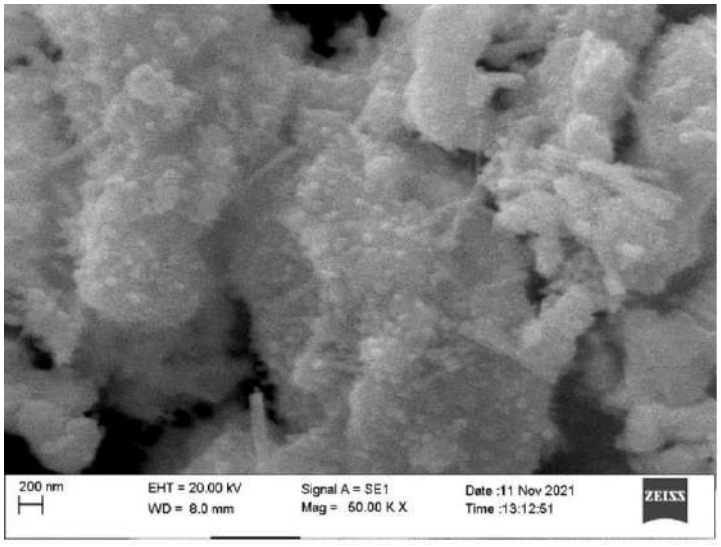

Figure 1: spheroidal and ellipsoidal shape of grains

Paper ID: C-44

Area: Crystal Growth

Structural, thermal and optical properties of self supporting PMMA films reinforced with β-Ga_2O_3 micro-spindle structures

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Gallium oxide (Ga2O3) is a wide band gap (~4.9 eV), transparent semiconducting oxide (TSO) material which finds applications in variety of current and future generation devices. Ga2O3 exhibits temperature dependent polymorphism, with the five polymorphs designated as α, β, γ, δ and ϵ. All the polymorphic forms transform to the most stable β phase at temperatures higher than 800°C. In this work, β-Ga2O3 micro-spindle structures were synthesized by a low cost hydrothermal route. The as prepared micro structures were successfully reinforced into poly (methyl methacrylate) (PMMA) matrix at different weight percentages (0, 1, 2, 3 and 4%) to fabricate self standing films through mechanical mixing and solvent casting technique. The formation of composite films was confirmed using X-ray diffraction and fourier transform infrared spectroscopic technique. Thermal analysis of the films using thermogravimetric and differential scanning calorimetric analyses revealed the improvement of thermal stability of the composite films compared to pristine PMMA films. The optical properties of the films were studied by utilizing spectrophotometric and photoluminescent studies. The composite films were characterized by a strong absorption in the deep UV region along with a broad emission in the visible spectrum centered at blue region. Thus the prepared PMMA/ β-Ga2O3 composite films mark its importance for different optical and technological applications.

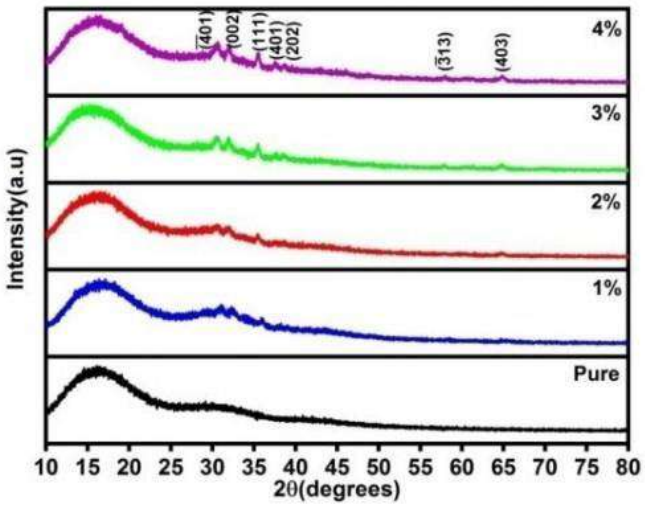

Figure 1: XRD patterns of pure and composite films

Paper ID: C-45

Area: Crystal Growth

Modification of structural, optical and dielectric properties of Mn3O4 NPs by doping of Nickel ions

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Un-doped hausmannite manganese oxide (Mn3O4) and Ni doped Mn3O4 (2%, 4% and 6%) nanoparticles have been synthesized at 400 oC using acacia concinna fruit extract by a simple one-pot sol gel method. The synthesized nanoparticles were characterized by various techniques like PXRD (Powder X-Ray Diffraction), FTIR (Fourier Transform Infrared Spectra), SEM (Scanning Electron Microscopy), RAMAN, UV-DRS (Ultraviolet Diffused Reflectance Spectroscopy) and PL (Photoluminescence) methods. Ni doping decreases the crystallite size as obtained from XRD data and after 2% Ni doping, there is change in the crystal phase from tetragonal to cubic. The surface morphology as seen from the SEM images indicates their porous nature withhomogeneous distribution of particles. Using UV-DRS, optical properties are analyzed. There is increase in the optical band gap from 2.79 eV to 3.16 eV upon Ni doping. Multiple PL emission spectra in the red-violet region was obtained. The dielectric permittivity, AC conductivity, dielectric loss, loss tangent and impedance studies were carried out in the frequency range of 1-106 Hz at room temperature. The dielectric properties of the materials increased appreciably with increase in Ni-doping concentration.

Keywords: *Mn3O4, Ni doped Mn3O4, Acacia Concinna, Photoluminescence, Optical properties, Dielectric properties*

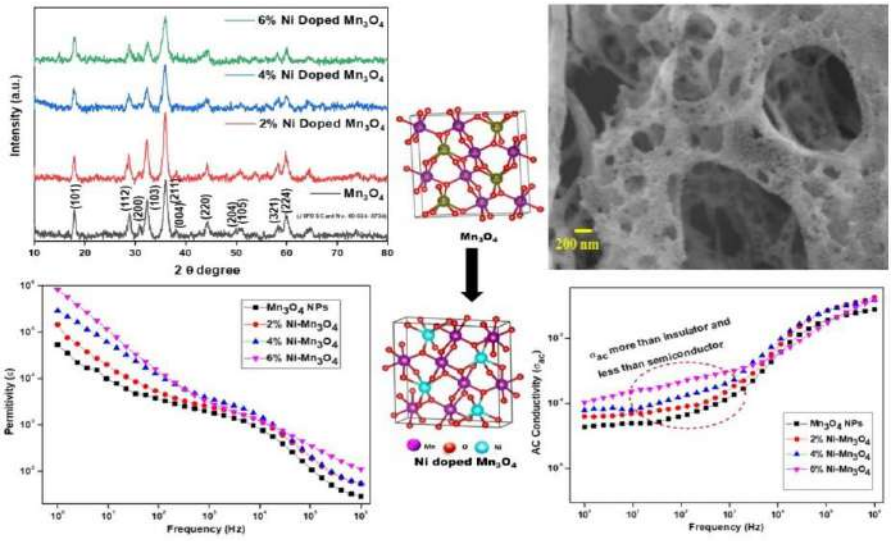

Figure-1: Graphical Abstract

Paper ID: C-46

Area: Crystal Growth

Deposition of Sn-doped ZnO for ethanol sensing

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This work reports the effect of Sn doping into ZnO for ethanol sensing. The required ZnO films were prepared by spray pyrolysis method and characterized by UV-visible (UV-vis) spectroscopy and X-ray diffraction (XRD) for optical and structural investigation. The result of band gap measurement showed a decreased band gap for Sn-doped ZnO (SnZnO) films. Likewise, a decrease in crystallite size was obtained for SnZnO films in the X-ray diffraction analysis. The multiple peaks signify the formation of the polycrystalline nature of as-prepared ZnO and SnZnO samples. The sensitivity measurement illustrated a good gas response of 18 at 400 ppm exposure for 2% Sn-ZnO film at the optimized operating temperature of 220 oC. At the same time, the authors also claim the successful detection of very low 0.5 ppm of ethanol vapors with a gas response of 2.3 at this temperature. The results also showed good values for the response and recovery times of SnZnO as 15 sec and 119 sec, respectively, for 2% SnZnO at an exposure of 400 ppm of ethanol vapors.

Keywords: *SnZnO, Spray pyrolysis, Structural properties, Ethanol sensing, Response ratio.*

Paper ID: C-47

Area: Crystal Growth

S-plane growth of gallium nitride on c-sapphire substrate using pulse laser deposition

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We report synthesis of S-plane Gallium Nitride (GaN) films c-sapphire substrate. Effect of growth temperature on the structural, micro structural, optical and electrical properties are investigated using respective techniques. The dramatic change in the surface morphology of the films grew herewith are observed to depend on the growth temperature changed only by the difference of 100 oC. Variation in the growth temperatures observed to potentially assist the crystalline phase of the films deposited. The results reported herewith are encouraging towards the use of GaN films to fabricate futuristic optoelectronic devices.

Paper ID: C-48

Area: Crystal growth and epitaxy of semiconductor materials

Large area growth of few-layer 2H-$MoTe_2$ on Si (111) using Molecular Beam Epitaxy

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Transition metal dichalcogenides (TMDCs) have emerged as an essential class of two-dimensional materials exhibiting exotic fundamental properties such as tunable bandgap and novel phenomena for future electronics and optoelectronics devices. Unlike sulfide and selenide-based TMDCs, telluride-based TMDCs such as $MoTe_2$ exhibit both 2H and 1T‘ phases stability owing to the small energy difference between the two phases, thus giving access to a range of properties from semiconducting to semi metallic. To exploit these properties, controlled growth of the different phases of MoTe2 over a large area is essential. Here we utilize a singlestep growth strategy with chalcogen-rich pre-annealing to demonstrate phase pure growth of few-layer 2HMoTe2 on silicon over a centimeter scale using molecular beam epitaxy. Different characterization techniques such as Raman spectroscopy, AFM, RHEED, XPS and spectroscopic-ellipsometry have been utilized to investigate the properties of the as-grown film. The higher growth temperatures and lower growth rates (~0.1 monolayers per minute) have been observed to promote layered growth mode over island growth with the increased flatness of the grown material. Also, controlling the chalcogen-to-metal flux ratio (X:M) is crucial for the high quality of the grown material

Paper ID: C-3010
Area: Crystal growth and epitaxy of semiconductor materials

Thermoelectric properties of Zn-doped InGaSb crystals grown by directional solidification

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Thermoelectric (TE) materials can convert heat energy in to electrical energy without any harmful radiation or emission. The search for various TE materials is evolving continuously as it is challenging to achieve high efficiency when TE materials are integrated in to devices because of their interrelated electron and phonon transport properties. To possess high efficiency, TE materials should exhibit high electrical conductivity and low thermal conductivity, simultaneously [1]. InGaSb is a III-V ternary semiconductor alloy having tunable physical properties with respect to its composition. Compositional segregation is a natural phenomenon that occur during the solidification of In-Ga-Sb melt because of the higher segregation coefficient of constituent elements. The compositional segregations can be controlled via controlling the growth kinetics of InGaSb crystals [2,3]. It was demonstrated that the TE properties of InGaSb crystals can be improved by controlling the crystalline defects and compositional segregations. The highest TE figure of merit (ZT) is achieved by InGaSb crystal with indium composition of 0.95 [4,5]. As $In_{0.95}$ $Ga_{0.05}Sb$ exhibit n-type conductivity, Zn atom was heavily doped (1 x 10^{20} and 1 x10^{21} atoms/cm^3) with $In_{0.95}$ $Ga_{0.05}Sb$ to change its conductivity from n-type to p-type and its TE properties were studied. Zn doped In0.95Ga0.05Sb crystals were grown by directional solidification method. Indium (In), Gallium (Ga), Antimony (Sb), and Zinc (Zn) elements with minimum purity of 4N were taken in a quartz ampoule at appropriate quantity. The quartz ampoule was evacuated and sealed under high vacuum (~ 3 x 10-5 Torr) condition. The sealed ampoule was placed in a multi-zone vertical gradient heating furnace. The furnace was heated up to 700 °C and kept hold for certain time for the melt to mix completely. The molten metals were solidified to grow crystals by maintaining the temperature gradient of the furnace. The grown crystals were cut and polished to analyze their structural, electrical and thermal conducting properties. The XRD pattern of Zn doped (1 x 1020 atoms/cm3) $In_{0.95}$ $Ga_{0.05}Sb$ ($In_{0.95}$ $Ga_{0.05}Sb$:E20) and Zn doped (1 x 1021 atoms/cm3) $In_{0.95}$ $Ga_{0.05}Sb$ ($In_{0.95}$ $Ga_{0.05}Sb$:E21) are shown in the figure 1. The heavy doping of Zn element with In0.95Ga0.05Sb retained the parent phase of cubic zinc blende structure. The Zn doped InGaSb crystals reveled p-type conductivity with carrier concentration varying of the order from 1017 to 1018 atoms/cm3 . The electrical resistivity was increased with temperature which is typical behavior of degenerate semiconductors resulting from heavy doping of elements. The maximum ZT of 0.24 was achieved by $In_{0.95}$ $Ga_{0.05}Sb$:E20 sample at 573 K. The results show Zn doping with InGaSb can change the

electrical conductivity from n-type to p-type and it can be used to enhance the ZT value of p-type InGaSb crystals. Figure 1: XRD of Zn doped In0.95Ga0.05Sb crystals.

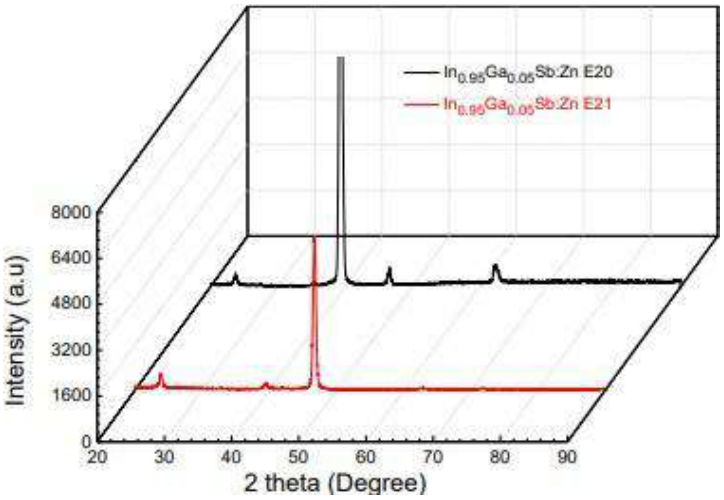

Figure 1: XRD of Zn doped $In_{0.95}$ $Ga_{0.05}Sb$ crystals

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Paper ID: C-51

Area: Crystal growth and epitaxy of semiconductor materials

Studies on the nucleation, photoluminescence, electrical conductivity, and photoconductivity of semi-organic lithium fumarate crystals

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Strong optical nonlinearity and thermal stability, both of which are characteristics of organic and inorganic semiconductors, are present in the semi-organic material. CNT is used to analyse the kinetics of LF nucleation. The kinetic parameters enthalpy, Gibbs free energy, real heat power, and entropy of activation are calculated in relation to temperature variations. Additionally, the breadth of the LF's Meta stable zone is computed as a function of super saturation. Thermogravimetric techniques are used by Horowitz-Metzger, Coats-Redfern, and Piloyan-Novikova to assess kinetic parameters. investigation on photoconductivity, electrical conductivity, and photoluminescence were discussed.

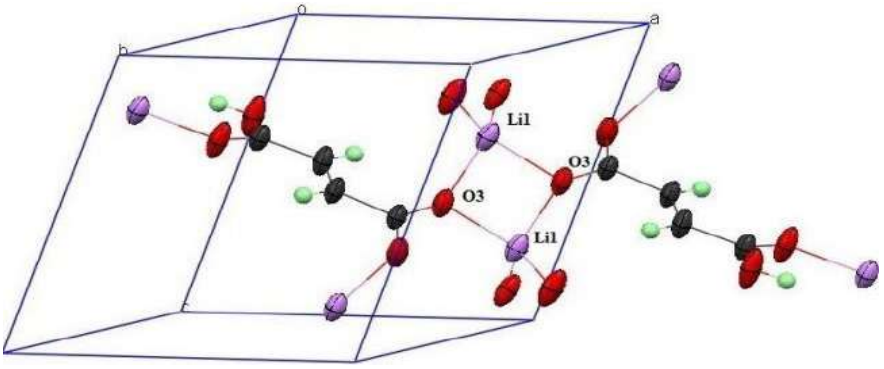

Fig 1. Inversion of molecular structure of Lithium Fumarate

Paper ID: C-52

Area: Crystal growth and epitaxy of semiconductor materials

State of art molecular beam epitaxy of GaSe material on different substrates and it's characterization

Nand Kumar[1] , Kamlesh[2] , Santanu Kandar[2] , Ashok Kapoor[2] and Rajendra Singh[1,2]

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Recently, growth of 2D layered transition metal chalcogenides (TMD) by molecular beam epitaxy (MBE) have attracted increasing interest in realizing novel devices due to exotic electronic and optoelectronic properties. Here, we report MBE growth of semiconducting GaSe on 3D single crystal Si (111) and CSapphire substrate regardless of lattice mismatch at growth temperatures (TS) of 400oC. For Se and Ga source, we have used cracking cell and emulsion cells, respectively. During growth, Se/Ga flux ratio was ~ 5. The in situ reflective high-energy electron diffraction was used to monitor the epitaxial growth. X-ray photoelectron spectroscopy, Energy Dispersive X-Ray and X-ray diffraction analysis are used to find the film structure and formation of additional phase. The photoluminescence and Raman spectra of the grown films are discussed in detail to confirm or correct the structural findings. These results provide the state of art of the MBE-growth process of GaSe on bulk substrate and pave the path to grow other 2D layered materials.

Paper ID: C-53

Area: Crystal growth and epitaxy of semiconductor materials

Studies of structural, optical and electrical properties of molecular beam epitaxy (MBE) grown Ge on SiC

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Silicon carbide (SiC) with a wider band gap, and higher thermal conductivity, and a stronger breakdown field shows an excellent electrical and physical properties which make it an important material for some future electronic devices. Because of these characteristics, SiC is ideal for hightemperature, high-power, high-frequency, and radiation-hardened electronic devices. In this work we investigate the physical, optical and electrical properties of germanium of different thicknesses (1- 5 nm) deposited on 4H-SiC substrates by molecular beam epitaxy (MBE) technique. SEM images depict the size of the Ge nanoparticles increases from 22.10 ± 1.04 nm to 75.64 ± 1.29 with increasing thickness from 1 nm to 5 nm. Atomic force microscopy (AFM) has been utilized to obtain the surface roughness. Optical band gap of the nanoparticles decreases with increasing Ge thickness which has been reflected from UV-Vis spectroscopy measurements. Many defects related to 4H-SiC have been observed through optical analysis. Temperature dependent current-voltage (I-V) measurements have been done for 5nm Ge sample as it has less surface roughness. It shows the schottky behavior with decreasing resistivity as temperature increases up to 200 °C.

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Paper ID: C-54

Area: Crystal growth and epitaxy of semiconductor materials

Interfacial engineering persuaded electronic and magnetic properties of BS/FS/BS heterostructure

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Magnetic impurity induced Bi2Se3 single crystals and ferromagnetic/topological layered structures were prepared to compare the structural, electronic, and magnetic properties of the systems. As the presence of the magnetic impurity potentially diminishes the time-reversal symmetry (TRS), opening a finite gap at the Dirac point, such phenomena modify the topological surface state effectively. Using the field emission scanning electron microscopy (FESEM) we confirmed the height of the prepared heterostructure, displayed in Figure 1 (a). Reducing the dimensionality, the interfacial magnetic domains modify the electronic properties of the heterostructures at the layers and the interfaces which were probed by the depth profile analysis with argon etching via X-ray photoemission spectroscopy (XPS) technique as shown in Figure 1 (b-f). From the in-depth investigation of the heterostructures, we succeed to draw a clear matrix of the layers and interfaces along the cross-sectional plane. Further, the magnetic properties were investigated to enlighten the effect of strain over the confined system to clarify that the magnetic inter-layer effect enhances the applicability of such heterostructures with new prospects.

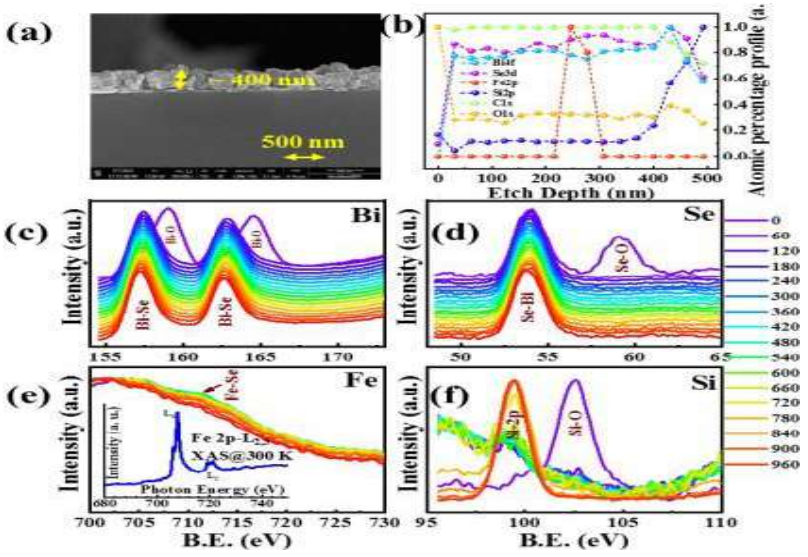

Fig. 1: Surface and cross-sectional FESEM images of as prepared heterostructures. XPS atomic percentage profile concerning the etch depth of the (a) FS/BS/FS and (b) BS/FS/BS heterostructures. (cf) and (g-j) represents the XPS depth profile spectra at different etching times for Bi-4f, Se-3d, Fe-2p and Si-2p elements in FS/BS/FS and BS/FS/BS heterostructures, respectively.

Paper ID: M-55

Area: Semiconductor device modeling and simulation

Optimization of DC and RF performances for an AlGaN/GaN MOS-HEMT with AlGaN sub-channel through Field Plate engineering

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There is an eminent requirement for optimized High Electron Mobility Transistors (HEMTs) that can withstand high-power operating conditions. Gallium Nitride (GaN)-based devices offer greater velocity, improved current conduction, and a large field-effect mobility. These devices have the advantage to not only forming large mobility and current densities without the requirement of channel doping, but also through theabsence of ionized impurity scattering. A fine geometrical structure not only improves the current and power density of the device, but also maintains good thermal conductivity. Shorter gate length device is required for achieving higher RF performance, but certain limitations arise when subject to lithography tools for low gate lengths. Hence in this work, field plate engineering has been performed by applying field plates (FP) at both gate and source regions. The device-level performances such as drain current, electric field, breakdown voltage and certain RF parameters like current gain, frequency has been analyzed for a L-gated $Al_{0.25}Ga_{0.75}N/GaN/Al_{0.06}Ga_{0.94}N$ MOS-HEMT device. The AlGaN sub-channel is incorporated below the GaN channel layer for bringing a flat transconductance curve, that leads to enhanced current gain. Apart from validating the model with experimental outcomes, advanced calibration has been performed by varying several dimensions such as gate length (LG), field plate length (LFP), AlGaN sub-channel mole fraction, passivation layer thickness (tP), AlGaN barrier thickness (tALGaN), gate-drain distance (LGD) and finding their corresponding DC characteristics. In doing so, a larger breakdown voltage is obtained, along with imrpoved electric field by field-plate engineering. A 45% improvement is observed for the current drive with better and linearized current gain. These outcomes prove the device to be a prime contender for high-power switching applications like Monolithic Microwave Integrated Circuit (MMIC) and Doherty amplifiers.

Paper ID: M-56

Area: Semiconductor device modeling and simulation

Effect of Temperature on Projection to DC analysis of Heterojunction based Tunnel Field Effect Transistor (HJ-TFET)

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This paper addresses a double-gate tunnelling field-effect transistor (DG-TFET) with silicon–germanium (SiGe) Source and channel and the performance is analyzed using Sentaurus TCAD 2D simulation to overcome the scaling limits of complementary metal–oxide–semiconductor (CMOS) technology. The device is simulated different performance parameters such as drain current characteristics, subthreshold swing (SS) and ION/IOFF ratio for different range of temperature varying from 200oK to 500oK. The narrower bandgap of the

SiGe source helps to reduce the tunnelling width and improves the on-state current and subthreshold swing. Less than 60 mV/decade subthreshold swing with extremely low off-state leakage current is achieved by optimizing the device parameters and Ge content in the source. We show that such a technology proves to be viable to replace CMOS for high performance, low standby power, and low power technologies through the end of the roadmap with extensive simulations.

Paper ID: M-57

Area: Semiconductor device modeling and simulation

Simulation of Tesla roadster regenerative braking in the near future dominated by Electric Vehicles

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Vehicles lose a tremendous amount of kinetic energy during frequent braking and constant drive at low speeds on designated city routes that leads us to an idea of storing and reusing that kinetic energy, which is also called as regenerative braking. This simulative research analysis shows the functioning capability of a regenerative brake in a lithium ion battery operated electric vehicle. The lithium ion battery assists energy retention in the vehicle thereby reducing sooner prospects of recharging and repair of battery. Automotive regenerative braking systems harness kinetic energy while a vehicle decelerates, and subsequently uses that stored energy to assist propulsion. Tesla‘s battery EV has one-pedal driving system which combines conventional acceleration, using the right-hand pedal, with a much higher degree of deceleration than in a conventional car. During regenerative braking, deceleration of the vehicle causes the vehicle‘s drive motor to act as a generator that recharges the drive battery. This recharging is essential to obtaining the high number of miles on a single battery charge that Tesla claims and drivers require. Commercially available hybrid vehicles use generators, batteries, and motors to electrically implement regenerative braking and increase overall vehicle efficiency. A simulation has been implemented in MATLAB software and is currently under development to study the model of an EV and the power retained in its regenerative braking compared to commercial IC engine vehicles.

Paper ID: M-58

Area: Semiconductor device modeling and simulation

Improvement of electron mobility mediated by interface roughness scattering in pseudomorphic GaAs/$In_{0.15}Ga_{0.85}As$ asymmetry double quantum well structure

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In pseudomorphic heterostructure, the interface roughness between different layers plays an important role to determine the transport properties of electrons which control the overall device performance. Here, we analyse mobility mediated by interface roughness (ir-) scattering i.e., μ^{ir} (m^2/Vs) as a function of electric field F (0 to 20×10^2 kV/m) applied from the substrate to the surface side of a pseudomorphic GaAs/$In_{0.15}Ga_{0.85}As$ asymmetry double quantum well (ADQW) structure. The asymmetry in the potential profile of the structure is obtained by taking different well widths (w_1 = 100 Å and w_2 = 150 Å). The μ^{ir} is calculated by considering screened *ir*-scattering potential by adopting RPA [1 - 2]. We obtain the non-monotonic nature of μ^{ir} for different central barrier of width b (b = 30 Å, 50 Å, and 70 Å) with $N_{d1} = N_{d2} = N_d = 1.25\times10^{24}$ m^{-3}. As shown in Figure 1, at $F = 0$, two subbands are occupied and μ^{ir} became maximum. As F increases, μ^{ir} gradually decreases and becomes minimum at the resonance point mediated by intersubband interaction where the gap between the Fermi energy E_{F0} and E_{F1} (inset of Figure 1) is minimum [3]. Then μ^{ir} increases up to a certain extent, after which decreases till the end of double subband occupancy. After which there is a slight enhancement in μ^{ir} due to the transition of double to single subband occupancy. It is interesting to note that as b increases the sharpness of the dip in μ^{ir} enhances at the resonance point which occurs at a lower value of F. This is due to the asymmetric potential profile becoming symmetric at a particular F where resonance occurs. As b increases, the potential profile becomes wider in length resulting occurrence of resonance at the lower value of F. We also reported that the effect of symmetric doping concentrations i.e., N_d modulates μ^{ir}. In Figure 2, we show the results of μ^{ir} as a function F for different N_d (1, 1.25, and 1.5×10^{24} m^{-3}) with w_1 = 100 Å and w_2 = 150 Å in the ADQW structure. Here, μ^{ir} enhances with N_d but the resonance point is marginally changed as shown in the inset of Figure 2. As N_d varies symmetrically, so its effect is negligible on resonance point. Our results will be helpful for the reduction of *ir*-scattering in emerging III-V compound semiconductor based devices.

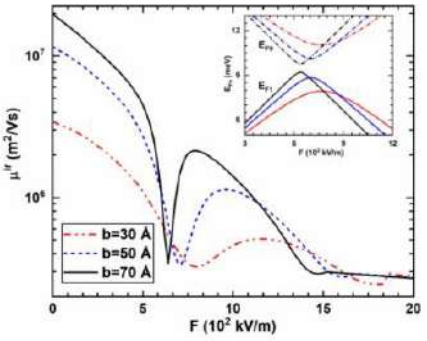

Figure 1: μ^{ir} as a function of F for different b in *GaAs/$In_{0.15}Ga_{0.85}As$* ADQW having well width w_1 = 100 Å, w_2 = 150 Å, spacer width $s_1 = s_2$ = 50 Å, doping width $d_1 = d_2$ = 20 Å, and doping concentration N_d =1.25×10^{24} m^{-3}.

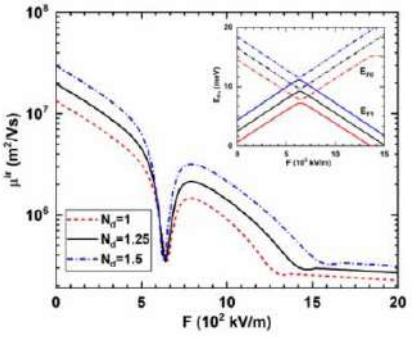

Figure 2: μ^{ir} as a function of F for different N_d (1, 1.25, and 1.5×10^{24} m^{-3}) in *GaAs/$In_{0.15}Ga_{0.85}As$* ADQW having w_1 = 100 Å, w_2 = 150 Å, $s_1 = s_2$ = 50 Å, $d_1 = d_2$ = 20 Å, and b = 70 Å.

Paper ID: M-59

Area: Semiconductor device modeling and simulation

Role of doping concentration, thickness of intrinsic layer and number of layers of Graphene in Graphene-Silicon heterojunction Solar Cells

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Graphene has unique characteristic of zero band-gap. Its electrical properties can be widely tuned by varying the number of layers or by doping as p or n type with different materials. Due to high optical transmittance, graphene can be used as both, electron, and hole extraction layer. By choosing suitable dopant compared to graphene (work function=4.5), we can dope it suitably by higher work function material for p-type doping and lower work function material for n-type doping. For example, Au (~5.4), Graphene Oxide (~5.3) and NiO_x (~5.7) can act as p-type dopant and TiO_x (~4.15), Ti (~4.3) as n-type dopant. To understand the role of graphene we have simulated n-graphene/Silicon hetero-structure using AFORS (Automat FOR Simulation of HETero structures) software under AM1.5 illumination and power density of 100mW/cm^2. Here, we varied the number of layers of graphene from 1 to 20, and the thickness of a-Si:H i-layer from 0 to 20nm, the n-type doping concentration of Graphene from 1×10^{10} cm^{-3} to 1×10^{20} cm^{-3} to get the optimized results. Corresponding to that, we studied the band diagram and hence barrier height, variation in Quantum efficiency etc. The best power conversion efficiency obtained is 18.13% where the V_{oc} is 602.9 mV, J_{sc} is 36.52 mA/cm^2 and FF is 82.36% corresponding to i-layer thickness 5nm, single layer graphene and n-type doping concentration of 1×10^{20} cm^{-3}.

Paper ID: M-60

Area: Semiconductor device modeling and simulation

Sensitivity analysis of a high-κ dielectric AlGaN/ GaN MOSHEMT-based biosensor

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Due to the tremendous requirement of biosensors in the present scenario, we examine the applicability of a Single Gate Metal Oxide Semiconductor High Electron Mobility Transistor for label-free neutral and charged biomolecule detection in this paper. The use of SiO_2 ($\kappa = 3.9$) and Al_2O_3 ($\kappa = 9$) as gate insulators has been reported previously but work based on HfO_2 ($\kappa = 25$) as gate dielectric is limited in MOSHEMT-based biosensors. So, here a dielectric modulation approach is employed to obtain the effective capacitance which is employed to investigate the sensitivity of an $Al_{0.31}Ga_{0.69}N$/ GaN/ HfO_2 MOSHEMT considering different biomolecules in a cavity under the gate. The simulation studies show that device parameters like threshold voltage, on-current, transconductance, drain current and output conductance vary due to the presence of biomolecules in a cavity under the gate, which can be exploited to perform the sensitivity analysis of the biosensor. The effect of the fraction of biomolecules entering the cavity (fill percent) and the effect of the availability of binding sites for biomolecules in the cavity (fill profile) on sensitivity analysis has also been analyzed and results indicate improved sensitivity with increased neutral biomolecule permittivity and charged biomolecules' charge density. One of the biomarkers of interest is Glucose Oxidase, obtained from nasal exhalation, and from the results, it was observed that for this biomarker, even with a fill percentage as low as 25%, the device exhibited a drain current sensitivity of 0.21, 0.44, and 0.19 for vertical, horizontal, and tapered profile respectively. The results obtained have shown improvement over previously reported structures, which indicates that using a higher-k dielectric gives an overall better device sensitivity towards biomolecule detection. All the simulation work has been carried out using the Visual TCAD 2D Simulator from Cogenda.

Keywords: MOSHEMT, biosensor, biomolecules, fill profile, fill percentage, sensitivity, TCAD.

Paper ID: M-61

Area: Semiconductor device modeling and simulation

Device modeling and simulation of memristor using finite element modeling

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Memristor is a two terminal semiconductor device that can interrupt scaling constraints and acts as a promising alternative nanoscale device to achieve draw backs of CMOS technology with respect to power, switching speed and time. There are numerous literatures exist on memristor where different materials-oriented fabrication is studied. The device structure is still under development to determine accurate mathematical model to achieve several application demands. The memristor with opposite polarities contains different threshold voltages. Resistance transfers from High Resistance state (HRS) to Low resistance state (LRS) and vice versa is achieved by controlling the applied voltage. Maximum memristor models need a window function to solve boundary conditions. The memristance of the device is occurred from the resistance of two thin film oxide layers sandwiched between two metal electrodes which depends on the direction and duration of the applied input voltages. We have already simulated the VTEAM model in virtuoso platform to characterize the memristor by its pinched hysteresis loop. In this work, we have studied and characterized the TiO2 based memristor to understand the switching behavior of the device model. The modeling parameters will be characterized in terms of i.e. I-V characteristics, changing temperature and current effects etc., in multi-physics modeler i.e., COMSOL. Multiphysics modeler or finite element modeler simulates partial differential equations of finite elements. The design technique is started with selecting appropriate material then geometry is designed. After that, material dependent equations are solved accordingly. Next, boundary conditions are applied to the geometry as per physics module i.e., semiconductor physics, fluidic flow, acoustic wave modelling. Finally meshing of the geometry is performed. As a result of mathematical computation like drift/diffusion current equation of oxygen vacancies realizes the switching mechanism of the device.

Paper ID: M-62

Area: Semiconductor device modeling and simulation

Circularly polarized inverted F antenna for UWB application

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A circularly polarized and compact dual band antenna with inverted F shaped structure is proposed in this paper. The designed antenna covers an area of size 60 x 60 mm2 and its substrate thickness is 1mm which is made up of FR4 epoxy substrate. The 3dB axial ratio can be produced by projecting two rectangular stubs in the ground plane at the opposite corners and then modifying the patch to give an inverted F shape. The designed antenna structure is simple but it gives a good agreement towards the realization of circular polarization. The impedance bandwidth covers a frequency range of 5.1 to 7 GHz (31.4 %) and 7.5 to 11.1 GHz (38.7 %) whereas the axial ratio ranges from 5.3 to 6.8 GHz (24.8 %) and 7.8 to 10.8 GHz (32.3 %) which falls under the impedance bandwidth range. Hence, the antenna is circularly polarized.

Paper ID: M-7010

Area: semiconductor device modelling and simulation

Study on effect of different HTL and ETL materials on the Perovskite solar cell performance with TCAD simulator

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Perovskite solar cells (PSCs) have gained lots of attention in short span due to high power conversion efficiency (PCE). Superior properties of perovskite materials (popularly $CH_3NH_3PbI_3$) such as high diffusion length, low crystallization barrier, low trap density, high absorbtion coefficient and low exciton binding energy makes perovskite a favorable material for solar cell application. The perovskite active layer is sandwiched between electron transport layer (ETL) and hole transport layer (HTL). As ETL and HTL help to extraction of charge carriers to the electrodes so, selection of right ETL, HTL material become very important for getting high performance. ETL materials can be either organic (i.e. PCBM, P3HT etc.) or inorganic (i.e. SnO_2, TiO_2, ZnO etc) similarly there are organic HTLs (i.e. PEDOT, PTAA, spiro-OMEtad etc.) or inorganic HTLs (i.e. NiO_x, CuS etc). Senturus TCAD simulation software is used to understand the role of different ETLs and HTLs in PSCs. The device structure for the simulation is ITO/ETL/$MAPbI_3$/HTL/Graphene, where SnO_2 is used as inorganic ETL, PCBM as organic ETL, spiro-OMEtad as organic HTL and NiO_x is used as inorganic HTL. Inorganic ETL and HTL have shown the best result due to superior band alignment compared to organic ones. It was also observed that the change in thickness of active layer has changed current density proportionally and voltage inversely. For organic ETL and HTL, the best PCE is 15.05%, V_{oc} is 0.85 V, J_{sc} is 22.14 mA/cm^2 and FF is 80% with the active layer thickness of 600 nm. On the other hand with inorganic ETL and HTL, the best PCE is 20.06% , V_{oc} is 1.07 V, J_{sc} is 20.38 mA/cm^2 and FF is 92% with active layer thickness of 800 nm. Results of all the simulated divices are summarized in table 1.

Table 1: Simulation results of different Perovskite solar cell structures

Device structure	Perovskite thickness (nm)	V_{oc} (V)	J_{sc} (mA/cm^2)	FF (%)	PCE (%)
ITO/SnO_2/$MAPI_3$/spiro/Ag	600	0.85	22.14	80	15.05
ITO/SnO_2/$MAPI_3$/Graphene	650	0.76	19.61	82	12.22
ITO/SnO_2/$MAPI_3$/Graphene	700	0.75	18.75	83	11.67
ITO/PCBM/$MAPI_3$/PEDOT/Graphene	700	0.94	15.83	81	12.05
ITO/PCBM/$MAPI_3$/PEDOT/Graphene	600	1.04	16.26	81	13.69
ITO/PCBM/$MAPI_3$/PEDOT/Graphene	600	0.94	16.77	86	13.55
ITO/PCBM/$MAPI_3$/NiO_x/Graphene	500	1.10	15.97	86	15.10
ITO/PCBM/$MAPI_3$/NiO_x/Graphene	600	1.09	16.66	89	16.16
ITO/PCBM/$MAPI_3$/NiO_x/Graphene	700	1.08	17.03	90	16.65
ITO/PCBM/$MAPI_3$/NiO_x/Graphene	800	1.13	17.53	87	17.23
ITO/SnO_2/$MAPI_3$/NiO_x/Graphene	600	1.10	19.67	90	19.47
ITO/SnO_2/$MAPI_3$/NiO_x/Graphene	700	1.09	20.02	90	19.63
ITO/SnO_2/$MAPI_3$/NiO_x/Graphene	800	1.07	20.38	92	20.06

Paper ID: M-7011

Area: Semiconductor device modeling and simulation

Optimal design of CMOS analog circuits using multi-objective differential evolutionary algorithm

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This paper deals with the optimal design of analog VLSI circuits, namely CMOS voltage reference circuit, CMOS ring oscillator (RO), and CMOS inverter cascaded with inverted current starved inverter-based oscillator (CICSI). The optimization technique used here is the Multi-objective Differential Evolutionary Algorithm (MDEA). All the circuits are designed in 90 nm technology. For the CMOS voltage reference circuit, the main objective is to minimize the voltage variation at output while validating all the design criteria. The targeted value of the reference voltage is 550 mV. CMOS ring oscillator (RO) is designed depending on the performance parameters like power consumption and phase-noise. The CICSI-based oscillator is designed for low-frequency clock generation with low power dissipation and lesser area. The optimal transistor sizing of each circuit is obtained from MDEA. Each circuit is implemented in SPICE by taking the optimal values of the transistors, and the performance parameters are achieved. The power dissipation of the CMOS voltage reference circuit is 600 nW. The MDEA-based optimal design of RO oscillates at 2.027 GHz frequency, a phase noise of –84.97dBc/Hz at 1MHz offset frequency while consuming 72 µW power. CICSI-based oscillator with 101 stages oscillates at 17 MHz frequency and has a power dissipation of 420 µW. SPICE results show that MDEA is a better technique for the optimal design of above mentioned analog VLSI circuits.

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Paper ID: M-65

Area: Semiconductor device modeling and simulation

Investigation of Mixed Cation Mixed Halide Perovskite for High Performance Photodetector Applications

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The emergence of metal halide perovskite materials has opened up a new path for the researchers for optoelectronics devices. Lead halide perovskites possess unique set of optoelectronic properties such as bandgap tunability, large carrier diffusion length, high absorbance, and small exciton binding energy which make them suitable for various applications like solar cell, LED, photodetectors etc. Among them perovskite photodetector has gained significant interest for its excellent figure of merits, for example, sensitivity, detectivity, response speed, large LDR range etc. Highly efficient mixed cation perovskites have shown good stability but it usually contains methylammonium (MA) which is not thermally stable. Formamidinium (FA) and Cesium (Cs)-based perovskites are recently shown reasonably good stability for solar cells and photodetector applications. In this work, perovskite photodetector with device configuration of FTO/TiO_2/$FA_{0.85}Cs_{0.15}Pb(I_{0.85}Br_{0.15})_3$/spiro-OMeTAD/Au is simulated using one-dimensional SCAPS-1D software. The photodetector based on p-i-n structure have shown high speed detection with higher external quantum efficiency, and good responsivity. The simulated device showed a low dark current density of ~1 μA/cm^2, responsivity of 0.46 A/W and detectivity of $8.1x10^{13}$ Jones which is comparable to other existing photodetectors. The device showed highest responsivity around 700 nm illumination. Moreover, by varying the halide content in $FA_{0.85}Cs_{0.15}Pb(I_{1-x}Br_x)_3$ the photodetector can be made to work till near infrared region. Figure 1(a-d) depicts the perovskite photodetector considered in this study, external quantum efficiency and responsivity, semilogarithmic J-V curve under light and dark condition, semilogarithmic J-V curve under different illumination wavelength respectively.

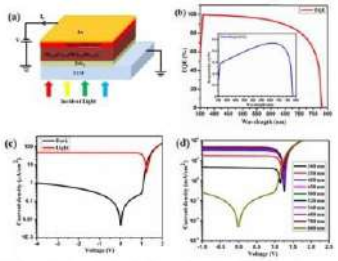

Figure 1: (a) Schematic diagram of p-i-n photodetector (b) Wavelength Vs external quantum efficiency and responsivity plot, (c)Semilogarithmic *J-V* curve under dark and light (d) Semilogarithmic *J-V* curve under different wavelength light.

Paper ID: M-66

Area: Semiconductor device modeling and simulation

Flatband Voltage in MOS Structures for Spatial Fixed Oxide Charge Distributions

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Flatband voltage is an important electrical parameter for metal-oxide-semiconductor (MOS) – based devices; it acts as a metric representing the significant variables, and the information about the state of the device in terms of conduction. This parameter is used as a quantitative parameter to analyze the responsivity of MOS semiconductor sensors, and evaluate the operation of novel MOS-devices. Oxide fixed charges, and oxide-semiconductor interface trap charges degrade the low power performance in MOS-devices. Flatband voltage is a primary parameter through which oxide fixed charges can be considered in the mathematical analyses of a MOS structure. The location of a fixed charge inside the gate oxide is an important factor in determining the flatband voltage of a MOS geometry. Therefore, a flatband voltage model must take the dependence of the fixed charge on its position into account for appropriate representation of the parameter. One of the parameters which affect the threshold voltage of a MOS structure is its flatband voltage. Therefore, a model of the flatband voltage dependent on the fixed oxide charge distribution is expected to offer a firsthand representation of the change in threshold voltage too. Considering the essence of the parameter, this work aims to analyze the impact of different spatial fixed oxide charge distributions on flatband voltage of a MOS geometry through a physics-based approach. A schematic of the concept of the work is shown in Figure 1. For any arbitrary spatial distribution of fixed charges across the oxide (enlarged in the inset in Figure 1), the flatband voltage is roposed to be solved. A comparison among different distribution of fixed oxide charges reveals the deviation of the flatband voltage from its ideal values.

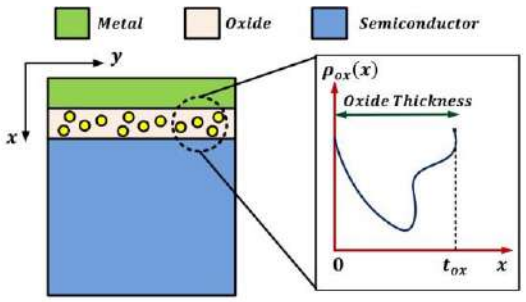

Figure 1: Conceptual schematic showing the overview of the proposed work

Paper ID: M-67

Area: Semiconductor device modeling and simulation

Effect of 2D perovskite layer in all-perovskite and perovskite/silicon tandem solar cells

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In a multijunction (Tandem) solar cell the quality of surface and interfaces played important role in determining its efficiency and stability. In perovskite-based solar cells, the application of 2D perovskite material on top of the 3D perovskite absorber layer is widely investigated. Here we have simulated and studied the performance of 2D perovskite in perovskite/perovskite and perovskite/silicon tandem solar cells. The effect of various 2D perovskite materials with their layer thickness and interfacial energy band offsets are studied extensively. The 2D perovskite layer was employed in the low bandgap sub-cell of all perovskite TSC and high band gap sub-cell of perovskite/silicon TSC as shown below in Figure 1 (a) and Figure 1 (b). The JV response of all perovskite 2T and perovskite/silicon tandem is shown below in Figure 1 (c) and Figure 1 (d) receptively. In all perovskite tandem solar cell, the absorber layers were chosen as $MA_yFA_{1-y}Sn_{1-x}Pb_xI_3$ (700 nm) bandgap 1.2 eV and $FA_yCs_{1-y}PbI_xBr_{1-x}$ (450 nm) bandgap 1.8 eV, while triple cation perovskite layer (450 nm) with bandgap 1.67 eV was chosen as the absorber layer of top cell in perovskite silicon tandem solar cell. The thickness of c-Si absorber layer was kept at 180 µm. Meo-2PACZ and PEDOT:PSS were simulated as the hole transporting layer for the top and the bottom solar cell respectively. Dual electron transport layer SnO2 and C60 were selected for the electron transport layer. For the perfect addition of open circuit voltage, an ideal tunnel recombination junction was assumed. Tandem solar cells were series-connected using a script file in SCAPS-1D software. The highest efficiency of the tandem solar cell was observed at 20 nm of 2D perovskite layer thickness. Interface defect density was studied to mimic the surface passivation impact of the 2D perovskite layer ontop of 3D perovskite layer. The charge carrier lifetime varied from 1 µs to 1 ns upon changing the surfacedefect density from $10^{14}/cm^3$ to $10^{17}/cm^3$ at surface recombination velocity SN=SP=10^7 cm/s. A higher photocurrent density and higher open circuit voltage was observed in all perovskite and perovskite/silicontandem solar cells with the variation of surface charge carrier lifetime from 1 ns to 1 µs. The improvement was observed due to the surface passivation effect of 2D perovskite on top of the 3D perovskite absorber layer. With the incorporation of 2D perovskite layer, PCE above 30% was observed in all perovskite and perovskite/silicon tandem solar cells.

Paper ID: M-68

Area: Semiconductor device modeling and simulation

InAs-Si heterojunction vertical TFET based hydrogen gas sensor

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In this paper, a novel hydrogen gas sensor based on Indium Arsenide (InAs) - Silicon (Si) heterojunction p type vertical tunnel field effect transistor (VTFET) is proposed. Source region of the VTFET is a heavily doped n type InAs material while the drain is a heavily doped p type Si material. Intrinsic Si has been used to make up the channel region. Palladium (Pd) has been chosen as gate metal for sensing hydrogen. Electrical characteristics and sensing behavior of the device with varying hydrogen gas pressure have been investigated using Silvaco TCAD 2D simulator (ATLAS). Simulation results show that sensitivity of the proposed device towards hydrogen gas is of the order ranging from 10^0 to 10^2.

Keywords: Indium Arsenide, Heterojunction, VTFET, Hydrogen gas sensor.

Paper ID: M-69

Area: Semiconductor device modeling and simulation

Influence of buffer layer on Copper doped Tin Sulfide solar cell: A Numerical Approach

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ABSTRACT

In the present work, we have studied the copper tin sulfide (CTS) which is a ternary compound with very high absorption coefficient (10^5 cm^{-1}) and optimal bandgap ranging from 0.9-1.6 eV. The constituent elements of CTS are non-toxic elements and earth abundant elements. In this work, we have numerically simulated the structure: ITO coated PET/ZnO/CdS or ZnS or CdZnS or TiO_2/CTS/Al using wx-AMPS software.

In the structure different layers are: ITO coated PET, front layer is a flexible substrate and has been optimized by optimizing its layer thickness as 140nm; ZnO as an intrinsic layer; CdS/ZnS/CdZnS/TiO_2 as buffer layers; CTS as absorber layer and Al as back contact. Different buffer layer variation was studied by varying its thickness and donor concentration. The QE curve shown in the result shows that at lower wavelength also, the QE value for CdZnS and TiO_2 is high. Therefore, for further investigation, these two buffer layers were considered. After optimizing the buffer layer, absorber layer optimization was carried out by varying its thickness, acceptor concentration and defect density values. By considering CdZnS as buffer layer, the optimized result obtained was, V_{OC} = 0.819 V, J_{SC} =25.77 mA/cm^2, FF = 85.59 %, Efficiency = 18.08 % and by considering TiO_2 as buffer layer, the optimized result obtained was, V_{OC} = 0.818 V, J_{SC} = 25.55 mA/cm^2, FF = 84.41 %, Efficiency = 17.66 %.

Keywords: *Thin film solar cell, CTS, Numerical simulation, ITO coated PET.*

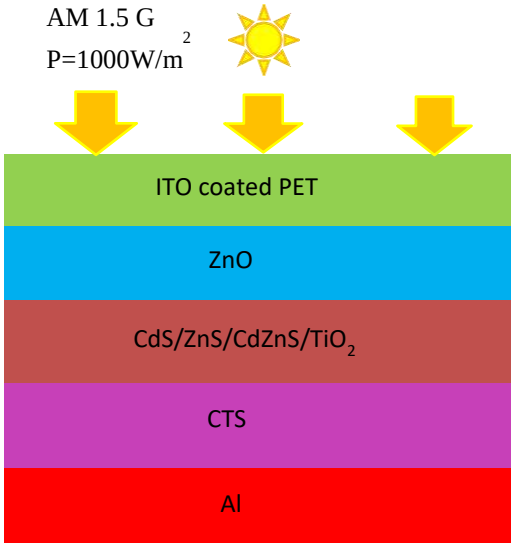

Fig.1 Solar cell structure for the simulation work

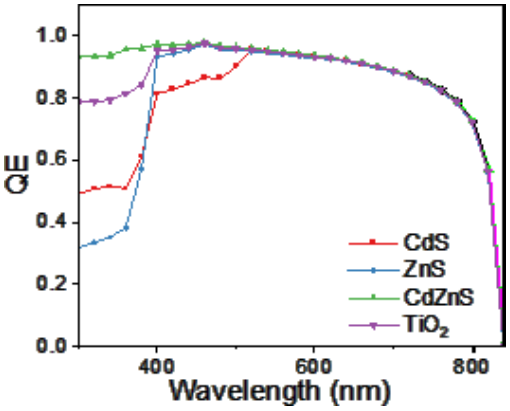

Fig.2 QE curve with all the buffer layers used in the simulation

Paper ID: M-70

Area: Semiconductor device modeling and simulation

Analysis of Sb_2Se_3/CMTS based photovoltaic cell : A numerical approach using SCAPS – 1D

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ABSTRACT

This paper, is about a new Sb_2Se_3/CMTS tandem solar cell design which has been proposed at low fabrication cost to reach high efficiency values. This proposed tandem structure consists of a Sb_2Se_3-based and CMTS-based for top and bottom cells respectively. By the use of the SCAPS-1D software, an investigation study involving the impact of different parameters such as thickness and doping concentration on the device performance is carried out. The maximum efficiency of 16.46% was obtained at a thickness of 1000 nm and 3000 nm for both the absorber layers respectively. Moreover, an effective method has been applied in the aim of boosting the efficiency, by adding one more absorber layer with Sb_2Se_3 layer. This layer helps to enhance the optical behaviour and reduces recombination losses, and consequently reducing the Voc deficit. We have found that the proposed design with CMTS absorber layer improves the efficiency of the tandem structure solar cell from 13.2% (Sb_2Se_3/ Sb_2S_3) to 16.46% (Sb_2Se_3/CMTS). This makes the optimized Sb_2Se_3/CMTS tandem solar cell a potential alternative to achieve a high-efficiency as well as a stable tandem solar cell designs.

Keywords *: Sb_2Se_3/CMTS, Solar Cell, Tandem, SCAPS-1D*

Paper ID: N-71

Area: Semiconductor Nanostructure & Devices

High energy ball-milling engendered evolutions in structural and microstructural properties of $Gd_2Zr_2O_7$ nanoparticulates

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ABSTRACT

A multi-crystalline composition of gadolinium zirconate ($Gd_2Zr_2O_7$) has been synthesized by a solid-state reaction route (un-milled sample) and then subjected to high-energy ball-milling for 6, 12, 18, and 24 hours duration. Samples collected at different hours of milling were characterized and studied. Interestingly, elemental analysis of the samples by energy dispersive X-ray analysis indicates the gradual reduction in the atomic percentage of Gd and Zr while enhancement in oxygen atomic percentage with the milling process. Rietveld refinement of powder X-ray diffraction patterns suggests that all samples possess defect fluorite structure and the values of goodness-of-fit parameter improve from 3.88 for an un-milled sample to 1.82 for 24 hours milled sample. The formation of fluorite is owing to the preparation temperature and the ionic radius ratio, r(Gd3+)/r(Zr4+) = 1.303,. Scanning electron micrographs, transmission electron micrographs, and selected area electron diffraction (SAED) patterns analysis confirm the nanophasic nature of milled samples, and particle size is found to reduce with increasing milling time. It is found that BET surface area continuously increases from 1.96 m2/g for an un-milled sample to 23.44 m2/g for 24 hours milled sample. The particle sizes determined from XRD patterns analysis, TEM analysis, and BET surface area analysis are in agreement. The findings have been discussed in depth.

Paper ID: N-72

Area: Semiconductor Nanostructure & Devices

Synthesis and characterization of CMC/ZnO polymer nanocomposite films for electronic applications

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ABSTRACT

By using the co-precipitation method Zinc oxide (ZnO) was synthesized, and a series of carboxy methyl cellulose (CMC) nanocomposites (NCs) were made using the solvent casting technique with different concentrations of ZnO nanofiller, namely 0.01, 0.04, 0.05, 0.1, 0.3, 0.4, 0.6, and 0.8 wt percent. The structural, morphological, optical, and electrical properties of the NCs were studied. The lattice properties and interplanar structure of pure ZnO NPs, as well as the microcrystalline features of nanocomposites, were studied using X-ray diffraction (XRD) studies. Changes in the NC's microcrystalline behaviour were indicated by a decrease in the intensity of crystalline peaks in NC films and a slight shift in peak location in XRD profiles. The morphological properties of the CMC/ZnO films were examined using Scanning Electron Microscopy (SEM). Fourier transfer infrared (FTIR) spectroscopy was used to investigate the interactions between the components in NCs. The opto-electrical characteristics of NC films, including their refractive index (RI), direct and indirect optical band gap energy, and optical conductivity, are measured using a UV-visible spectrophotometer. To evaluate the electrical characteristics of nanocomposites, the current-voltage (I-V) method was employed.

Keywords: *Nanocomposites; Refractive index; Direct and Indirect optical band gap energy; Conductivity; dielectric properties.*

Paper ID: N-73

Area: Semiconductor Nanostructure & Devices

Detection of germanium isotopes in biosynthesized Ge nanocrystals through different optical spectroscopy techniques

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ABSTRACT

The aim of the present work is to study the isotopic effect in the Raman and IR absorption spectra of synthesized Germanium (Ge) nanoparticles (NPs) formed on the surface of the germanium crystal with a high chemical and isotopic purity. Ge NPs are formed on the surface of germanium crystal by treating bulk germanium crystal with microbes under magnetic field. The structural and optical properties of the fabricated Ge NPs are characterized by employing various techniques such as X-ray diffraction technique, photoluminescence spectroscopy, micro-Raman spectroscopy, and FTIR spectroscopy respectively. There is a shift in the PL, Raman and IR peaks of the synthesized material which are recorded at different time intervals. The shift in the PL peak of the synthesized material is observed because of the quantum confinement effect. Raman and IR absorption spectra study reveals that there may be possible presence of germanium isotopes. Raman and IR absorption spectra studies are conducted at room temperature. It is observed that the phonon absorption peaks of synthesized germanium NP material shifts to longer wavelengths with increasing average atomic mass of germanium. The observed optical properties of the synthesized Ge NPs have provided great help to study the change in structural and optical properties of the synthesized Ge crystal.

Keywords: *DC sputtering, ZnO:Al thin films.*

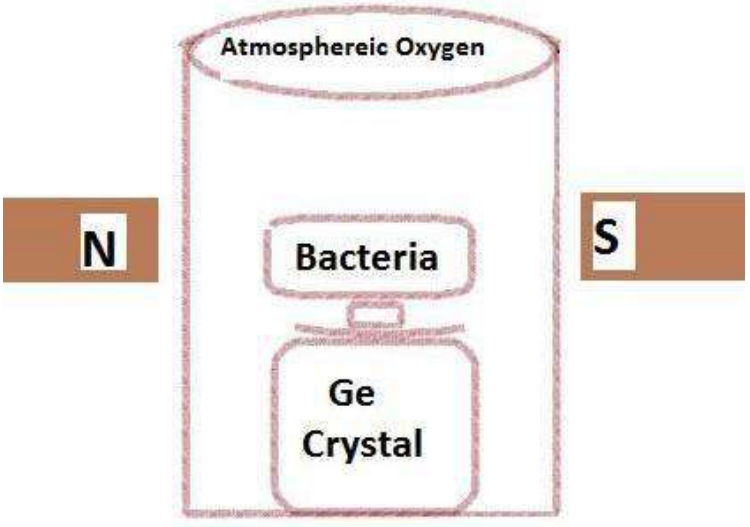

Figure 1. Schematic diagram for synthesis of Ge NPs.

Paper ID: N-74

Area: Semiconductor Nanostructure & Devices

Iron oxide embedded CNT/Polymer network as anode active material for Li-ion cells

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ABSTRACT

Transition metal oxides are widely used to meet the requirements of high capacity anodes for Li-ion batteries in electric vehicles and hybrid electric vehicles. On the basis of energy storage mechanisms, anode materials are classified as insertion, conversion and alloying type. Iron oxide is a conversion type anode material that has drawn extreme attention due to high specific capacity (theoretical capacity of Fe_2O_3 is 1007mAhg-1 and that for Fe_3O_4 is 926 mAhg-1), environmental friendliness and the possibility of using simple synthesis routes. Efficient and continuous shuttling of lithium ions during charging and discharging (or lithiation and delithiation) between electrodes is the desired mechanism of an ideal Li-ion cell. For efficient cell performance, the electrodes should retain their structural stability, porosity and conductivity after many cycles of charging and discharging. In the present study, improved structural stability of nanostructured iron oxide, embedded in carbon/polymer network has been assessed and its prospects as a promising anode material for Li-ion cells has been investigated. Anode material, Fe_2O_3/CNT/PANI has been synthesized by simple hydrothermal method and insitu-polymerisation method. The performance of pure Fe_2O_3 and Fe_2O_3 embedded carbon nanotubes (CNT)/polyaniline (PANI) network has been investigated in detail and compared. The cells assembled with Fe_2O_3/CNT/PANI as anode against Li metal in half cell configuration are found to deliver initial discharge capacity of 1633 mAhg-1 and charge capacity of 353 mAhg-1. After 50 cycles, charge discharge capacities are 155 mAhg-1 and 130 mAhg-1 with a columbic efficiency of 84% and capacity retention of 39%. The failure mechanism is explained and capacity fading is studied using post mortem analysis.

Key words :
Nanostructured iron oxide, Carbon nanotubes, Polyaniline, Insitu-polymerisation, Conversion type anode

Paper ID: N-75

Area: Semiconductor Nanostructure & Devices

Effect of Mg doping on dielectric properties of ZnO nanoparticles synthesized by Microwave-assisted combustion route

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ABSTRACT

Electrically conductive polymer blends have attracted profound attention as dielectric materials. However, achieving isotropic behaviour, electrical stability and low current leakage is still challenging. The primary aim of this investigation is to introduce the dielectric properties of nanoscale ZnO and Mg-doped ZnO nanoparticles (NPs). ZnO and a series of (2, 4 and 6%) Mg-doped ZnO NPs were synthesized by microwave-assisted combustion route. The samples were characterized by XRD, FTIR, TGA and SEM techniques. The phase confirmation and crystallite size of MgO and Zn-doped MgO NPs were calculated from XRD pattern. The study of dielectric permittivity, dielectric loss, AC conductivity and impedance was investigated in the frequency range of 1-106 Hz at room temperature. The dielectric permittivity of ZnO and 6% Mg-doped ZnO showed an enhanced dielectric property than other doped materials at higher frequency due to the formation of charge cluster in the synthesized materials. The extra mobile carriers added to the material by increasing the percentage of doping resulted an increase in the dielectric loss of the material. The AC conductivity values of doped nanoparticles increased gradually with increase in the frequency range due to the hopping and tunnelling mechanism, which may be attributed to the migration of electrons into the conductive network formed by the crystallites of ZnO NPs and 6% Mg-doped ZnO NPs. The real and imaginary impedance was found to decrease with increase in the Mg doping percentage.

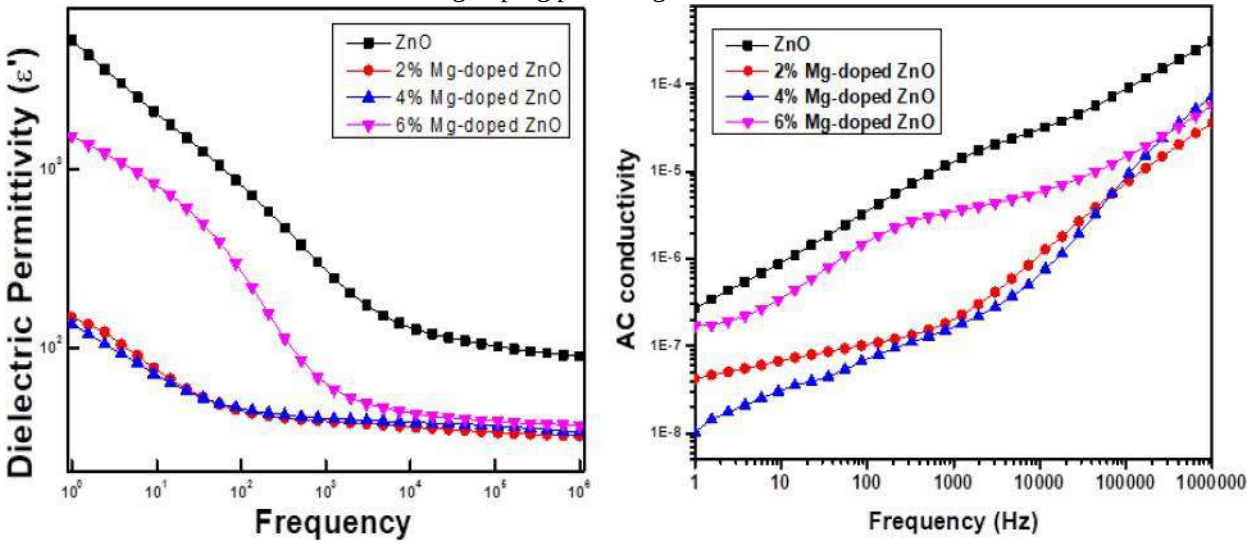

Figure 1: Variation of dielectric permittivity and dielectric loss with frequency of ZnO and Mg-doped ZnO NPs.

Paper ID: N-76

Area: Semiconductor Nanostructure & Devices

Effect of temperature on Photocalaytic study of TiO_2 Nanoparticles Prepared by Non-conventional Sol-gel technique

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ABSTRACT

In this work, TiO_2 powder was synthesised by cheap and easy non-conventional sol-gel method starting from powder precursor. The prepared powders were annealed at different temperatures and used for photocatalytic Methylene Blue (MB) dye decomposition. The annealing temperatures were varied as 250^o C, 500^o C. The structural and morphological characterizations of the annealed powders were carried out by X- ray diffraction analysis (XRD) and scanning electron microscopy (SEM). From SEM analysis the average grain size of the nanoparticles are estimated to be about 123, 124, and 95nm for as prepared, annealed at 250^o C, and annealed at 500^o C respectively in comparison to 177 nm for the procured raw powder. The processed and procured raw powders were used for photocatalytic decomposition of MB dye for waste water treatment from textile industries. For each differently processed powders, the reaction kinetics and reaction rate are estimated by observing the dye decomposition behaviour with respect to UV light exposure time. The reaction kinetic was found to be pseudo first order and rate constants were estimated. From this estimation it was found that the sample annealed at 500^o C show nearly four times higher reaction rate constant with respect to procured raw TiO_2 powder. The BET surface area analysis of the prepared samples supports the enhanced photocatalytic activity of the powder annealed at 500^o C.

Keywords: XRD, SEM, Photocatalysis, Methylene blue(MB) dye

Paper ID: N-77

Area: Semiconductor Nanostructure & Devices

Investigation into the possibility of local symmetry breaking on Ni doping in SnO_2 nanocrystals

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ABSTRACT

Ni doped SnO_2 nanocrystals ($Sn_{1-x}Ni_xO_2$, $0.00 \leq x \leq 0.06$) have been synthesized using chemical coprecipitation technique. The structural characterisations of the nanocrystals have been performed using X-ray diffraction (XRD) and Field Emission Scanning Electron Microscopy (FESEM) techniques. Rietveld refinement of the X-ray diffractograms reveal that the nanocrystals are of single phase and belong to the P42/mnm space group of tetragonal cassiterite SnO_2 throughout the doping concentration. FESEM images show that the nanocrystals have been formed with nearly spherical morphology. Raman spectroscopy and Fourier Transform Infrared (FTIR) spectroscopy have been employed to study the probability of inducing any local symmetry breaking on Ni doping in SnO_2 nanocrystals. Raman spectra have been recorded using 532 nm laser source and FTIR spectra have been recorded in ATR mode using diamond crystal. Moreover, tuning of band gap of the SnO_2 nanocrystals on Ni doping has also been studied using diffuse reflectance (DR) spectroscopy. It has been observed that doping of Ni affects the SnO_2 nanocrystals in a contrary manner as compared to that of other transition metals, such as, Co and Mn, as reported earlier in terms of inducing local inversion symmetry breaking as well as tuning of optical band gap. Through this study, the earlier observed behaviour of Co, Ni codoped SnO_2 has also been partially explained. The results will be presented in detail during the conference.

Paper ID: N-78

Area: Semiconductor Nanostructure & Devices

One-pot hydrothermal synthesis of CuTe/NiTe nanostructure: A structural and optical study

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ABSTRACT

Chalcogenides are inorganic compound groups consisting of at least one chalcogen anion and one more electropositive metal element. In the research of semiconductors, metal chalcogenides have dominated the research because of their physical, optical, electronic, and magnetic properties. Metal Chalcogenides have wide varieties for which they are being used hugely in the present day. These elements also form an important part of studying the chemical reactions of elements with non-covalent bonds. In this work, the samples are synthesized by the one-pot hydrothermal synthesis method (reactions are conducted in an aqueous solution under high temperature-pressure conditions) for different compositions. The characterization of the samples, like X-ray diffraction (XRD), UV-Visible spectroscopy, field emission scanning electron microscopy (FESEM), energy dispersive X-ray analysis (EDAX), Raman spectroscopy and PL (photoluminescence) are performed. From XRD data (fig.1), the average crystallite sizes are calculated which are found to be 30.88nm, 24.214nm, and 23.43nm for different compositions according to the 2θ and FWHM values. Also, lattice strain and dislocation densities are calculated for the values of each 2θ. In UV-Visible spectroscopy, the direct optical band gap of the sample is calculated, which is found to be 1.637eV. The morphologies are found to be nanoparticles from FESEM data. Fig 2(a),(b) and (c) represent the FESEM images of the CuTe, NiTe and CuTe/NiTe nanostructures respectively. EDAX data identified the elemental composition of the materials. The vibrational spectra and the peaks corresponding to the vibrational bond are studied from Raman spectroscopy. The impact of devising the parameters on the morphology, crystal structure, and composition has been looked over systematically.

Keywords: Nanostructure; hydrothermal method; optical properties; surface morphology

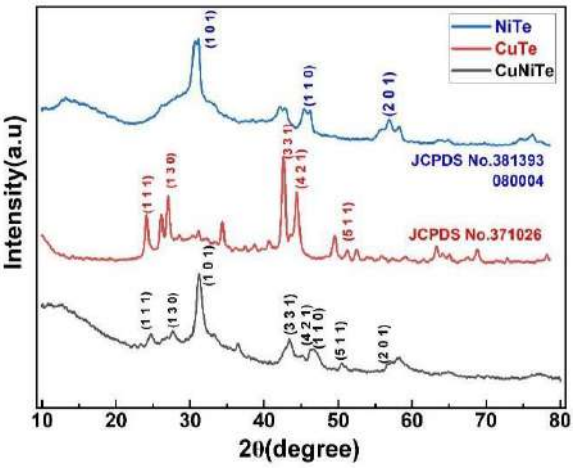

Fig:1- XRD plot of the sample

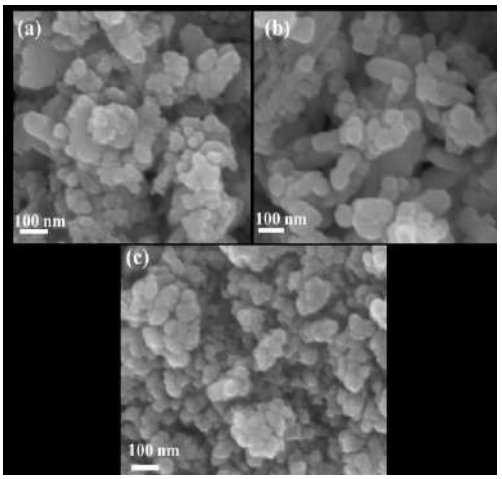

Fig:2 – FESEM image of (a)CuTe , (b)NiTe and (c) CuTe/NiTe nanostructures

Paper ID: N-79

Area: Semiconductor Nanostructure & Devices

Effect of UV, IR & Microwave radiation on Tween-80 porogen based low-k films

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ABSTRACT

Low dielectric constant (low-k) films due to their potential application as an inter-layer dielectric (ILD) attracted significant attention of researchers and scientists. Porous low-k films like xerogel, aerogel, porogen based and hybrid films are extensively investigated as they have dielectric constant value less than that of SiO2. Considering the advantages of porous low-k films, current investigation focussed onto the study of porogen based porous low-k films. To obtain low-k films, solgel based spin-on technique is used. Incorporation of Tween-80 porogen in deposited low-k films is confirmed through the presence of $-CH_2-CH_3$ group around 2856-2916 cm-1 in FTIR spectra. Removal of porogen material from film matrix was done by using radiation exposure of samples and is confirmed through FTIR analysis as shown in Figure 1. Refractive indices (RI) of deposited porogen based films treated with IR, UV & microwave radiations are observed to be 1.287, 1.283 and 1.33, respectively. Further, density of IR, UV and microwave radiation is calculated from RI, and is observed to be decreased for UV radiation up to 1.40 gm/cm^3. Dielectric constant value k = 2.7 was achieved for UV treated samples. Investigation suggests that low-k films having lower k value may have potential applications as ILD for ULSI technology.

Keyword : Porogen, Tween-80, Low-k, Dielectric Constant, Radiation Effect.

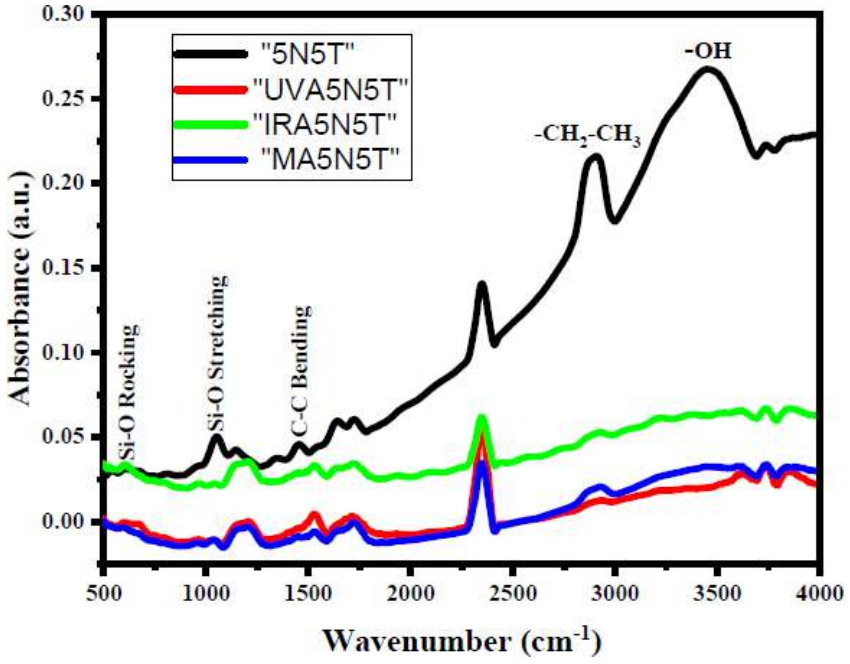

Figure 1: FTIR spectra of porogen based porous low-k films as deposited and treated with radiation exposure on porogen based films

Paper ID: N-80

Area: Semiconductor Nanostructure & Devices

Tailoring electrical characteristics of Si nanowires and etched Si by MACE temperature

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ABSTRACT

Optoelectronic applications prefer Si nanostructures over bulk Si due to improved optical and electrical properties. However, tuning the electrical properties of Si nanostructures is a bottleneck for a broad range of applications. Metal-assisted chemical etching (MACE) is a cost-effective method to fabricate silicon nanowires (SiNWs) array and etched silicon (eSi) using bulk Si and porous substrates, respectively. Among various fabrication parameters, MACE temperature is appropriate to tailor the nanostructure dimensions-length and diameter of SiNWs and thickness of the porous layer of eSi, on which the bandgap and the electrical biasing characteristic depend. The study addresses the dimensional change of nanostructures as the impact of MACE temperature variation on the bandgap and the DC bias characteristics. Increasing MACE temperature reduces the nanowire diameter and the porous layer thickness. As a result, the bandgap widening and the lowering of the DC bias current are characterized by the series diode-resistance equivalent circuits.

Paper ID: N-81

Area: Semiconductor Nanostructure & Devices

Preparation and characterizations of reduced graphene oxide reinforced silicon composites

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ABSTRACT

Si-reduced graphene oxide(RGO) composites with varying weight percentage of RGO from 0.1 to 0.5 in silicon matrix were prepared by dry planetary ball milling route. The ball milling was carried out for 7 hrs. X-ray diffraction (XRD) of composites show peaks of both Si and graphene. In Raman spectra along the peaks of Si, different peaks for carbon were observed in the composites. Purity of composite was confirmed from energy dispersive spectra (EDS) analysis showing only peaks of Si and C. X-ray photoelectron spectroscopy (XPS), high resolution transmission electron microscope (HRTEM) and selected area electron diffraction (SAED) results further confirm the successful formation of Si-graphene composites. XPS spectra for typical Si-graphene (0.5 wt%) composite show peaks due to Si-C, Si and C-C. The specific surface area of Si was increased from 97 to 192 m^2g-1 after addition of RGO (0.5 wt. %) to it. It was observed that Si with 0.5 wt.% of graphene showed increased electrical conductivity (104%) in comparison to pure Si. The prepared composite materials have the great scope for developing advanced anode material to improve energy density of lithium-ion batteries.

Keywords: *Reduced graphene oxide; Composite; Mechanical ball milling; Microstructure; XRD; XPS*

Paper ID: N-82

Area: Semiconductor Nanostructure & Devices

Development of 2 square inch all-solid-state Electrochromic Devices

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ABSTRACT

Today the potential applications of Electrochromic Devices (ECD) have reached various sectors including architecture, transportation, electronics, and others in different countries [1, 2]. The global energy consumption associated with heating, air conditioning (cooling), and lighting of buildings (which is about 40 %) can be significantly reduced using electrochromic devices (ECD), the so-called ―Smart Window‖ technology. 20–25 % of thermal energy can be saved by reducing heat loss through the windows, and 25–30 % of the electrical energy spent on lighting will be saved by using Smart Window technology instead of conventional windows. In India, development is accelerating rapidly in all sectors but lack of information and higher cost such technology is not available. Moreover, the manufacturing technology for optoelectronic devices is still in its infancy in India. Previously we have reported 2 square cm size all thin film ECD having the structure of ITO/NiO/ZrO2/WO3/ITO on a glass substrate [3]. This shows good transmittance modulation (59 %-3 %) and can be controlled at any intermediated state. The ECD has coloration and bleaching times of 120 s and 2 s, respectively, with desirable cycle life. We have a plan, to develop 2 square inches all solid-state inorganic ECD module with optimum efficiency and reproducibility with the feasibility of industrial manufacturing of the panels. The schematic diagram of 2 square inch all-solid-state ECD module is shown in fig. 1. Where Indium tin oxide (ITO) is used as a transparent conductor, Tungsten oxide (WO_3) is used as a cathodic coloration material, Zirconium oxide (ZrO_2) thin film is used as a ―proton conducting‖ solid electrolyte and Nickel oxide (NiO) is used as an anodic coloration material. The simulations for the optimum current density required for long-term stability will be conducted.

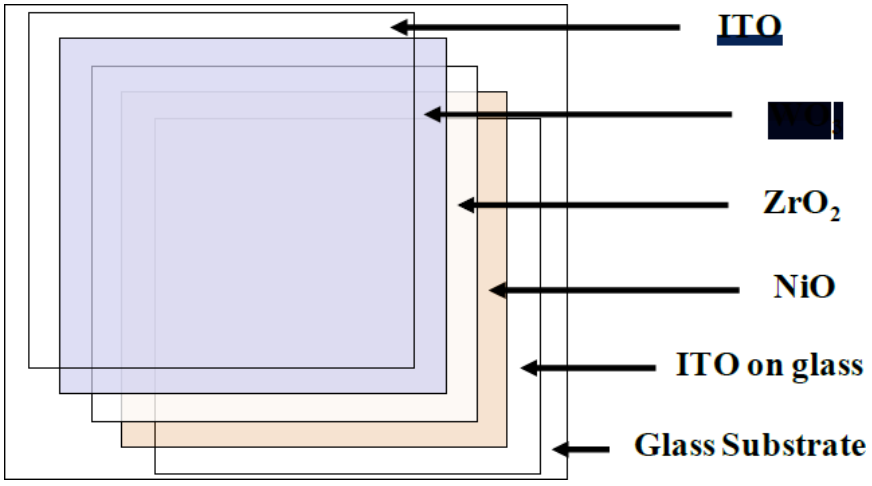

Figure 1: The schematic diagram of a 2 square inch all-solid-state ECD module.

Paper ID: N-83

Area: Semiconductor Nanostructure & Devices

CO sensing characteristics of CuO thin films developed by physical vapour deposition process

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ABSTRACT

Due to ferocious industrialization and an ever-growing population, air pollution has recently become a major concern on a global scale. To identify and detect the levels of air pollution, we require movable and trustworthy gas sensor equipment. The low cost and long life of metal oxide-based gas sensors make them more desirable in this situation. In this work, copper films deposited by using DC sputtering process were thermally oxidised to produce copper oxide thin films on alumina substrates. Cu thin film layers are converted to cupric oxide (CuO) by a solid state reaction during the thermal annealing of Cu films, which was carried out in ambient air at temperatures at 400 °C for a short period of time [1]. CuO is a p-type semiconductor with a bandgap in the range of 1.2~1.5 eV [2-3]. In order to evaluate the sensing performance of CO gas, the prepared CuO films were designed with Pt finger electrodes on the surface of films. Using 91 ppm of calibrated CO gas at temperatures between 250 and 400 °C, the produced CuO film's CO sensing properties have been studied. When exposed to CO gas, CuO thin film's resistance increased, showing that it could detect this hazardous gas and the sensing response was found to be maximum in the measuring temperature range of 350-400 °C. The experimental process, physical properties and sensing performance of CuO films will be discussed in detail.

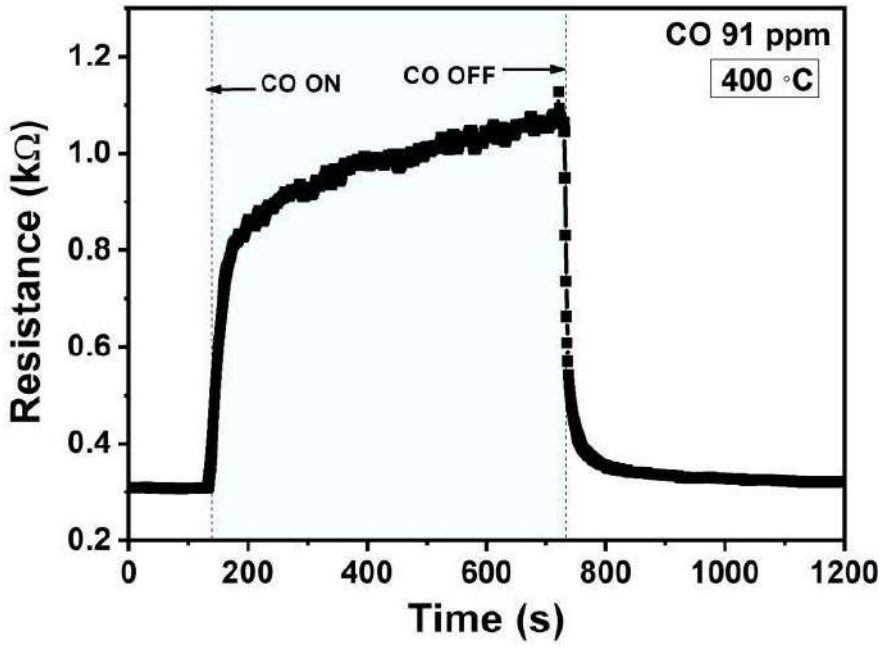

Figure 1. Sensing properties of CuO films for CO gas.

Paper ID: N-84

Area: Semiconductor Nanostructure & Devices

Oxygen vacancy assisted interfacial polarization and high dielectric constant in atomic layer deposited $Al_2O_3/TiO_2/Al_2O_3$ nanolaminates for high-density storage capacitors

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ABSTRACT

Recently, multilayered nanolaminates (NLs) have emerged as potential dielectric for high density storage capacitors and have demonstrated the feasibility of achieving high dielectric constant (k) at low loss owing to interface induced Maxwell–Wagner (M-W) polarization between semiconducting and insulating phases. We report growth of ultra-thin Al_2O_3/TiO_2 (ATA) NLs by atomic layer deposition (ALD) where in M-W interfacial polarization was realized and engineered by precisely controlling sublayer thicknesses and number of interfaces to achieve high dielectric constant and low loss. A thermal ALD system was optimized towards realization of ATA NLs at 200 °C using Al $(CH_3)_3$ and $TiCl_4$ precursors as source for Al and Ti respectively, while deionized water (H2O) as source for oxygen. The thicknesses of Al_2O_3 and TiO_2 sublayer in different NLs was varied in a range ~ 2.4 to 0.17 nm, keeping the total stack thickness fixed at ~ 60 nm. X-ray reflectivity curves with intense Bragg peaks (Figure 1(a)) confirmed thickness uniformity and physically distinct interfaces in these NLs, whose schematic is shown in the inset of the same figure. The dielectric properties were investigated by impedance spectroscopy technique using Au/ATA-NL/Au devices configuration in frequency range ~ 10–106 Hz. The dielectric constant and dielectric loss at 10 Hz were found to improve from ~ 23 to 217 and ~ 0.8 to 0.15 with decreasing sublayer thicknesses from ~ 2.4 to 0.35 nm respectively as shown in Figure 1(b) and further reduction in sublayer thicknesses deteriorates the dielectric performances due to enhanced interface intermixing. Significantly enhanced dielectric constant observed in case of ATA NLs compared to both Al_2O_3 (k ~10) and TiO_2 (k ~ 25) films may be attributed to accumulation of charge carriers across the semiconducting TiO_2 and insulating Al_2O_3 interfaces leading to M-W type dielectric relaxation. Further with decrease in sublayer thickness the high frequency shift of the relaxation peak positions (shown by arrow marks in the inset of Figure 1(b)) indicates increase in semiconducting nature of TiO2, which promotes conductivity contrast between Al_2O_3 & TiO_2 sublayers supporting M-W polarization driven high-k values. These results clearly indicate that M-W relaxation is mainly determined by the amount of a charge carrier arising from the semiconducting TiO_2 sublayers, which can be tailored by varying sublayer thickness. Temperature dependent dielectric dispersion in these NLs shown in Figure 1(c) clearly revealed two sets of thermally activated relaxations, supporting the existence of interfacial M-W relaxation. The calculated activation energy values for different NLs are found to be in between ~ 0.3 to 0.5 eV, which suggests that oxygen vacancy (OVs) related point defects in TiO_2 layer are the charge carriers responsible for M-W relaxation. The resonant photoelectron spectroscopy (ResPES) measurements around Ti 2p-3d transition edge (~ 458.4 eV photon energy) of these NLs carried out using a tunable synchrotron source at beamline-10 of Indus-2 confirmed increasing concentration of OVs induced Ti3+ states with decrease in sublayer thickness as shown in inset of Figure 1(c). The ATA NL with ~ 0.35 nm sublayer thickness (k~ 217) displayed a high capacitance density of ~ 35 fF/μm2, low loss of ~ 0.15 at 10 Hz, low leakage current density of ~ 9.67×10^{-4} A/cm2 at 0.16 MV/cm and low equivalent oxide thickness (EOT) of ~ 1.3 nm, which are promising for next generation electronic memories and high-density storage capacitors.

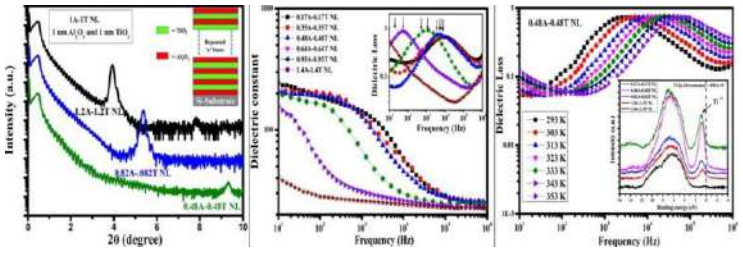

Figure 1: (a) X-ray Reflectivity curves (inset) a NL Schematic (b) Frequency dependent dielectric constant and (inset) loss spectra (c) Temperature dependent loss spectra and (inset) Ti 2p-3d transition ResPES measurements of few representative ATA NLs with sublayer thicknesses varying between 2.4 to 0.17 nm.

Paper ID: N-85

Area: Semiconductor Nanostructure & Devices

Magnetic circular dichroism analysis of giant Zeeman splitting in CdTe / $Cd_{1-x}Mn_xTe$ semimagnetic quantum ring

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ABSTRACT

Doping non-magnetic semiconductors with paramagnetic transition metal ions yields Diluted magnetic semiconductors (DMS) , which combine magnetism and semiconducting properties in a single material with a modified electrical, optical and magnetic properties. In bulk DMS and the heterostructures based on them, the effective sp-d exchange interaction between the localized magnetic moments of the magnetic ions and the spins of the charge carriers gives rise to a characteristic magneto-optical (MO) phenomenon as giant Zeeman splitting (GZS) of the electronic states (Figure 1). Though, various MO experiments give a vivid picture of this exchange mechanism in DMS, the predominant is the Magnetic Circular Dichroism (MCD) technique which shows its unrivalled ability in explaining the GZS of the excitonic transitions. Similar to the magnetic field induced differences created between the refractive indices of left circularly polarized (LCP) and right circularly polarized (RCP) light is responsible for the giant MO rotation, the difference in the absorption of LCP and RCP light in the longitudinal magnetic field gives rise to the origin of MCD. The qualitative and quantitative assessment of the MCD to analyse GZS in Mn2+ doped colloidal quantum dots have been well documented . The GZS is determined from MCD signal as, $\Delta Ez=\sqrt{2}e2\zeta\, \Delta A A0$, which involves FWHM of the Gaussian absorption line (ζ), the peak intensity of the MCD (ΔA= ALCP−ARCP) and absorption (A0) spectra at the exciton transition energy (Figure 2). Despite having a remarkable progress and achievement in the study of MCD in epitaxial heterostructures and colloidal QDs , the special attention still requires for the unified interpretation of experimental observation and theoretical arguments for the magnetic field and temperature dependent MCD in DMS nanostructures with various topologies. Hence, the present work aims to report the theoretical analysis of MCD in Mn2+ doped II-VI epitaxial DMS Quantum Ring (Figure 3) to interpret the GZS based on the simultaneous Gaussian fitting of the MCD and absorption spectra.

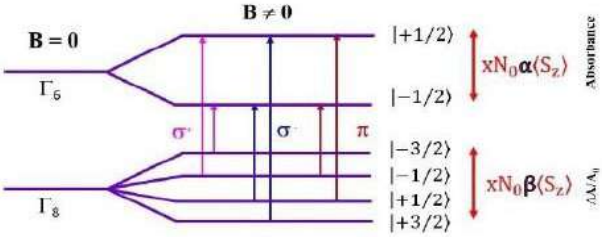

Figure 1: Giant Zeeman splitting of excitonic transitions in bulk DMS

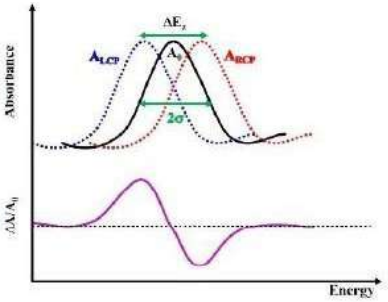

Figure 2: Interpretation of GZS using Absorption and MCD spectra

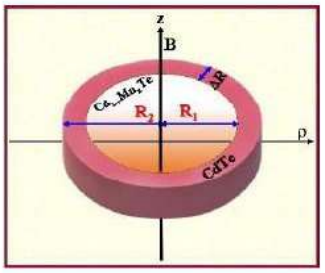

Figure 3: Schematic of Semimagnetic QR

Paper ID: N-86

Area: Semiconductor Nanostructure & Devices

Fabrication and characterisation of memrsitor device using sputtered hafnium oxide

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ABSTRACT

Being the fourth fundamental passive element, the memristors play a vital role in emerging technology. A simple two-terminal device structure and small dimension extend the application of memristor in super-fast computing, memory and neuromorphic systems. The high dielectric constant of hafnium oxide (HfO_x) attracts considerable interest in resistive switching. In this work, HfO_x thin films (65 nm) were deposited on a commercial platinized silicon substrate using radio frequency magnetron sputtering with 3 inch HfO_2 target and an radio frequency power of 100 W without any post-deposition annealing. 200 nm Silver (Ag) was thermal evaporated as the top electrode. The device shows bipolar resistive switching behaviour with set/reset voltages less than 1 V at an operating current range of 1 mA. This low voltage switching might be due to the formation of metallic Ag filament from electrochemically active silver top electrode along with the migration of oxygen vacancies in the hafnium oxide dielectric matrix. The device shows good retention and high on/off ratio. In light of these results, the fabricated device can be used for low-power memory and neuromorphic applications.

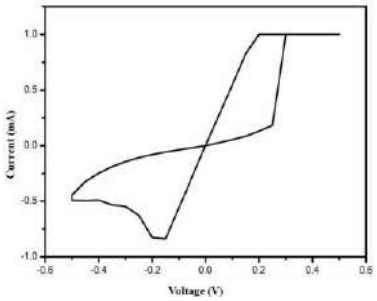

Figure 1: Resistive Switching I –V characteristics of Ag/HfOx/Pt device.

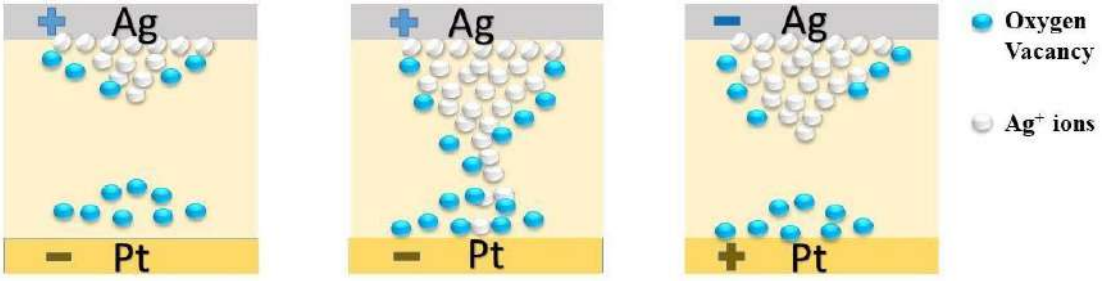

Figure 2: Schematic diagram of resistive switching of Ag/HfO_x/Pt device. a) Initial state b) Set process and c) Reset process.

Paper ID: N-87

Area: Semiconductor Nanostructure & Devices

The structural and electronic properties of zigzag BP nanoribbons with coved edges

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ABSTRACT

The peculiar electronic properties of 2-D nanomaterials have always inspired the research community to discover novel materials. Although III-V nitrides have been extensively explored for various remarkable phenomena, phosphides of the same group are yet to be explored. Taking a step in this direction here we report the structural and electronic properties of zigzag BP nanoribbons (ZBPNR) with cove edge defects. The effect of sp2 and sp3 edge functionalization has also been compared to reveal interesting findings. The position of cove defect is considered in a number of different possibilities. It is observed that all the structures are energetically stable and maintain their planar geometries. The H-passivated ribbons exhibit a semiconductor behavior with their band gap reciprocal to the ribbon width. However, for coved edge nanoribbons, a semiconductor as well as pure metallic nature has been predicted depending upon the site of cove defect. Furthermore, the nature of the band gap is direct in H-passivated nanoribbons whereas for coved ribbons a direct to indirect alteration has also been observed. The obtained wide range of the electronic band gap (0.15 eV to 1.34 eV) indicates that ZBPNR could be useful for designing beyond silicon semiconductor devices.

Keywords: *BP, nanoribbon, cove edge, electronic structure, density of states.*

Paper ID: N-88

Area: Semiconductor Nanostructure & Devices

Fabrication and characterisation of MoO_3/ZnO bilayer based memristor showing enhanced memory retention

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ABSTRACT

Memory technologies have been essential for transferring and preserving data. As the digital age progressed, memory device size, speed and efficiency were tuned to address demands. Resistive random access memory (RRAM) devices are the promising candidate for future memory applications and have many advantages, such as scaling, speed, endurance and power consumption over conventional flash memory. In this work, bilayer metal oxide (MoO_3/ZnO) based devices are fabricated with Ag and ITO as top and bottom electrodes to investigate resistive switching characteristics for non-volatile RRAM. ZnO and MoO_3 thin films are deposited over ITO substrate by radio frequency magnetron sputtering, while the top electrode is thermally evaporated. Each layer in the device is characterized by Raman spectroscopy, UV visible spectroscopy, atomic force microscopy, FESEM, etc., and the results are interpreted. The I-V characteristics of the device are analyzed for the characteristic pinched hysteresis loop where bipolar switching has been observed with SET voltage at 1.1 V and RESET at -0.8 V. The field-dependent migration of oxygen vacancies in metal oxide layers accounts for the formation and rupturing of conduction channels, resulting in bipolar switching. The conduction mechanism for this metal-insulator-metal structure is studied, revealing Ohmic conduction in the low voltage region while space charge limited conduction (SCLC) dominates in the high voltage region. Furthermore, memory retention was also studied by applying a constant voltage of 10 mV over time. The results are compared with switching characteristics reported for a single metal oxide device (Ag/ZnO/ITO) in sandwiched structure. Conclusively, this study suggests that the device switches at comparatively lower voltages and has remarkable data retention properties with the addition of MoO_3 layer over ZnO layer. Since the device shows excellent endurance and data retention properties, the fabricated device can be a good candidate for non-volatile memory applications such as RRAM and neuromorphic computing.

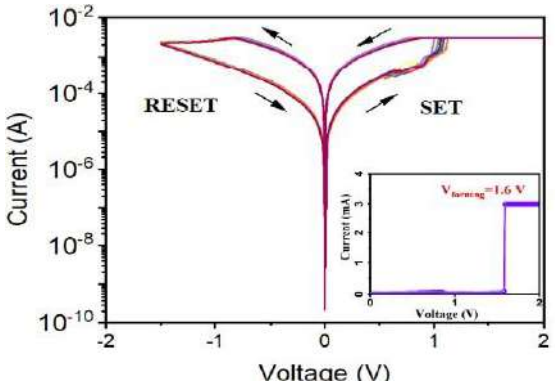

Fig 1: I–V characteristics of fabricated Ag/MoO_3/ZnO/ITO device. Inset, forming operation of the device.

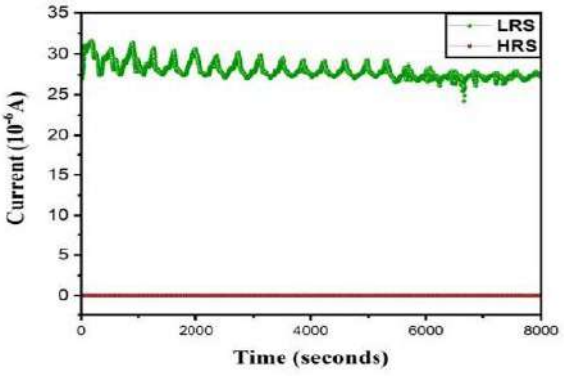

Fig 2: Retention curve of Ag/MoO_3/ZnO/ITO device. LRS denotes low resistance state and HRS denotes high resistance state.

Paper ID: N-89

Area: Semiconductor Nanostructure & Devices

Ammonia Sensing Performance of Hydrothermally Grown Mixed Phase WO_3 Hetero-nanostructure

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ABSTRACT

Cost-effective high-quality gas sensors are of high demand for real-time monitoring of toxic, inflammable gases and volatile organic compounds. Real-time measurements can be carried out using resistive gas sensors due to their easy miniaturization for portable use, low cost, simple design, better gas response, and rapid response speed compared to other gas sensors. The sensing material in a resistive type gas sensor is primarily a metal oxide semiconductor, carbonaceous nanomaterials, or 2D nanomaterials. Among the different kinds of sensing materials, tungsten trioxide (WO_3) has attracted great interest due to its unique physical and chemical properties. WO_3 is a metal oxide with different stable structures such as monoclinic, hexagonal etc.; different phases can exhibit different gas sensitivity. Engineering the formation of heterojunctions of various phases of WO_3 is an effective method for the enhancement of gas sensing properties. The gas molecules tend to get adsorbed and diffuse into these heterojunctions, which may further alter the junction properties and improve the sensing performance. A mixed phase of nanotextured h-/m-WO_3 (hexagonal-monoclinic) heterostructure was successfully synthesized via a simple hydrothermal route. The hydrothermal solution was synthesized by adding 5 mM WCl_6 and 10 mM thiourea in 80 mL ethanol. The mixture solution was continuously stirred for 1 hr to obtain a clear homogenous solution. The as-prepared solution was kept under hydrothermal treatment at 200℃ for 4 hrs. Resultant powder was collected after centrifugation and washing using ethanol and DI water followed by overnight vacuum drying at 60℃. For comparison, pure WO_3 nanostructure was synthesized by the hydrothermal route using a mixture solution of 9 mM WCl_6 and 45 mM thioacetamide in 40 ml DI water at 200℃ for 24 hrs. The as-prepared materials were further subjected to structural and morphological characterizations. FESEM images reveal the broken nanorod structure of the mixed-phase of WO_3. The XRD and Raman spectra of the heterostructure confirm the formation of mixed-phase of hexagonal and monoclinic WO_3 nanostructure whereas that of the pristine WO3 corresponds to the purely monoclinic phase of WO_3. The materials were then drop-casted on the interdigitated Ti/Au pattern with finger size and spacing of 5 μm on a glass substrate using ethanol as solvent. The fabricated devices were tested for various reducing gases. The h-/m-WO_3 heterostructure-based sensor exhibited enhanced sensing properties compared to the pristine WO_3 sensor and was more selective towards ammonia gas compared to other reducing gases tested.

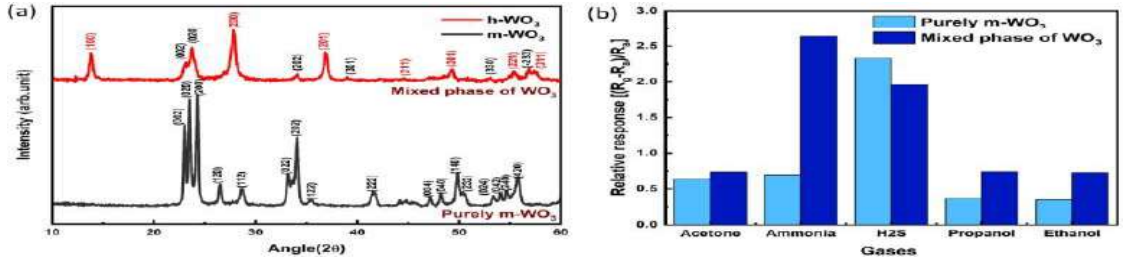

Figure 1: (a) XRD spectra of WO3 nanostructures and (b) Comparison of responses of WO3 nanostructures towards different gases (100 ppm) at 100 □C

Paper ID: N-90

Area: Semiconductor Nanostructure & Devices

Hydrothermal synthesis and characterization of cubic $CuCo_2S_4$ nanosheets

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ABSTRACT

Due to their physical and chemical characteristics, transition metal chalcogenides (TMCs) are receiving increased interest in the field of energy conversion and storage devices. $CuCo_2S_4$ is one of these well-researched and acknowledged compounds due to its availability, non-carcinogenicity, greater conductivity, and smaller band gap than oxides. Hydrothermal synthesis was used to synthesize the $CuCo_2S_4$ over the course of 24 hours at 180° C. The morphology, crystalline structure, and composition of the as-produced $CuCo_2S_4$ powder were further investigated. The cubic structure of $CuCo_2S_4$ and pure phase development are shown by X-ray diffraction (XRD) and Raman spectroscopy. The development of the cation-anion complex was shown by Fourier transform infrared spectroscopy (FTIR), and no impurity phase was seen. In the material, nanosheets of $CuCo_2S_4$ powder have accumulated as shown by scanning electron microscopy (SEM), and energy dispersive spectroscopy (EDS) confirms the existence of all three elements. The band gap of $CuCo_2S_4$ nanosheets was calculated with the help of a UV-Vis spectrophotometer. The results demonstrate that $CuCo_2S_4$ may be used in energy conversion and storage.

Paper ID: N-91

Area: Semiconductor Nanostructure & Devices

Solar light enhanced hydrogen evolution reaction on $CoMoS_2$ semiconducting electrocatalysts

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ABSTRACT

The progress of unconventional systems for energy conversion and storage has sparked a lot of research interest due to rising energy demands and environmental concerns. The electrocatalysts based on two dimensional transition metal dichalcogenides have shown great promise owing to their tunable intrinsic catalytic properties and high surface-to-volume ratio. Herein, we report the enhanced electrocatalytic hydrogen evolution of 2D-MoS_2 sheest by doping of cobalt. Doping of cobalt enhances the hydrogen adsorption capabilites, which leads to accelrated HER in acidic medium. Co doped MoS_2 nanosheets have been synthesized by facile and high-yield liquid phase exfoliation techhnique which is capable of large scale production of electrocatalysts. $Co_XMo_{1-X}S_2$ electrocatalysts show excellent catalytic activity for HER with low overpotential and Tafel slope. Additionally, the electrolysis of water is successfully accelerated by solar heating by increasing the ionic diffusion between electrode and electrolyte and by increaing the electronic charge density due to injection of hot electrons. Overall, this research highlights a feasible approach for producing improved HER electrocatalysts, which can replace noble metals in a variety of renewable energy applications.

Keywords: *2D-TMDCs; MoS_2; Semiconductors; Hydrogen evolution reaction.*

Paper ID: N-92

Area: Semiconductor Nanostructure & Devices

NOx sensor based on semiconductor metal oxide and MXene nanostructures

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ABSTRACT

Nitrogen oxide (NOx) is the dominating source for toxic air pollutants originating from fertilized soils. Semiconductor metal oxides have been widely investigated for monitoring different toxic gases due to their outstanding properties such as wide band gap, intrinsic oxygen vacancies, high chemical as well as thermal stability, and environmental friendly nature. Further, MXenes have attracted researchers due to their exceptional properties such as surface termination group, modulating work function and highly conducting nature. In this work, we demonstrate the enhancement in gas sensitivity by interfacial engineering of semiconductor metal oxide (SnO_2) with MXene ($Ti_3C_2T_X$) using hydrothermal method for developing low-cost nitrogen oxide (NOx) gas sensor. The structural and morphological characterization of $SnO_2/Ti_3C_2T_X$ nanostructures were analysed using X-ray diffraction, field-emission scanning electron microscopy, and Brunauer-Emmett-Teller techniques. Further, the gas sensing studies of the $SnO_2/Ti_3C_2T_X$ nanostructure-based sensors were investigated by estimating their sensitivity and selectivity toward different gases (isopropanol, methane, nitrogen oxide, ammonia, ethanol and acetone) at room temperature. In comparison to pristine SnO_2 and $Ti_3C_2T_X$-based sensors, the $SnO_2/Ti_3C_2T_X$ sensor demonstrated strong selectivity and gas sensing response toward NOx with improved response/recovery time, suggesting a promising application prospect in soil NOx sensing.

Paper ID: N-93

Area: Semiconductor Nanostructure & Devices

CuS/NiO Heterostructure Based Electrodes for Enhanced Hydrogen Evolution Reaction under the Light Illumination

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ABSTRACT

Since long, considerable research has been carried out to develop a promising catalyst for photo-electrochemical hydrogen evolution reaction (HER). Hybrid electrocatalysts based on transition metal chalcogenides and oxides have shown great promise for hydrogen generation owing to their superior intrinsic catalytic properties and strong light meter interactions over the broad spectral region. Herein, we report the in-situ synthesis of CuS/NiO (CSNO) nano-heterostructures based catalyst via a facile co-precipitation approach for photoelectrochemical hydrogen generation. The structure of CSNO is investigated by powder X-ray diffraction (XRD). The Morphology of the catalyst was investigated using a scanning electron microscope (SEM), revealing the porous nature of the CSNO heterostructure, which is advantageous for hydrogen adsorption/desorption in the HER process. UV-Vis spectroscopy confirms that the as-prepared catalyst shows high absorbance in the visible range compared to the pristine CuS and NiO. Owing to these characteristics of the catalyst, the CSNO-based electrodes show excellent HER activity under light irradiation. The CSNO catalyst shows low overpotential and low charge transfer resistance under illumination, implying inhibition of electron-hole recombination and a high charge transfer rate at the electrode/electrolyte interface. Furthermore, the CSNO heterostructure-based electrode exhibits long-term stability, offering an opportunity for the development of non-noble electrodes for clean energy generation via photo-electrochemically HER in the future.

Paper ID: N-94

Area: Semiconductor Nanostructure & Devices

Effect of the microstructure on the optical properties of silver nanoparticles investigated by spectroscopic ellipsometry

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ABSTRACT

This paper presents a study on the optical properties of silver nanoparticles (Ag NPs). Ag NPs were grown by vacuum annealing of rf sputtered silver (Ag) thin films. The Ag thin films were deposited on corning 1737 glass substrate by varying rf power from 40 to 80 Watt to change the microstructure of as deposited films and Ag NPs. The optical properties of Ag NPs were investigated from spectroscopic ellipsometry (SE) data using Drude-Lorentz (D-L) model along with two Gauss oscillators. The void fraction and the surface roughness were calculated from SE using Bruggeman Effective Medium Approximation (BEMA). It was observed that the peak of the imaginary part of the pseudo dielectric function, which is due to the localized surface plasmon resonance (LSPR) of the silver nanoparticles, shifted towards the lower energy at higher RF power due to increase in the thickness of the precursor films which subsequently resulted in to increase in particle size. These observations show the similarity with the optical properties measured by UV-Vis-NIR spectroscopy. With the increase in RF power the void fraction and surface roughness measured from SE, decreased indicating a transition from the growth of nanoparticles to the continuous films which was also shown by scanning electron microscopy (FESEM). FESEM and X-ray diffraction (XRD) was used to probe the microstructure of the Ag NPs. The root mean square (RMS) roughness was evaluated from atomic force microscopy (AFM) matched well with surface roughness measured from SE.

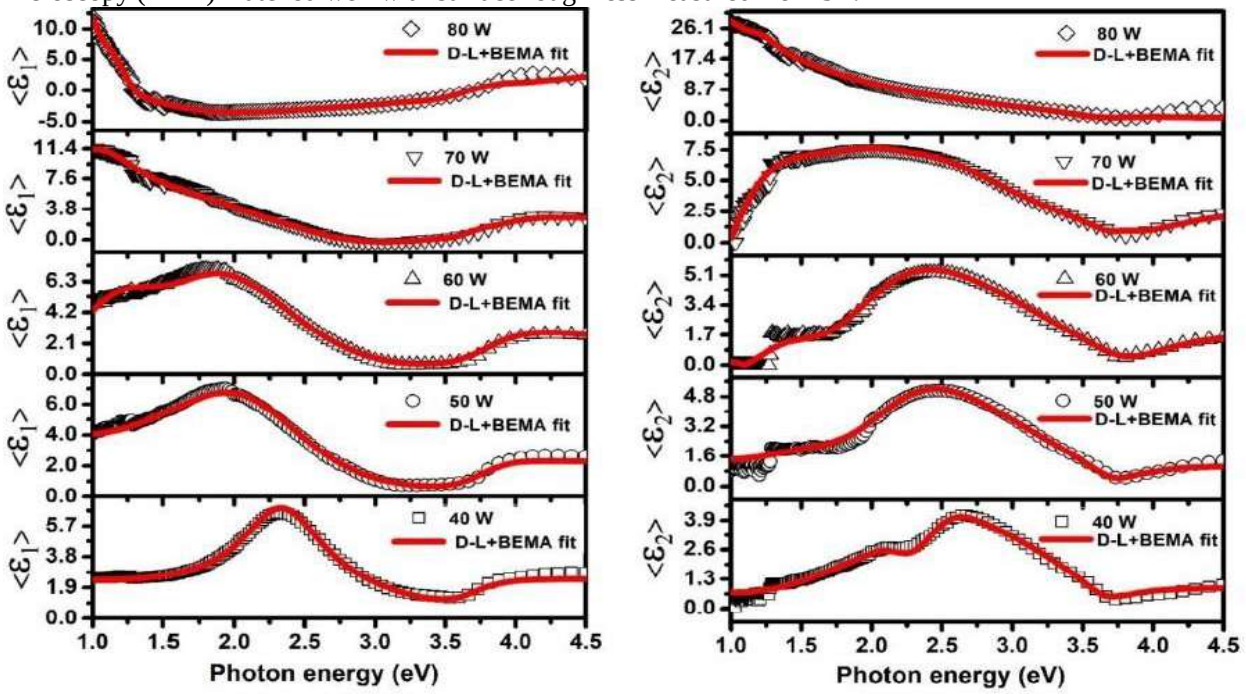

Fig 1. The measured and fitted real (<ε1>) (a), and the imaginary (<ε2>) part (b) of the pseudo dielectric function spectra of Ag NPs on corning glass deposited at different RF power: 40-80 Watt.

Paper ID: N-95
Area: Semiconductor Nanostructure & Devices

Functionalization of CVD grown monolayer WS_2 for molecular sensing via defect engineering

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ABSTRACT

Real-time and label-free detection of pathogenic bacteria is essential for continuous monitoring of public health and food quality. Field-effect transistors (FETs) based biosensors are highly sensitive for real-time detection of pathogens. FETs made by using 2D TMDs like WS_2 have received great attention because of their planar structure, excellent electrical properties, high electron mobility, on-off ratio, biocompatibility, and compatibility with existing semiconductor fabrication industries. Herein, we have synthesized WS_2 monolayer on highly doped p-type SiO_2 substrate by chemical vapour deposition (CVD) method. To use WS_2 as biosensors, its surface modification followed by surface functionalization using a suitable receptor is crucial for improving the specificity in the detection. Surface modification is essential due to the non-sensitive nature exhibited by layered TMD surfaces. ssDNA aptamers are selected as receptors because of their small size, thermal stability, low cost, and higher specific binding with bacteria. For surface modification we have carried out vacuum annealing of the samples at 300, 400, 500 and 600 °C for 30 minutes at a pressure of 2.5×10^{-2} mbar. The surface properties of all the samples are then characterized using micro-Raman and Photoluminescence (PL) spectroscopic tools. The Raman modes E^12g and A_{1g} are sensitive to strain and doping effect respectively. From Raman analysis we observe a sharp increase in the full width half maxima (FWHM) of A1g mode owing to annealing, with respect to the pristine monolayer WS_2. However, with increase in the annealing temperature, the FWHM exhibits a systematic linear decrease. This indicates an increase in the electron density in the monolayer WS2 induced by the annealing process. The PL spectra of monolayer WS_2 consists of neutral (A0), trion(A-), and defect (X^d) transitions. The light n-type doping in the annealed samples is confirmed by the increase of the trion contribution to the PL spectra. We have drop casted 1 µM thiol modified aptamer solution in Tris-hcl buffer at pH 8 to the as grown and 300 °C annealed samples. The PL spectral analysis of the functionalized samples shows redshift in the spectra accompanied by quenching of emission intensity. The quenching of PL spectra and increase of trion contribution indicates negative charge transfer from thiol-aptamer to WS_2 surface. Our results indicate successful surface functionalization of WS_2 films with thiol-modified aptamers. These results can be extended for sensing of bacteria using WS_2 FETs and other molecular functionalization-based sensing applications. Figure 1 shows optical properties of the as grown as well as annealed samples.

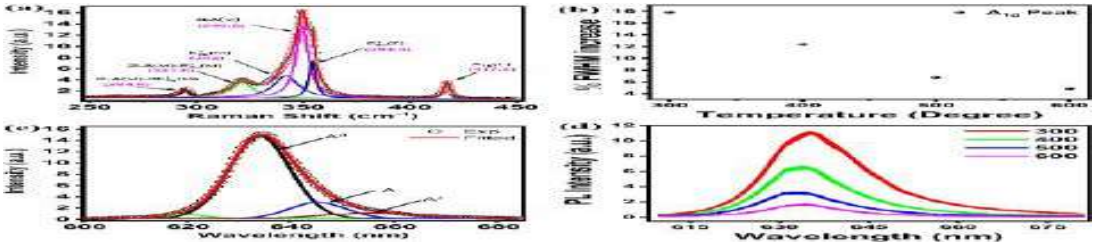

Figure 1: (a) Raman spectra of monolayer WS2 at 532 nm laser excitation. (b) Change of FWHM corresponding to A1g Raman mode of monolayer WS2. (c) PL spectra of as grown monolayer WS_2. (d) PL spectra of all the annealed samples under different annealing temperatures. Laser excitation of 532 nm was used for the PL measurement.

Paper ID: N-96

Area: Semiconductor Nanostructure & Devices

Bifunctional Application of Viologen-MoS2-CNT/Polythiophene Device as Electrochromic Diode and Half-Wave Rectifier

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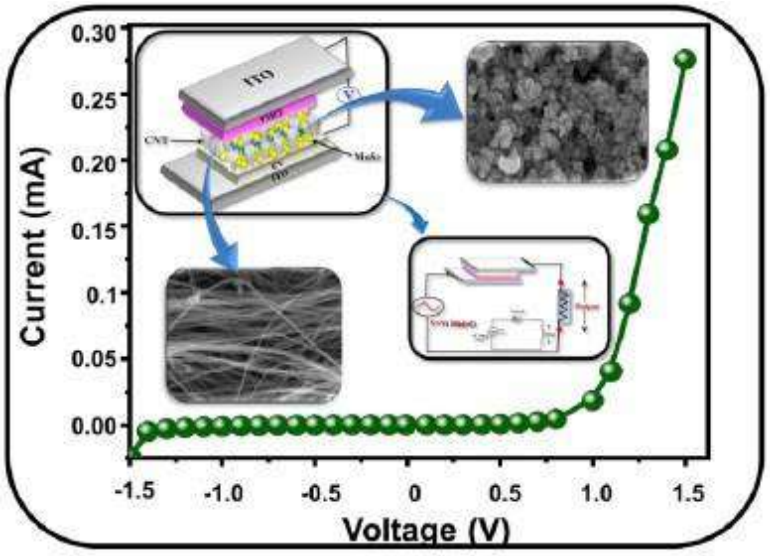
ABSTRACT

A dual-purpose solid state electrochromic device has been fabricated using polythiophene (P3HT) and ethyl Viologen (EV), pre-doped with multi-walled carbon nanotubes (MWCNTs) and MoS2. The MoS2 nanoflower and MWCNTs are synthesized by one-step hydrothermal and pyrolysis techniques and well characterized by SEM, XRD, and Raman spectroscopy. The charge holding properties of MoS2 & MWCNTs gives the asymmetric diodic I-V characteristic to the device which has been exploited to use the electrochromic device for rectification application. Electrochromic properties of the device reveal its improved performance in terms of faster switching speed (0.47s/0.8s) between two colored states (Magenta & Blue), high coloration efficiency (642cm2/C), and good color contrast (46% at 515nm). Along with its electrochromic property, it has been realized as a half-wave rectifier that rectifies an AC voltage of frequency 1Hz or less making it suitable for low-frequency operation. This study opens a new possibility to design and fabricate multipurpose frequency selective electrochromic rectifiers.



Paper ID: N-97

Area: Semiconductor Nanostructure & Devices

Growth of few layers of WS2 thin films by pulsed laser deposition

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ABSTRACT

Graphene was the most sensational material of the 20th century that has made a tremendous revolution in the field of material science research. The exceptional material properties at the 2D limit make them suitable for different applications. But on the downside, it lacks intrinsic band gap energy which limits its device level applications to a considerable extent. Beyond graphene, mainly transition metal dichalcogenides (TMDs) were investigated widely due to their captivating material aspects. Tungsten disulphide (WS2) is a prominent material among 2D transition metal dichalcogenides (TMDs) for the next generation of optoelectronic devices. Therefore, fabricating high quality thin films with controlled growth parameters is essential for device applications. In this study, we are reporting the growth of few layers of WS2 thin films on Si/SiO2 substrates by pulsed laser deposition (PLD) technique. A sintered WS2 target was ablated at room temperature using the fourth harmonics of Q-switched Nd:YAG laser (λ=266nm, pulse width=10ns) followed by a post deposition annealing at different temperatures. The dependence of post annealing temperatures on the formation of WS2 was investigated. Few layers of WS2 thin films were confirmed by RAMAN, Atomic force microscopy (AFM) measurements. The surface chemistry of the prepared sample was investigated by X-ray photoelectron spectroscopy (XPS). The controlled growth of WS2 thin films employing the versatile PLD technique will open up a wide arena in optoelectronic device fabrication.

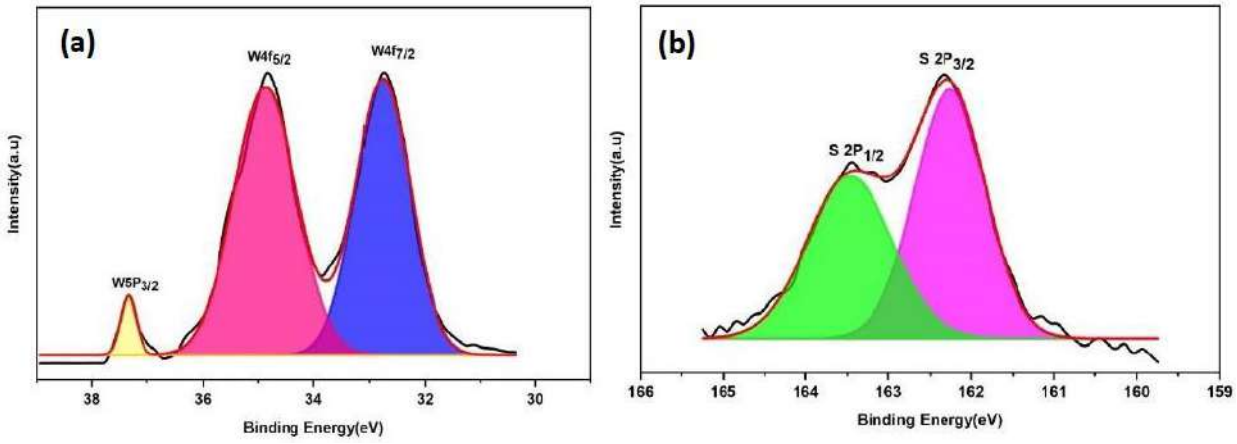

Figure 1: XPS spectra of deposited (3min) WS_2 thin films (a) W4f (b)S2p core level spectra

Paper ID: N-98

Area: Semiconductor Nanostructure & Devices

Experimental and computational analysis of structural, electronic and optical properties of Germanium selenide

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ABSTRACT

Semiconductor of the transition metal chalcogenide family, germanium monoselenide (GeSe) has shown great promise in the field of opto-electronics due to suitable energy band gap and multiple exciton generation. Herein, we report the experimental and theoretical analysis of the structural, electronic and optical properties for the application in fabrication of large area and visible light photodetector. Large area and semi-transparent thin film of GeSe, deposited by vacuum thermal evaporation technique, has shown light absorption over visible region of the spectrum. GeSe thinfilm has orthorhombic crystal structure. Ag/GeSe/Ag photodetector shows excellent photo-switching action under visible light. Additionally, to analyze the electronic properties such as band structure and density of states of the compound Germanium Selenide (GeSe), we have employed the first principle density functional theory (DFT) using the linear combination of atomic orbitals (LCAO) calculator which is implemented in the software package –QuantumATK‖ (Atomistic Tool Kit). The simulations of orthorhombic germanium selenide were carried out using the hybrid density functional (HSE06) wherein the band structure gave the bandgap of 1.04eV showcasing the semiconducting behavior of the material which was also proved by the density of states.

Keywords*: GeSe; Thermal evaporation; Photodetector; DFT calculation.*

Paper ID: N-99

Area: Semiconductor Nanostructure & Devices

Dielectric and electrical properties of Sm3+ ions doped magnesium calcium titanate ceramics synthesized via ceramic route

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ABSTRACT

The present work reports dielectric and electrical properties of undoped and samarium ions doped magnesium calcium titanate ceramics, prepared by ceramic route. The frequency dependent dielectric studies were performed in the frequency range of 102 Hz to 105 Hz. The value of dielectric constant (ε) in the high frequency region is low and shifts towards higher value in low frequency region. The temperature dependent dielectric studies performed in temperature range 30℃ (RT) to 300℃. The value of dielectric parameters increases with increasing temperature. The higher value of ac conductivity in high frequency region indicates that the prepared ceramics obey universal power law. Increasing trend of ε value is observed with Sm3+ ions substitution.

Keywords: *MCT, electrical properties, capacitors, dielectric constant*

Paper ID: N-100

Area: Semiconductor Nanostructure & Devices

Multilayer ferroelectric gate oxide FET using (Al/BiFeO3/BaTiO3/Si) structure for nonvolatile storage application.

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ABSTRACT

This paper presents the ferroelectric, structural, and electrical properties of a non-volatile memory gate stack structure composed of Al/BiFeO3/BaTiO3/Silicon. The BiFeO3 and BaTiO3 thin film stack is deposited on a silicon substrate through the RF magnetron sputtering process. The polarization hysteresis for the applied voltage on the stack structure is observed. The XRD results of the fabricated structure provide the crystal and the structural properties of the film. The presence of perovskite structure with a smooth surface with no cracks is achieved for the annealing temperature of ~ 650 oC. The capacitance, the leakage current and the dielectric properties of the metal-ferroelectric-silicon (MFS) structure are obtained to get the memory window and dielectric loss of the film. The refractive index and thickness of the film are measured using the multi-angle ellipsometry analysis. A maximum memory window of ~ 2 V is obtained with leakage current in the range of a few nano Amperes and for the endurance is checked using iteration PUND pulse of 1010 cycle. No fatigue in the charge shift for the PUND signal up to 109 cycles is obtained.

Keywords: *Ferroelectric, Perovskite, Sputtering, Non-Volatile, Memory window, Leakage current*

Paper ID: N-101

Area: Semiconductor Nanostructure & Devices

Optimizing the electrospun SnO2-ZnO fiber thickness for low concentration ethanol detection

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ABSTRACT

The present work demonstrates the ethanol analyte sensing potential of SnO_2-ZnO composite based sensor. SnO_2-ZnO composite solution has been synthesized using sol-gel method and nanofibers in the thickness range of 50 nm to 250 nm have been successfully deposited on Interdigitated gold electrode (IDGE) using electrospinning technique. The effect of the fiber width on the ethanol analyte sensing properties of the nanofibers is studied to provide the optimum fiber thickness for ethanol sensing. The n-n heterojunction based sensing mechanism of SnO_2-ZnO composite is presented. The optimal sensor has shown excellent % response of 43.4 % and 371 % at 0.5 ppm and 100 ppm of ethanol respectively at 180 ˚C. The high sensitivity is attributed to the low average crystallite size of 91 nm. The sensors exhibit quick response and recovery times along with appreciable selectivity towards ethanol. Furthermore, X-ray Diffraction, X-ray photo spectroscopy and Field emission scanning electron microscopy characterizations have been done to analyze the crystal structure, valence states and surface morphology of the SnO_2-ZnO composite respectively.

Paper ID: N-102

Area: Semiconductor Nanostructure & Devices

Dependence of thermal conductivity of graphene on the coefficient of linear expansion and temperature

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ABSTRACT

Graphene attracts particular interest recently due to its extraordinary properties. Xu et al.1 have studied length-dependent thermal conductivity in suspended single-layer graphene. They observed that the thermal conductivity of graphene increases and remains logarithmic divergence with sample length. Yoon et al.2 observed that the coefficient of linear expansion (α) for graphene is always negative between at least up to 2500 K. In this paper, we study the dependence of thermal conductivity of graphene on the coefficient of linear expansion (CLE). We find that the thermal conductivity of graphene bears an exponential relationship with its CLE and is directly proportional to the sample length. Using the Slack equation, we have also found that the thermal conductivity of graphene is inversely proportional to the temperature and verified the relationship between the thermal conductivity of graphene and CLE. Due to this property graphene can be utilized to remove fishplates in railroads which can increase the efficiency of railway tracks.
PACS Numbers: 61.48.Gh; 44.10+i; 63.22.Rc; 65.80.Ck

Keywords: *Graphene; heat conduction; phonons in graphene; thermal properties of graphene*

Paper ID: N-103

Area: Semiconductor Nanostructure & Devices

Performance investigation of pulsed laser ablated of MoS2 based thin film transistors

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ABSTRACT

The impact of graphene has attracted the attention of scientific communities to explore various two-dimensional (2D) materials owing to their striking electronic, mechanical and optoelectronic properties. Even though graphene exhibits exceptional properties, the lack of an electronic bandgap restricts its application in optoelectronic devices. Molybdenum disulphide (MoS2), a layered semiconductor belonging to the family of transition metal dichalcogenides (TMDs) having a bandgap of ~1.9 eV (monolayer) has emerged a good candidate for optoelectronic devices applications especially in thin film transistors (TFT). Mono/few layered MoS2 thin films were synthesized using pulsed laser deposition technique (PLD) on thermal oxide silicon (SiO2/Si) substrate. The formation of mono/few layered MoS2 was confirmed using micro-Raman spectroscopy. The surface morphology and thickness of the films were determined by atomic force microscopy (AFM). Thin films transistors are fabricated using mono/few layered MoS2 thin films as channel layer in back gated configuration with SiO2 (100 nm) as the dielectric layer, thermally evaporated gold (Au) as source and drain electrodes and Si (n++) as gate electrode. The TFT characteristics of the fabricated device were analyzed using semiconductor parameter analyzer. The device showed a p-type behavior with an on/off ratio of 103 which can be used for switching applications in optoelectronic devices. The transfer characteristics of the device is shown in figure.1

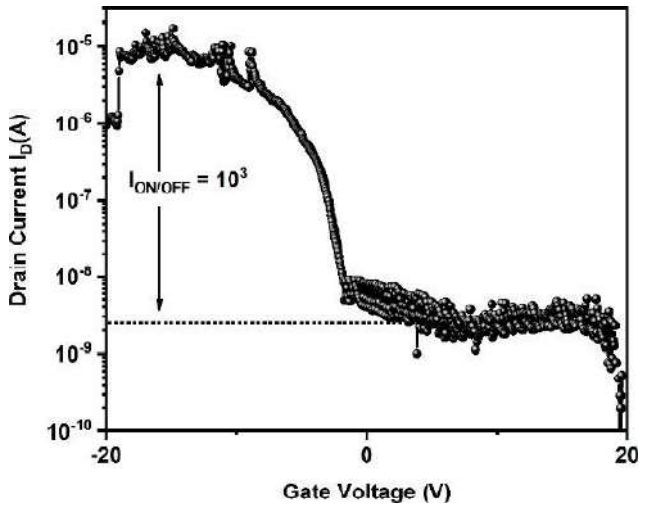

Figure 1: Transfer characteristics of PLD grown MoS_2 based TFT

Paper ID: N-104

Area: Semiconductor Nanostructure & Devices

Negative temperature coefficient behaviour of ZnSnO3 nanomaterial for temperature sensor applications

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ABSTRACT

We report, the temperature sensing behaviour of hydrothermally prepared ZnSnO3 nanomaterials. The as-synthesized and annealed ZnSnO3 nanoflakes and nano-cabbages were characterized by field emission scanning electron microscope (FE-SEM) (as shown in figure 1(a,b) and X-ray diffraction (XRD) for their surface analysis and structural properties respectively. The fabrication of temperature sensor, the sensing film formation is carried out on the ITO substrate by using drop casting method. It was observed that the resistivity of sensing film decreased with the increase of temperature resulting in NTC behaviour. The measured NTC and sensitivity of the sensor were found to be −0.00172 Ω / Ω / K and 0.51256 Ω /K respectively for as prepared nanoflakes of ZnSnO3.Whereas, the sensor made out of annealed samples showed NTC and sensitivity values of −0.00213 Ω / Ω / K and 0.63474 Ω /K respectively as shown in figure 1 (c). This proves ZnSnO3 as an attractive material for making temperature sensors. Since the output is linear with respect to temperature variation, the electronic readout circuitry will be simpler. However, the mechanism of electrical resistance change of nanocomposite films can also be used in sensing environmental parameters such as chemical, biological, moisture and mechanical for their gas, glucose, humidity and strain/pressure sensor applications respectively.

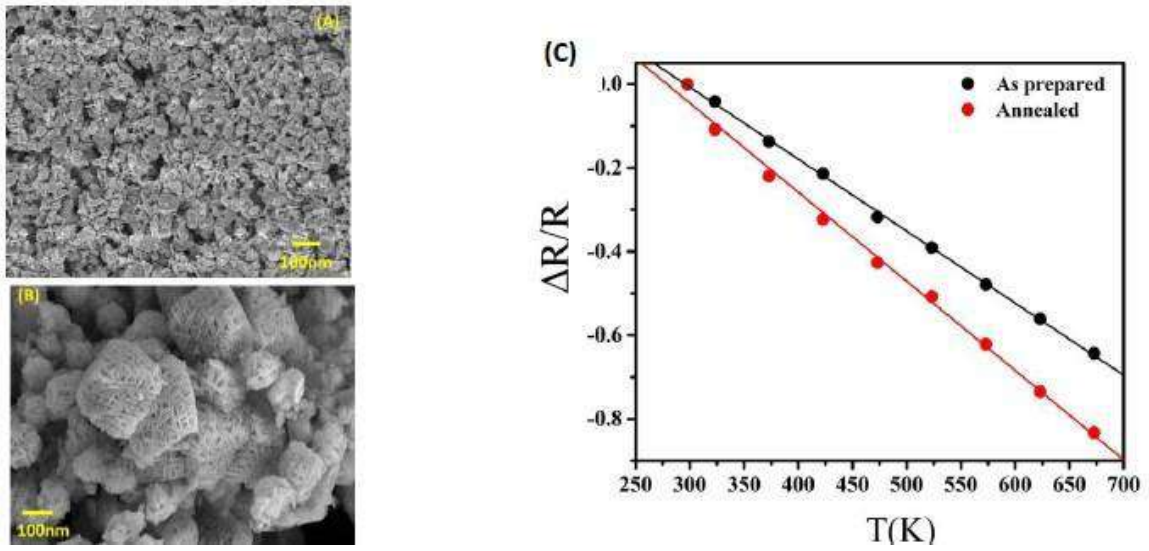

Figure 1: FESEM images of (A) as prepared and (B) annealed $ZnSnO_3$ samples; (C) The relative change in resistance as change in temperature resulting as TCR value of $ZnSnO_3$ samples

Paper ID: N-105

Area: Semiconductor Nanostructure & Devices

Role of Antisolvent Based Two-step Fabrication Process in Retention of Structural Stability of Organic-Inorganic Halide Perovskites

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ABSTRACT

The organic-inorganic metal halide perovskites (OIMHPs) have been widely explored in recent years due to their competent performance in energy conversion storage applications. We compare the time dynamics of structural, morphological, and optoelectronic attributes of Methylammonium lead Iodide ($MAPbI_3$) thin films synthesized by a two-step solution processing route in two different ways viz. without and with anti-solvent vapor exposure. The time-dependent GIXD profiles reveal the better structural preservation of the anti-solvent exposed synthesized sample over 25 days, manifested by only slight emergence of PbI_2 peak at 12.71°, unlike the other film devoid of anti-solvent exposure where strong PbI2 peak appears after 25 days, indicating the structural decomposition of $MAPbI_3$. The structural degradation of the films devoid of anti-solvent treatment is also corroborated by the appearance of an absorption onset ~2.3 eV in the Tauc plot, attributed to the PbI2 bandgap. On the other hand, only a slight spectral shift, from ~1.55 eV (0 days) to ~1.67 eV (25 days), occurs in the assessed optical bandgap in the anti-solvent-exposed films. The significant structural degradation may be attributed to humidity exposure. This investigation may be helpful to address the issues of structural decomposition, which have been impeding the widespread application of OIMHPs into photovoltaics and other light energy harvesting applications.

Keywords: *Organic-inorganic halide perovskite, $MAPbI_3$, Thin film, Photovoltaic.*

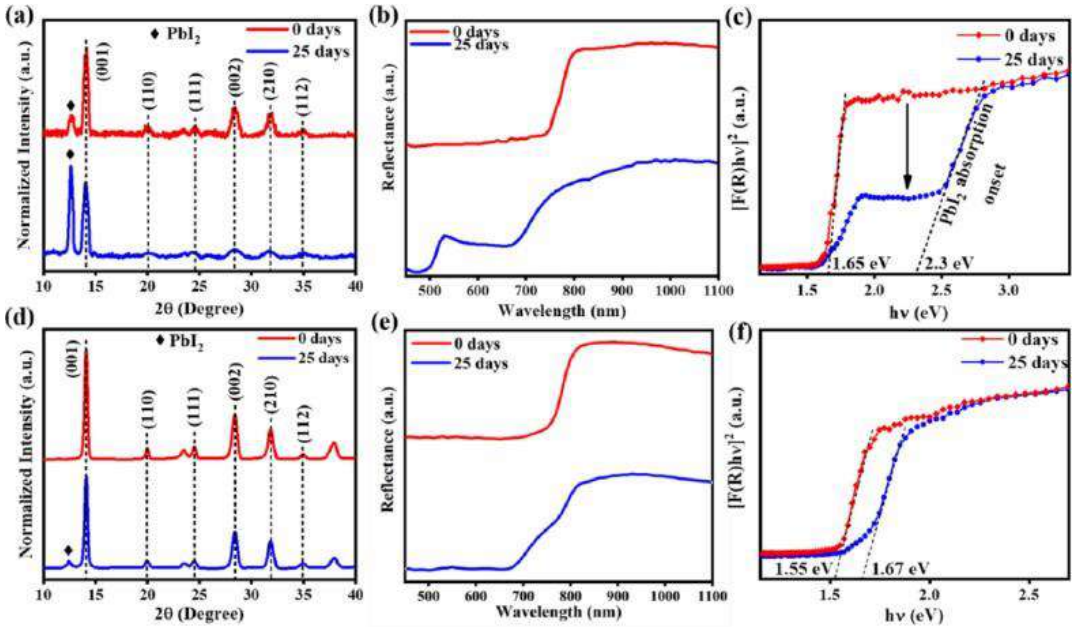

Figure 2: Time-dependent XRD profiles in a grazing incidence mode, UV-vis reflectance spectra and Tauc plots of fresh/0 days and 25 days old samples respectively of $MAPbI_3$ thin films synthesized by two-step solution synthesis route in two different ways: (a, b, c) without antisolvent, and (d, e, f) with antisolvent vapor exposure. Both the XRD profiles and Tauc plots systematically indicate more degradation in $MAPbI_3$ thin films synthesized without exposure to antisolvent vapors

Paper ID: N-106

Area: Semiconductor Nanostructure & Devices

Ultrasensitive non-enzymatic glucose sensing using layered copper selenide

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ABSTRACT

Copper-based layer two-dimensional materials have drawn tremendous attention in catalytically sensing applications. Here, a mere attempt has been made to synthesize copper selenide (CuSe) by a facile wet chemical approach. The phase and crystallinity of the layered materials have been analyzed using the X-Ray diffraction technique. Field emission scanning electron microscopy-based surface morphology observation depicts layer structures in assembled flower form and the sequential change in the growth morphologies with alteration in precursor concentration. The linear variation of amperometric current with glucose concentration (0- 6.0 mM) is evidenced by the catalytic oxidation of the as-synthesized materials as electrodes. Superior sensitivity of 28.1 μA mM-1 cm-2 has been estimated for the sample with a precursor concentration of 0.2 Mole. Moreover, the high sensitivity of the as-fabricated electrode shows that both the material synthesis and the sensor fabrication method have been promising for scalable processes based on clinical device design.

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Paper ID: N-107

Area: Semiconductor Nanostructure & Devices

Network analysis and charge transport parameters of semiconducting nano petal-structured Mo1-xWxS2 based schottky diode

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ABSTRACT

$MoWS_2$ (Molybdenum Tungsten Di-Sulphide) is a semiconducting alloy of different TMD (transition metal dichalcogenide) materials which has huge tunable structural, optical absorption and electrical properties. In this work, we have synthesized Mo1-xWxS2 nano composites with different molar concentration of tungsten (i.e. x=0, 0.1, 0.2, 0.4) and the obtained PXRD data is shown in Figure 1. We have also calculated the d values, lattice parameter and crystallite size of the synthesized materials from the XRD data (Table-1). Characterization of their structural, optical and charge transport properties are compared. It is noticed that the amount of tungsten alloy concentration has a great impact on the particle size of composites. The charge transport through the metal-semiconductor junction is the basis for the superiority of semiconductor devices like the Schottky diode. As a result, we fabricated an Al/ Mo1-xWxS2/ITO device and used equivalent circuit network analysis to investigate the impedance characteristics to look into the resistance of the interfacial region. According to network analysis study, Al- Mo0.8W0.2S2 has superior charge transportation than other fabricated devices, making it suitable for use in optoelectronic applications. In addition, we evaluated the current-voltage (I-V) and capacitance-voltage (C-V) characteristics. We have examined series resistance, barrier height and used SCLC (space charge limited current) theory in I–V characteristics to determine mobility, transit time. The calculated mobility and transit time for the Mo0.8W0.2S2 device are $5.65\times10\text{-}4$ m^2 V^{-1} s^{-1} and 1.59×10^{-3} s, respectively while both the values are best than the other devices. Dramatic conductivity enhancement for $Mo0.8W0.2S^2$ based Schottky device is observed. As a result, this work not only investigates the metal semiconductor charge transit using IS (Impedance Spectroscopy) network analysis and SCLC theory, but also explains it from a structural perspective.

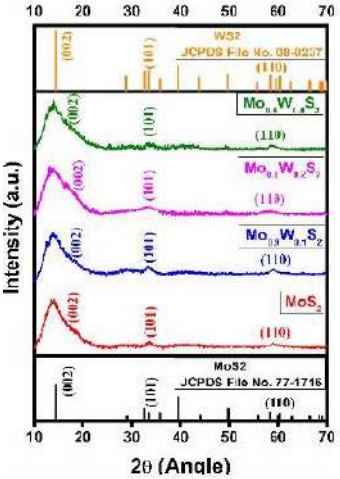

Table 1: Parameters from XRD analysis

Molybdenum Composition	Peak Position (2θ)	FWHM (β) (°)	d-spacing (A°)	(hkl) crystal system	Lattice Parameter (a=b, c) (Å)	Crystallite Size (D) (nm)	Micro strain(ε) × (10^3)
1	13.717 33.693 58.927	4.65 1.11 3.01	6.387 2.654 1.550	002 101 110	a=b=3.10 c=12.77	1.72 7.47 3.04	20.152 4.641 11.386
0.9	13.837 33.393 59.023	4.68 1.65 3.23	6.419 2.695 1.556	002 101 110	a=b=3.11 c=12.84	1.71 5.02 2.83	20.278 6.899 12.247
0.8	13.217 33.313 58.547	5.98 2.96 3.86	6.419 2.695 1.564	002 101 110	a=b=3.13 c=12.84	1.34 2.80 2.36	25.912 12.385 14.661
0.6	14.097 32.693 58.527	5.20 2.91 3.79	6.646 2.727 1.595	002 101 110	a=b=3.19 c=13.29	1.54 2.84 2.40	22.548 12.182 14.468

Figure 1: XRD spectra of MoS2, Mo0.9W0.1S2, Mo0.8W0.2S2 and Mo0.6W0.4S2

Paper ID: N-108

Area: Semiconductor Nanostructure & Devices

Low toxic semiconducting metal halide perovskite nanocrystals for potential optoelectronic applications

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ABSTRACT

In the last few years, metal halide perovskites (MHPs) have grabbed the central position for many flourishing applications like Solar cells, Photodetectors, LEDs, Memory devices, Schottky diodes, Piezoelectric generators, etc. The attractive properties of this class of semiconductors include direct and tuneable bandgap, long diffusion lengths, high carrier mobilities, longer carrier lifetimes, and ease of fabrication. However, inherent challenges like lead (Pb)-toxicity and structural instability under ambient conditions hamper the overall success of MHPs. Usually, perovskite compounds with Pb as the metal cation form the most structurally stable compounds with a tolerance factor lying between 0.89 and 1, and therefore, replacing Pb from the perovskite compound has been observed to degrade the performance of perovskite based devices. Thus, the substitution of Pb with other compatible metallic cations seems to be a convenient way to address the toxicity issue. This study performs different electrical characterizations of halide perovskite nanocrystals (HPNCs) with lowered toxicity. The HPNCs are developed using the easy solution processed recrystallization method. The toxicity reduction is achieved by selecting a non-toxic metal that can potentially replace Pb from the perovskite compound partially or completely. After characterizing different ratios of Pb and the non-toxic element, the best ratio for such HPNCs compounds with enhanced optoelectronic properties and stability has thus been reported.

Paper ID: N-109

Area: Semiconductor Nanostructure & Devices

Study of dielectric and ferroelectric properties of flexible PVDF-based copolymers and terpolymers thin films

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ABSTRACT

Ferroelectric high k-dielectric polymer thin film of Polyvinylidene difluoride (PVDF) copolymer (PVDF-TrFE) and terpolymer (PVDF-TrFE-CFE) were prepared using spin coating process on ITO coated PET substrates. The films were annealed in between glass transition and melting temperature. Annealed films cooled in two ways-i) Normally-cooling and ii) Fast-quenching, to study film crystallinity and ferroelectric property. Dielectric and leakage current property study of the prepared PVDF-TrFE and PVDF-TrFE-CFE thin film were done by making Metal/Insulator/Metal (MIM) device. MIM device was prepared by depositing aluminum electrodes of diameter 2 mm; 3 mm and 4 mm via thermal deposition on a 1 X 1 inch ITO coated PET substrates having ferroelectric polymer thin film as shown in Figure 1(a). The fast quenched PVDF-TrFE thin film shows higher dielectric constant and low leakage current compared to normal cooled PVDF-TrFE thin film. Similarly, dielectric properties was observed for quick cooled and fast quenched PVDF-TrFE-CFE thin films. For PVDF-TrFE, the fast quenched thin film shows higher remnant and saturation polarization at an applied electric field of 200 MV/m compared to normally cooled thin film as shown in Figure 1(b). Similarly, for PVDF-TrFE-CFE, the fast quenched thin film shows the better ferroelectric property as shown in Figure 1(c).

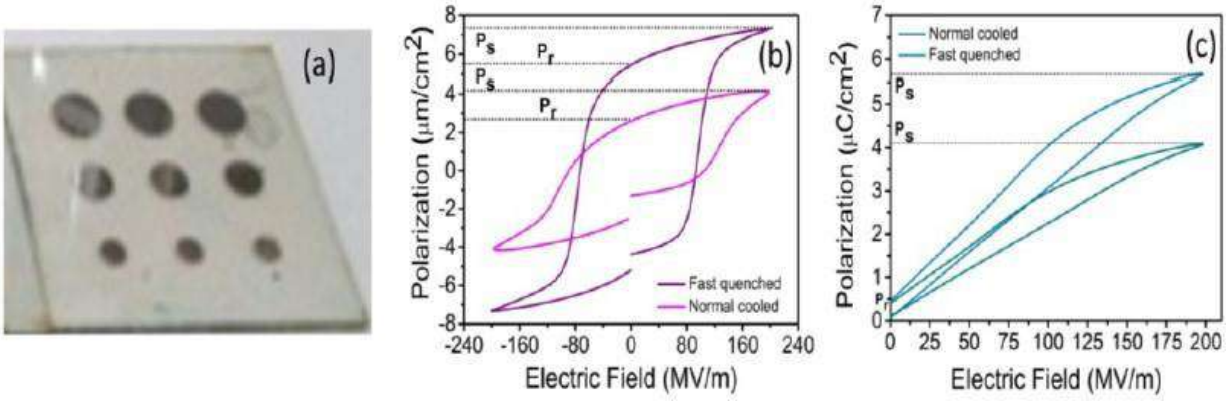

Figure 1: (a) Shows the image of fabricated ferroelectric polymer based MIM capacitor, (b) Polarization Vs Electric Field (*P-E*) hysteresis loop of fast-quenched and normally-cooled P(VDF-TrFE) thin film and (c) Polarization Vs Electric Field (*P-E*) hysteresis loop of fast-quenched and normally-cooled P(VDF-TrFE-CFE) thin film.

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Paper ID: N-110

Area: Semiconductor Nanostructure and Devices

Site-selective artificial nociceptor on Au-ion implanted TiO_x (x<2)-based memristor

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ABSTRACT

A nociceptor is the most important receptor in the sensory nervous system of human body that responds to damaging stimuli from external sources (like electrical, temperature, pressure, mechanical, etc.) by sending possible threat signals to the central nerves system. Now-a-days memristors as an artificial synapses as well as sensory neurons, draw a tremendous attention towards developing advanced information technology for neuromorphic computing applications. At present the understanding of nociceptive behaviour in a memristor has a lot of issues for researchers to design neuromorphic devices. In this work, we report nociceptor behaviour in a simple two-terminal Au ion-implanted TiOx/*p*++-Si memristor. The current-voltage characteristics of Pt/TiOx/*p*++-Si device characterized by conducting atomic force microscopy (cAFM) show a site-specific prominent and highly stable hysteresis loop, which is ascribed to the electric field-induced migration of oxygen vacancies in TiOx layers. Further, the electrical-stimuli-induced fundamental nociceptive phenomenon such as a ―threshold‖, ―relaxation‖, ―overlapping‖, ―allodynia‖, and ―hyperalgesia‖ are found in this TiOx device (at nanoscale) using cAFM technique for the first time to our knowledge. Hence, this present study imparts an important and unique platform to design highly stable and reproducible electronic artificial nociceptors for artificial intelligence systems like humanoid robots.

Keywords: *nociceptor, central nerve system, memristor, neuromorphic computing, humanoid robots, TiOx films, ion-implantation.*

Paper ID: N-111

Area: Semiconductor Nanostructure and Devices

Effect of Oxygen concentration in ZnO based transparent flexible memristor synapse

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ABSTRACT

In recent days the development of neuromorphic computing is very popular by mimicking the working principle of the human brain expected to overcome the bottlenecks of the present days von-Neumann computing system. Memristor which acts as an artificial synapse and is truly inspired by the biological neurons is very popular for neuromorphic computing. This device does emulate various synaptic behaviour as in the brain of a human. Oxide-based flexible and transparent memristor device has evolved as a special candidate that offers a great advantage in the area of neuromorphic computing. Among t he several oxides, zinc oxide-based devices are very popular for their versatile applications and easy fabrication process. Zinc oxide (ZnO) based transparent flexible memristor is fabricated on a commercial ITO coated flexible PEN substrate. The switching ZnO layers were deposited on it by using radio frequency (RF) magnetron sputtering at various Ar/O_2 gas ratios. Further, Aluminum doped Zinc Oxide films were sputtered on it. The composition and binding energy of the thin-film device is analyzed by using X-ray photoelectron spectroscopy (XPS). The XPS analysis indicates that the decrease in O_{II}/O_{total} ratio from the top to the bottom layer. UV-Vis spectroscopy confirms the high transparency of the device over 90%. Figure 1 represents the bipolar electrical current-voltage (IV) switching characteristics of the fabricated device maintaining the ratio of Ar/O_2: 30/00 SCCM. During I-V measurement, the ITO bottom electrode was grounded, and the voltage is applied at the top AZO electrode. The positive forming is essential for the device as shown in the figure. During forming the filament starts forming from the AZO/ZnO interface. Under the action of positive and negative voltage sweep, the current gradually increases and decreases, respectively. So, an anticlockwise hysteresis loop was found in the device. The device shows good endurance for more than 500 cycles and has a long retention time of upto 10^4 seconds. Synaptic behaviour, which is the basic requirement for neuronal applications, is represented by long-term potentiation (LTP) and long-term depression (LTD) (figure 2). The optimized device shows improved non-linearity during potentiation and depression. To study the conduction mechanism during LTP and LTD in the device, an oxygen vacancy is estimated using the XPS analysis. The O1s spectra are simulated to calculate the oxygen vacancy accumulation

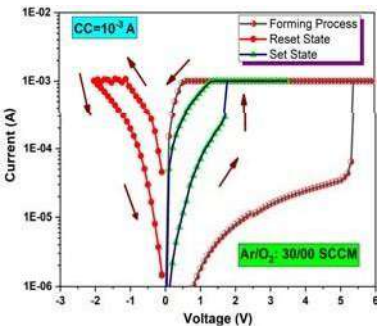

Figure 1: Electrical switching characteristicsof AZO/ZnO/ITO/PEN device deposited at Ar/O2:30/00 SCCM

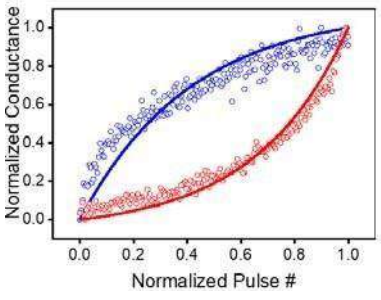

Figure 2: Synaptic property of the devicedeposited at Ar/O2:20/10 SCCM

Paper ID: N-112

Area: Semiconductor Nanostructure and Devices

CdTe quantum dots labelled lateral flow immunoassay tests for the luminescence-enhanced diagnosis and quantitative assessment of Malaria infection

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ABSTRACT

Lateral flow immunoassay (LFI) is a simple, low-cost and quick diagnostic tool to identify various diseases by detecting analytes such as antibodies, parasites, or other relevant biomarkers. However, most LFIs diagnose the infections only qualitatively. Also, the conventional LFIs, which rely on visual inspection of the test line suffer from the low-sensitivity in case of mild or early infections and might cause false-negative interpretations. Here, we report the application of Thioglycolic acid (TGA) capped CdTe quantum dots (QDs) as a label to enhance the luminescence and subsequently the detection sensitivity of the LFIs for diagnosis of Malaria. The chemical route synthesis of TGA capped CdTe QDs was optimized systematically by probing optical properties; such as UV-visible absorption and photoluminescence spectroscopies; of the QDs. These optimized QDs of TGA capped CdTe have been conjugated with the anti-malaria antibodies against HRP2 protein (P. falciparum) and were subsequently incorporated into the LFIs. The FTIR analysis confirmed covalent linkage between TGA capped CdTe QDs and the anti-Malaria antibodies against HRP2 protein. Further, an image processing code has been developed to carry out the quantification of malaria parasites in terms of the ratio on intensities of Control (C) and Test (T) lines on the LFIs. The results have been compared with the standard, colloidal gold based, LFIs. It has been demonstrated that the sensitivity of the detection of malaria infection under low parasite concentration improves significantly due to enhanced luminescence of C and T lines under UV illumination, owing to the TGA capped CdTe QDs. It has also been shown that the image processing based quantification of malaria infection can reduce the chances of false-negative results under low parasite concentration and help in carrying out early diagnosis of malaria.

Keywords: *CdTe, Quantum dots, Nanotechnology, Lateral flow Immunoassay, Malaria, Diagnostics*

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Paper ID: N-113

Area: Semiconductor Nanostructure and Devices

Influence of set compliance in TaOx memristor for synaptic learning

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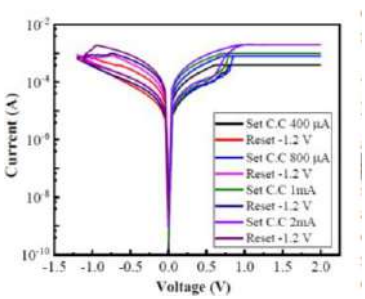
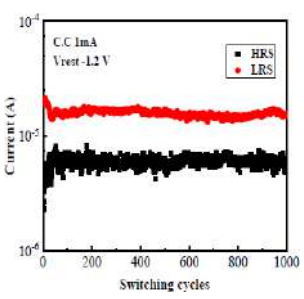
ABSTRACT

In the explosive growth of digital data in the era of the Internet of Things (IoT), highly scalable, low power consumption and high-density memory for data storage and data-driven computation are needed. Memristor is a potential candidate as a memory element in realizing the IoT system; due to its high speed/performance and ease of integration in the back end of line process. However, reliability issues including data lifetime and endurance are challenges hindering memristor technology from reaching market scale. All deposition was conducted employing a sputtering technique. A 200-nm TaN bottom electrode (BE) was deposited onto Ti/SiO_2 wafer at 180^{o}C with sputtering power, working pressure and Ar ambient flow of 300 W, 5 mTorr and 100 sccm, respectively. Hereafter, a 5-nm thick of TaOx and NiO was sputtered on it with the same power and working pressure with a 1:2 Ar and O_2 ratio. An 80 nm and 50 µm diameter Ni top electrodes (TE) were sputtered at room temperature using a metal shadow mask using the same condition of bottom electrode deposition. The switching characteristics of the devices were measured using an Agilent B1500 semiconductor parameter analyzer. The device shows bipolar switching with a positive set and reset. Before initiating the switching phenomenon, the forming is essential with a positive forming voltage of 3.2 V. To investigate the effect of set compliance on the switching performance we have measured the device at different set compliances varied from 400 µA to 2 mA, as shown in Fig. 2. A significant effect on the endurance is observed with the variation of set compliance current. 1 mA set compliance current gives better endurance with a stable low resistance state (LRS) and high resistance state (HRS) with more than 1000 cycles than the others. However, all the other devices are limited 100 cycles of endurance with very unstable LRS and HRS. This indicates that filament formation by oxygen ions is controlled by the compliance current attributed to the variation in endurance. Not only the endurance is affected by the compliance current, but the set voltage is also varying with the compliance current, supporting the influence of the compliance current on filament formation. To investigate the filament rupture effect, we measured the devices at different reset voltages. A lower reset voltage (-1.4 V) stables the low resistance state but the high resistance state controls at a higher reset voltage (-1.8 V). The thickness obtained from the cross-sectional TEM spectra corroborates the deposited thickness with smooth interfaces between the electrodes and oxide layers. The formation and rupture of the conducting ionic filaments are studied at different compliance currents with the help of XPS results and schematic diagrams. This study will be very useful to tune the device for synaptic applications.





Paper ID: N-114

Area: Semiconductor Nanostructure and Devices

Novel TiO_2-based memristors FET with programmable SET/RESET for neuromorphic computing

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ABSTRACT

Technology and consumers have demanded high package density and low-power devices. A memristor is a nonvolatile memory that can be realized using solid electrolytes, and metal-insulator-metal (MIM) with many different metal oxides. Many studies in the past were carried out to understand the underlying mechanisms of conduction and programming in memristors. For different applications of these devices, it's essential to control the conduction process. Memristor FET devices are fabricated by sputtering of 10nm Ti on 50nm/5nm Pt/Ti on oxidized p-Si that was patterned to form the 3µm wide source electrode. The top Ti layer was then oxidized at 500°C for 10 minutes in an oxygen ambient to form a 10-15nm TiOx switching layer. Subsequently, 5nm Ti followed by 50nm Pt was sputtered and patterned to form the drain electrode that was intentionally overlapped (ideally by 0.1µm) with the source. 100nm Pt has sputtered again and patterned to achieve a mechanically robust electrical connection. Finally, a 50nm thick HfO2 layer is deposited by ALD and patterned as the gate dielectric that was followed by 100nm Pt that formed the gate electrode. Source-drain electrodes are 3µm wide and 10µm long. The length of the active switching TiOx layer is about 15nm. Forming is essential for the devices before investigating the switching effect. There is an oxygen vacancy gradient that naturally occurs after titanium oxidation. The oxygen vacancies initially have lower densities near the top surface of the switching active layer under the gate oxide and below the overlapping drain electrode. However, oxygen vacancies have higher concentrations near the bottom interface over the titanium-rich source electrode. We anticipate that the gate field effect rearranges the oxygen vacancies in the channel between the drain and source and also can impede or enhance the conductive filament formation. A negative gate (Vg= -2V) reduced the SET voltage while a positive gate (Vg= 2V) increased it in our devices as shown in Figure 1. The change in the SET voltage seems to be due to the attraction of positively charged ions/vacancies to the surface of the channel at Vg<0 and their repulsion from the channel at Vg>0. Additionally, we note that once the conducting filament was formed, the gate voltage can rupture it reducing the RESET voltage (Figure 2) for Vg>0. But the gate field effect cannot –form‖ the conducting filament; it can only enhance its formation by attracting oxygen vacancies to the surface. A negative gate voltage increased the RESET voltage by attracting positive ions/vacancies to the channel surface where the filament is formed. By integrating the current curve, we estimated that ~5×10-10 coulomb positive ions/vacancies were attracted to the channel surface at Vg=-2V. In addition to enabling us to understand the conduction process in memristors, the gate field effect can be used to isolate the input/output circuits of these non-volatile memories. Or, we can use a global gate to RESET all the devices at once. Given that the sub-threshold slope of current in our devices was around 1 mV/decade, we can also use the three-terminal memristors as very low power switches with integrated memory

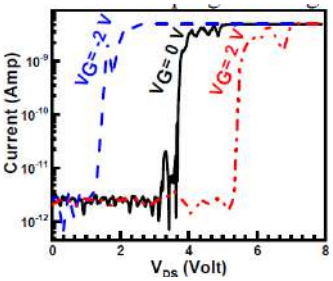

Fig. 1: Effect of gate voltage on the SET process of a typical gated memristor FET. I_S~pA; V_{SET}=3.6V (V_G=0V); V_{SET}=1.1V (V_G=-2V) V_{SET}=5.2V (V_G=+2V)

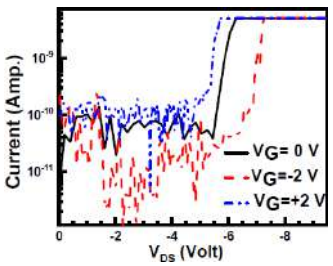

Fig. 2: Effect of gate voltage on the RESET process of a typical gated memristor FET. VRESET=-6.3V (VG=0V); VRESET=-7.2V (VG=-2V), VRESET=-5.8V, (V_G=+2V).

Paper ID: N-115

Area: Semiconductor Nanostructure and Devices

Halide Perovskites for Optoelectronic Application

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ABSTRACT

In recent decades, lead-based perovskites have emerged as strong candidates for widespread applications in the field of optoelectronics and solar cells. All inorganic metal halide perovskites have attracted significant attention of researchers owing to their intriguing optoelectronic features and thereby their usage perspective in photovoltaic applications, light-emitting diodes, and lasing devices. Here, we have adopted a simple, ambient-conditioned chemical synthesis approach to realize high-quality triple cation containing lead iodide perovskite nanorods. The crystallinity and morphological characterizations were performed by X-ray diffraction and field emission scanning electron microscope measurements, respectively, while the chemical composition was examined via energy-dispersive X-ray spectroscopic measurement. The synthesized nanorods have an average length of 2-3 □m and a diameter of 150-200 nm. These nanorods are much more stable than their respective single cation halide perovskite and thus offer a significant improvement in addressing the stability issue pertaining to the usage of perovskite materials as photovoltaic devices.

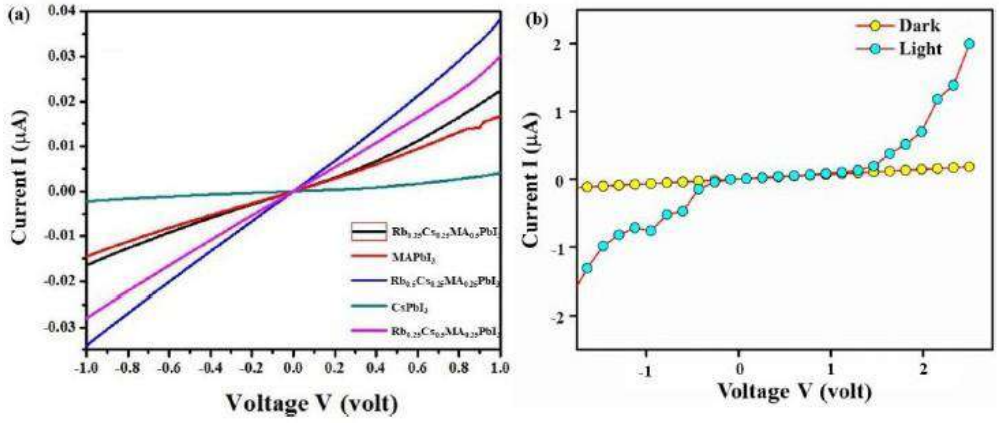

Figure 1: (a) Combined current-voltage (I-V) characteristic curves for halide perovskites

Paper ID: N-116

Area: Semiconductor Nanostructure and Devices

Controlling diffusion dynamics with electrode engineering for stable and reliable Resistive Switching in AlN/Ag-Based CBRAM.

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ABSTRACT

Due to high scalability, quick operating speed, wide dynamic on-off resistance range, and analog current switching, cation migration-based conductive bridge random access memory (CBRAM) has received much attention for a wide range of applications including data storage, logic gates, and neuromorphic circuits. The CBRAM device consists of a switching layer sandwiched between electrochemically active metal (Ag, Cu) top electrode and inert bottom electrode. As one of the promising wide bandgap dielectric materials, AlN has shown high thermal stability, good insulating characteristics, and compatibility with industrystandard nitride electrodes. Previously, AlN-based CBRAM devices have been reported for non-volatile storage and neuromorphic applications. However, Inadequate controllability of metal-ion injection and the creation of numerous filaments are the major issues for the switching stability. In this work, we investigated Ag/Ta/Ag stacked electrode structure to improve cycle-to-cycle and device-to-device switching uniformity by controlling the Ag-ion diffusion into the host material. We fabricated Ag/Ta/Ag/AlN/Pt memristor by depositing 10 nm thick AlN switching layer on Si/SiO2/Pt bottom electrode via dc magnetron spurting, top stacked Ag/Ta/Ag electrode deposited and patterned through e-beam evaporator and shadow mask. The I-V characteristics measured for CBRAM with Ag/Ta/Ag electrode demonstrate improved switching stability compared to the device with only Ag electrode as shown in Figure 1 (b)-(c). The insertion of the Ta layer controls the cation supply as well as diffusion rate which leads to gradual and uniform switching. The reduced cycle-to-cycle variation in the high resistance state (HRS) and low resistance state (LRS) shown in figure 1 (d) confirms the Ag/Ta/Ag stacked electrode structure is effective for improving the performance of CBRAM.

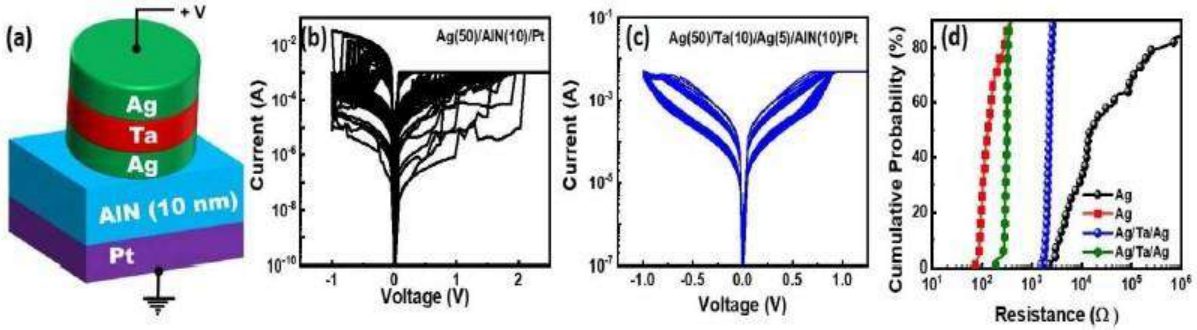

Figure 1 (a) Schematic structure of the stacked electrode CBRAM device. I-V characteristics of device with (a) Ag
(b) Ag/Ta/Ag electrode. (c) cumulative distribution of resistance for 50 dc cycles

Paper ID: N-117

Area: Semiconductor Nanostructure and Devices

Tin doped ZnFe2O4 thin film based ethanol sensor

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ABSTRACT

In this work, tin doped $ZnFe_2O_4$ film was deposited onto microscope glass substrates by spray pyrolysis process followed by subsequent calcinations. The morphology and structure of the as-prepared thin films have been characterized by X-ray diffraction (XRD) and scanning electron microscopy (SEM). Temperature dependent current measurements were performed by two-probe method to analyze electrical properties, and electrical conductivity at room temperature. The effect of the tin component in $ZnFe_2O_4$ thin films on the gas sensing properties has been evaluated by the responses to ethanol vapor. The results have showed that the $ZnFe_2O_4$ thin films containing 2.5 wt% tin exhibit the best sensing properties to ethanol vapor. The response and recovery time are about 10 and 24 s, respectively. In addition, the as-prepared sensors exhibit excellent selectivity and stability. These results indicate that tin doped $ZnFe_2O_4$ thin films can be used in fabricating high performance gas sensors.

Keywords: *spinel tin doped ZnFe2O4 thin films, ethanol sensor, spray pyrolysis, fast response and recovery, selectivity and stability.*

Paper ID: N-118

Area: Semiconductor Nanostructure and Devices

Impact of Metal Doping in Photo-detection with MAPbBr3 NCs Based Schottky Devices: An Inquest

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ABSTRACT

The paper presents a case of Schottky junction photodiode, fabricated by pure and metal doped MAPbBr3 nanocrystals (NCs); where, the metal doped (FTO/Perovskite NCs/Al) Schottky junction diode produced a better rectification behavior with low reverse saturation current for detecting light. The nanocrystals were synthesized following ligand assisted re-precipitation method (LARP). The structural and optoelectronic properties of the devices were investigated systematically. Optical and structural analysis of the nanocrystals were carried out by UV-vis absorbance spectroscopy, photoluminescence spectroscopy and x-ray diffraction method. All of the devices were also characterized by current-voltage (*I-V*) characteristics and electrochemical impedance spectroscopy (*EIS*) under both dark and illumination conditions. Enhancement of the device current under illumination specifies generation of photocurrent in the device. Impedance spectra of all devices have been recorded in the wide range of frequency from 100 kHz to 2 MHz at 500mV biasing. From *I-V* characteristics, important parameters like ideality factor (η), saturation current ($I0$), barrier height (φB), rectification ratio (*RR*) were obtained under dark and photo condition. Besides , it was evinced thereupon, that the device with metal doped sample had good stability after storage for six months at ambient conditions.

Keywords: *Perovskite, Metal Doping, Photocurrent, Schottky Diode, Photo-detection, Charge trap*

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Paper ID: N-119

Area: Semiconductor Nanostructure and Devices

Can oxygen vacancies enhance the electrochemical performance of tungsten nano structures in symmetric supercapacitors

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ABSTRACT

Herein, we report the synthesis of tungsten based nanostructures such as WO_3, WO_{3-X} ($W0_{2.72}$:WS_2), and WS_2 through a facile single step hydrothermal technique. The optical, structural, and morphological studies are conducted, and the electrochemical performance of each electrode materials are evaluated in symmetric two electrode configurations. An enhancement in the electrochemical energy storage performance has been observed while changing the phase from WO_3 to WS_2, which can be due to the accompanying changes in morphology and surface area. At 1 A g^{-1}, the symmetric supercapacitors with WO_3, WO_{3-X}, and WS_2 electrodes exhibit specific capacitance values of 62, 86, and 215 F g^{-1}, respectively. At a power density of 0.76 kW kg^{-1}, the WO_3, WO_{3-X} and WS_2 based devices offer energy density values of 5.5, 7.6, and 19.1 Wh kg^{-1}, respectively. WS_2 electrode based supercapacitor retains an excellent cyclic stability rate of 97% over 10,000 continuous charge discharge cycles.

Keywords: *Tungsten nanostructures; WS_2; Symmetric supercarpacitor; Specific Capacitance; Oxygen vacancy*

Paper ID: N-4052

Area: Semiconductor Nanostructure and Devices

Annealing Effect on the Structural, Morphological,Mechanical,and Electrical Properties of Magnetron Sputtered Cu_2Se Thin Films for thermoelectric application

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ABSTRACT

As an emerging semiconductor, environmentally friendly thermoelectric material, Cu_2Se has drawn great attention due to its outstanding thermoelectric performance. In this study, the effect of annealing temperature on the structural, morphological, mechanical and electrical properties of Cu_2Se thin films has been observed. Thin films of Cu_2Se are deposited on glass substrate by magnetron sputtering method using RF source at 70W and 150 ℃ substrate temperature fixed. After deposition, these films are air annealed at 200 ℃, 250 ℃, 300 ℃, 350 ℃ and 400 ℃ respectively. Different characterization techniques like X-Ray Diffraction (XRD), Field Emission Scanning Electron Microscopy (FESEM), Energy Dispersive X-Ray Spectroscopy (EDS), Nanoindentation, Seebeck measurement etc were carried out for the analysis of the properties. XRD studies reveal that with annealing, impure phases are formed due to the formation of oxides which can be confirmed by the presence of oxygen apart from copper and selenium in the films through EDAX. FESEM micrographs also shows the morphological changes in the deposited films with increase in annealing temperature showing structural stability till 250 ℃ annealing and after that the films start dissociating at 300 ℃ annealing. The hardness and elastic modulus measurements carried out showed improvement in mechanical properties till 250 ℃ annealed sample and these values decreased from 300 ℃ annealing. The electrical conductivity of the Cu_2Se films in the entire temperature range shows enhancement till250 ℃ annealed sample and starts decreasing after 300 ℃ annealing. The highest power factor of 1.8m W/mK^2 is achieved for 250 ℃ annealed sample measured at temperature of 450 ℃ which is higher than that of Cu_2Se thin film deposited at 70W 150 ℃ substrate temperature.

Keywords: *Power factor, Nanoindentation, Hardness, Dissociation*

Paper ID: N-4053

Growth of Good Optical Quality Zinc Oxide Films by Controlling The Aging Time with Less Number of Dips by Non-Conventional Sol-Gel Method

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Abstract

This work shows the effect of gel aging time on morphological, structural and optical properties of Zinc oxide (ZnO) thin films grown using ZnO powder as a precursor. X-ray diffraction and Emission Scanning Electron Microscopy were used to study the crystallinity and morphology structure respectively. It was found that increase of aging time from 1 day to 13 days have led to increase of film thickness linearly by 337% which lead to improvement of the crystallinity and optical properties. Due to this, despite thickness increasing by 337% the transmittance reduced only by 6%. Also because this, the absorption coefficient has been reduced up to 43%. Due to this, ZnO films prepared under aging conditions can found to be very useful for different applications like Second Harmonic Generation, Dye sensitized solar cells, resistance-based gas sensors, Varistors, Field Effect Transistor, etc.

Paper ID: N-4054

Annealing Atmosphere Variation and its Effect on CZTSe Film

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Abstract

The CZTSe is a very sensitivity absorber for the annealing parameter. Variation in annealing parameter affects the properties of the CZTSe. The annealing environment is one of the critical aspects of all the annealing parameters. The variation in annealing environment affects the properties of the film. To study the effect of annealing atmosphere, each elements were deposited in the form of CuSn/Zn/Se by thermal evaporation technique. To form the CZTSe compound, films were annealed in Se and Se+N2 atmosphere at same temperature in two step process for 230°C for 10 min and 450°C for 10 min and fabricated two different film. The impact of Se and Se+N2 atmosphere on the properties of CZTSe absorber material is discussed.

Keywords: CZTSe; Thermal evaporation; Annealing Atmosphere, AFM

Paper ID: O-8002
Area: *Others*

Partial Shading Performance Analysis of Alternative Triple Cross Tied (ATCT) PV Array Configuration for Enhancement of Global Peak

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ABSTRACT

Photovoltaic arrays (PV) are widely used as renewable energy sources for standalone applications and grid connected PV system. But due to Partial Shading Conditions (PSCs) these PV systems face major reduction in output power and efficiency. This research paper focuses on the choice of optimum PV configuration under a different shading pattern to extract maximum power from the PV arrays.In this paper various PV configurations such Series Parallel (SP), Bridge Linked (BL), Honey Comb (HC) and Total Cross Tied (TCT) are modelled and analysed under various PSCs such as centre, diagonal, corner, and L shaped of 6x6 array form of PV Configuration. The performance of these configurations are compared based on the global maximum power point (GMPT) and maximum voltage (Vmax). And also in this paper a novel hybrid configuration called Alternate Triple Cross Tied (ATCT) PV configuration is proposed to generate maximum power under PSCs and the simulation results prove the capability of this proposed ATCT PV configuration to generate maximum power, compared to S, SP, BL, HC and TCT PV configuration under most of the PSCs investigated. User defined PV module is considered for simulation of the PV configurations in Matlab /Simulink software.

Paper ID: O-8003
Area: ***Others***

Design considerations of Piezoresistive Sensor for Tactile SensingApplications

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ABSTRACT

Piezoresistive sensors has wide variety of applications in the biomedical field due to its features like simple fabrication methods, high sensitivity and low cost. In this paper, piezoresistive biosensor developed for tactile sensing applications. A square diaphragm is developed on the handle layer and piezoresistive elements placed on device layer at the edge centre of the diaphragm where maximum stress is induced. N-type and P- type silicon material is taken as piezoresistive materials and it is analysed in Comsol Multiphysics version
5.5. For the analysis, force varied from 1N to 10N and from the results it has been found that p-type silicon piezoresistive material is obtained as the better choice fortactile sensing applications.

Keywords: Piezoresistive sensor,diaphragm, tactile sensing

Paper ID: O-8004
Area: *Others*

Theoretical and Experimental Investigation of Cobalt Diselenide

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ABSTRACT

Two-dimensional transition metal dichalcogenides (2D TMDCs) materials are the impactful candidates in nanotechnology for diverse applications. In the present study, electronic properties such as band structure and density of states of the compound cobalt diselenide ($CoSe_2$) were investigated using the first principle density functional theory (DFT). A Linear combination of atomic orbitals (LCAO) calculator is used which is implemented in the software package –QuantumATK‖ (Atomistic Tool Kit). The simulations of orthorhombic cobalt diselenide were carried out using the hybrid density functional (HSE06) wherein the band structure gave the bandgap of 0 eV showcasing the metallic behavior of the material which was also proved by the density of states. Moreover experimentally, the $CoSe_2$ was synthesized by the hydrothermal technique. Hydrothermally grown $CoSe_2$ is further analyzed by XRD, SEM, and TEM. A state-of-the-art preparation of large area electrodes was investigated for supercapacitor applications.

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Paper ID: O-8005
Area: ***Others***

Spectroscopic Investigation of Er^{3+} doped $BaGd_2O_4$ Phosphors for Solid State Lighting Applications

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ABSTRACT

Er^{3+} doped $BaGd_2O_4$ phosphors have been synthesized by high-temperature solid- state reaction technique. The structural characterizations of the samples have been done using X-ray diffraction (XRD) and Field Emission Scanning Electron Microscopy (FESEM) techniques. X-ray diffractograms revealed that the samples have been crystallized in the orthorhombic phase with space group Pnma. FESEM images show that the samples have been formed with spherical morphology. The UV-Visible reflectance spectra revealed that the optical band gap of the synthesized samples is around 5 eV. The photoluminescence properties of the synthesized phosphors have been studied by recording their fluorescence spectra at an excitation wavelength of 377 nm using a Xenon source. The PL spectra shows the presence of green emission from the phosphors, with prominent peaks centred at ≈ 545 nm and ascribed to the $(^4S_{3/2} - {}^4I_{15/2})$ transition of Er^{3+} ions. The photometric properties reveal that the synthesized $BaGd_2O_4:Er^{3+}$ phosphors exhibit green emission and hence carry potential for applications in field emission display (FED) and light emitting diodes (LEDs).

Paper ID: O-128
Area: ***Others***

Physical properties of thermal annealing induced In_2O_3 thin films for sensingapplications

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ABSTRACT

Detection and monitoring of flammable, toxic and explosive gases are crucial, where active research on nanostructured metal oxide materials and thin films is enthusiastically performed to explore new paths for improving the characteristic parameters of sensors. The higher stability and conductivity along with wide band gap of In_2O_3 material make it suitable for active layer of gas sensors where properties of In_2O_3 films could be engineered by post treatments. The present work demonstrates an influence of thermal annealing on structural, optical, and electrical properties of In_2O_3 films for gas sensor applications. The In_2O_3 films of thickness 500 nm are grown onto soda lime glass and conducting ITO substrates employing physical vapor deposition based thermal evaporation technique followed by thermal annealing at 200°C, 300°C and 400°C for one hour in air environment. The XRD analysis indicated phase transformation from metastable rhombohedral to stable cubic phase with annealing where crystallite size is tuned in range of 32-51 nm with annealing. Optical analysis unveiled higher transmittance in ultraviolet and visible regions whereas absorbance of films is fluctuated with thermal annealing. All the In_2O_3 films indicated the Ohmic nature where the resistivity is detected to be enhanced with annealing. Hence structural, optical and electrical properties of gas sensitive In_2O_3 layers are greatly stimulated by thermal annealing.

Keywords: Thin films, Thermal evaporation, Annealing, Physical properties, Gas sensor.

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Paper ID: O-8008
Area: *Others*

Influence of asymmetric contact Area of Ag/SnSe Schottky Diode on their characteristics

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ABSTRACT

Influence of contact shape and area of Ag/SnSe Schottky diode on the current-Voltage (I-V) and capacitance-Voltage (C-V) characteristics have been investigated. Prior to their diode formation, the optimization of the substrate temperature as well as thickness of SnSe thin films has been done. We have tried to determine some intrinsic and contact properties, such as barrier heights and ideality factor. The change in various parameters of the Diode like Schottky barrier height(SBH), ideality factor and reverse breakdown voltage as a apparent function of shape and area. The variation of Schottky barrier height and ideality factor with area has been explained and considering the defect in the larger area. The acceptor concentration N_A and zero bias barrier height Φ_{b0} for the Ag/SnSe Schottky diode have been calculated from the experimental C^2-V Characteristics.

Paper ID: O-8009

Area: ***Others***

Frequency dependent study of electrical impedance, modulus and scaling behaviour of $CaCu_3Ti_4O_{12}$ ceramic

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ABSTRACT

For the preparation of calcium copper titanate (CaCu3Ti4O12: CCTO) ceramic, solid-state reaction technique is adopted and sintering of sample is completed at 1050 °C for 4 h. Detailed investigations of crystal structure is performed by X-ray diffraction with cubic phase and space group *Im3*. Fathomless examination of microstructre of CCTO is accomplished by Field emission scanning electron microscopy with observation of densed grain, distingushiable grain boundaries and less foraminous. The average grain size in the system of CCTO ceramics is 7.05 μm. XPS analysis confirms the oxidation state of elements, present in the ceramic. Complex impedance spectroscopy has given better understanding of electrical and dielectric measurement along with relaxation behaviour of the material in the temperature and frequency range from (230-330 °C) and (150 Hz-1 MHz). At 300 °C and 112 Hz the dielectric constant is 1924. The activation energy estimated by linear fitting of dc-conductivity is 0.71 eV, which confirms that conduction in material is due to hopping of electrons. Impedance study confirms the presence of negative temperature coefficient resistance (NTCR) behaviour in CCCTO ceramic. Electric modulus study certifies that, non- Debye type behaviour is present in the synthesized material. This confirmation is also done by combined plot between Z''/Z''_{max} Vs frequency and M''/M''_{max} Vs frequency curves. Scaling behaviour of material indicates the temperature dependent relaxation which confirms the Maxwell-Wagner (M-W) type relaxationin the CCTO material.

Keywords: *Microstructure, spectroscopy, conductivity, coefficient.*

Paper ID: O-8010

Investigation on Hybrid Solar and RF energy harvesting system for low power Internet of Thing(IoT) devices.

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Abstract:

Recently, energy harvesting system have been widely adopted for potential solutions to powering the sensor based electronic devices. Among various energy sources, electromagnetic energy source like radio frequency (RF) is the most suitable method used as energy harvesters. RF energy waveform is of two types: radiative energy and non-radiative energy. In this investigation, it uses radiative or far field energy transfer system. The availability of radiative RF energy is high because of various cellular communications bands, TV signals and radiation from base station antenna. Because of air loss and the energy transfer loss, impedance matching network has been designed for its solution for stable input of the RF-DC rectifier circuit. RF energy harvester system Architecture will be presented in the posture or presentation , where RF energy is received by the receiving antenna from the nearest base station antenna. The matched RF ac signals with adequate voltage from the matching network , then convert into a dc signal through the rectifier, then goes to the super capacitor or DC-DC boost converter to act as as energy storage device. Because of the conductor loss and internal loss of antenna, a matching network is placed between the receiving antenna and rectifier. This investigation reveals a low-cost energy harvesting device with a rectenna to minimize the issue in the sector where battery power usage constraint is a major factor. The fabricated prototypes consist of antennas, rectifiers, filters and other components are integrated into the proposed system. A DGS based microstrip patch antenna at 900MHz to 3GHz is designed using commercially available Ansys HFSS Software. Schottky diodes (HSMS-2820) are used to design voltage doubler circuit for RF to dc conversion.Power levels measured in CDMA, GSM900, GSM1800 bands are: -60.2 dBm at 883.2 MHz, -59.49 dBm at 951.46 MHz and -55.75dBm at 1.82 GHz respectively.For first 10 seconds, recorded voltage across Arduino dc output voltage is 1.4 volt for a single stage schottky diode based voltage doubler rectifier circuit.The RF Bnergy harvesting system was tested from a nearby cell tower site with the spectrum of various bands received.The RF power received at the output port of the rectenna circuit is -64.4 dBm. Hence, this design provides an extensive deployment of self-operable next-generation IoT implemented devices.

Keywords: Multiband band antenna, Solar cell, RF energy, Schottky diode, impedance matching network.

Paper ID: P-132

Area: Photovoltaic Devices

Investigation of photovoltaic response in brownmillerite multiferroic KBiFe2O5 thin film

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Brownmillerite structured Multiferroic $KBiFe_2O_5$ (KBFO) is a promising photoactive material for subsequent optoelectronic applications due to its smaller bandgap and intrinsic polarization. Herein, we reported the preparation, optical and electrical properties of the KBFO thin film. The phase confirmation of KBFO thin film prepared by a simple spin coating technique was characterized by X-ray diffraction (XRD) pattern. The surface morphology as well as thickness of the KBFO thin film deposited on FTO coated glass was identified by scanning electron microscopy (SEM). The bandgap of KBFO film was investigated by UV-Vis spectroscopy which extends visible to the infrared region compared to conventional perovskitestructured multiferroic. The evidence of photovoltaic responses in KBFO device was explained based on Current-Voltage characteristics under dark as well as visible light illumination. In summary, the intrinsic polarization and photo absorption properties in KBFO could be regarded the material as a suitable candidate for ferroelectric photovoltaic applications.

Paper ID: P-133

Area: Photovoltaic Devices

Indium doped SnS/Si heterostructure based Photodetector for detection of visible light

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Since few years, two dimensional transition metal chalcogenides have shown tremendous attention owing to unique electronic properties and tunable energy band gap. In present research, we demonstrate the facile and high-yield hydrothermal synthesis of pristine SnS and Indium-doped SnS nanoflakes for fabrication of large area photodetectors. Powder XRD patterns of as-grown Indium-doped SnS nanoflakes show the high crystallinity with orthorhombic crystal structure. The energy band gap of pristine and Indium doped SnS was studied using UV-Vis Spectroscopy. Encouragingly, the substitution of In in SnS crystal structure successfully tunes the energy band gap. Also, the photodetection properties of pristine SnS and Indium-doped SnS were studied by fabricating on indium doped p-SnS/n-Si heterostructures. In the visible light region, pristine SnS and Indium-doped SnS photodetectors display optimal results. Pristine SnS and Indium-doped SnS photodetector show the optimized results in the visible light region. The photodetector shows excellent photoresponsivity and specific-detectivity with fast switching photoresponse. Overall, these results demonstrate that Indium-doped SnS has a huge impact on the field of optoelectronics and light sensing.

Keywords: *Indium-doped SnS nanoflakes, p-SnS/n-Si heterostructures, Photodetector*

Paper ID: P-134

Area: Photovoltaic Devices

Synthesis and characterization of $NaYF_4:Pr^{3+}@NaYF_4:Eu^{3+}$ core@shell nanoparticles as downconversion material for enhancing the performance of organic solar cell

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Organic solar cells (OSCs) in photovoltaic technology have recently come out as flexible, solution processable, cost effective, and improved performance device as compared to already existing inorganic photovoltaic technologies. OSCs have received tremendous attention of the scientific community and businesses since its projected to be a cost-effective and sustainable source of energy and in the last halfdecade, its PCE performance crossed the barrier of 18%. Lanthanide complexes have a broad ultraviolet absorption range and can convert absorbed ultraviolet light to visible light, allowing organic solar cells (OSCs) to take use of ultraviolet light for increased photocurrent and efficiency. In this work, a transparent luminescent down-conversion material (DCM) of $NaYF_4:Pr^{3+}@NaYF_4:Eu^{3+}$ core@shell nanoparticles has been used for improving the light utilization efficiency of OSCs. The core@shell nanoparticles were prepared via a chemical sol-gel process through a two-step procedure that includes the synthesis of core in the first-step followed by the synthesis of shell in the second-step. The ultraviolet absorption of the DCM based on $NaYF_4:Pr^{3+}@NaYF_4:Eu^{3+}$ core@shell nanoparticles is wide, and the current findings show that dopants Pr^{3+} and Eu^{3+} based transparent luminescent layer coated over the backside of the OSCs may increase photovoltaic performance. The spectral response range of OSC was effectively expanded to the ultraviolet range using down conversion technology, resulting in a photocurrent gain for active OSCs. The OSC coated with DCM of $NaYF_4:Pr^{3+}@NaYF_4:Eu^{3+}$ core@shell nanoparticles in solvent 2-Methoxyethanol with a concentration of 5 mg/ml reaches a PCE of 9.6%, which is approximately 7 % higher than that of OSC without DCM layer. Because of the efficient use of ultraviolet light, the J_{SC} of OSC has increased dramatically from 18.73 to 19.41 mA cm^{-2} . Additionally, the VOC is also increased slightly from 0.80 V to 0.82 V. As a result, a down-conversion material exhibiting an ideal absorption band which absorbs accessible short-wavelength ultraviolet radiation in 300 nm to380 nm range and consequently emits visible radiation with a spectral response which is well-matched to the OSC might be a potential alternative to boost the photoelectric performance of OSCs. Our findings might open up new opportunities for improving OSC performance by synthesizing $NaYF_4:Pr^{3+}@NaYF_4:Eu^{3+}$ core@shell nanoparticles through a chemical sol-gel approach which is time-saving as well as facile.

Paper ID: P-135

Area: Photovoltaic Devices

Antisolvent assisted low toxic bismuth-based halide perovskite thin film for photocatalytic application

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For light-driven multifunctional applications, the hybrid organic-inorganic halide perovskite (HOIP) semiconductors based on lead (Pb^{2+}) have demonstrated exceptional optoelectronic characteristics. However, a significant problem with Pb^{2+} is its toxicity. Bi-based halide perovskite can be a potential substitute because of its ambient stability and low toxicity. Here, we report antisolvent assisted pin-hole-free dark-reddish $RBiI_4$ (R=organic amine) film via one-step spin coating method. A band gap of 2.18 eV was calculated using a Tauc plot from the UV-Vis transmittance spectrum of the Bi-HOIP thin film. PL, TGA, XRD, and SEM were also performed to examine optical, thermal, structural, and morphological features of the thin film respectively. To comprehend the photocatalytic activity of Bi-based film under visible light illumination, MBT (a hazardous dye used in rubber technology, λmax = 325 nm) was used.

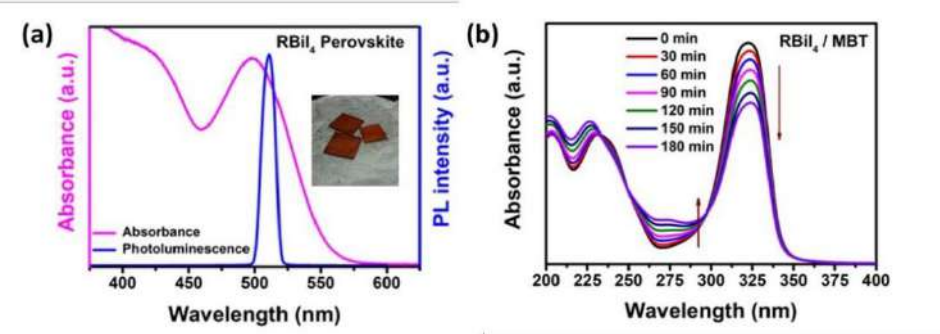

Figure 1: (a) UV- Visible absorbance and Photoluminescence spectra of $RBiI_4$ Perovskite thin film. (b) UV- Vis Photocatalytic absorbance curve of MBT dye degradation.

Paper ID: P-136

Area: Photovoltaic Devices

Investigation on the structural and optical properties of $MAPbI_3.H_2O$ and $MAPbI_3$ perovskite materials for efficient photovoltaic cells

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Inorganic-Organic Perovskite solar cells have reached efficiency near to c-Si cells, however, they suffer from electronic degradation due to various environments. Our study is an attempt to address this issue by using 2D crystalline I-O Perovskite absorber layers in solar cells. Methyl ammonium lead iodide ($MAPbI_3$) crystalline Perovskite materials were prepared by conventional solution synthesis process using hydrated and non hydrated solvents. Photograph of as grown single crystal of $MAPbI_3$ is shown in Figure 1. Synthesized Perovskite materials were subjected to single crystal X-ray diffraction and powder X-ray diffraction studies to understand the crystal system and molecular arrangements. The structures of $MAPbI_3.H_2O$ and $MAPbI_3$ confirmed the tetragonal and monoclinic crystal system respectively. The molecular ORTEP diagram of $MAPbI_3.H_2O$ is presented in Figure 2. The interactions of Pb-I, C-H and C-N in $MAPbI_3.H_2O$ crystal were studied through their bond length and bond angles and the results were compared with the $MAPbI_3$ crystal structure. The unit cell parameters of $MAPbI_3.H_2O$ single crystal were found to be a = 10.5660 Å, b = 4.6831 Å, c = 11.2070 Å, α =γ= 90°, β = 101.171° and V = 544.03 Å3 and for the MAPbI3 crystal a = 8.9300 Å, b = 8.9300 Å, c = 12.5641 Å, α=β=γ= 90° and V = 1000 Å3. Optical band gaps (from Tauc plot) of these two Perovskites were found to be 1.486 eV and 1.518 eV respectively. The conductivity studies were performed on the as-grown Perovskite single crystals using solar simulator experimental setup and the photographs of the testing samples are given in Figure 3. Initial dark and AM 1.5 light I-V test on these samples showed that only non-hydrated $MAPbI_3$ Perovskites have two orders of photo-response. Based on the I-V results of $MAPbI_3$ Perovskite, suitable solar cell architecture was designed using appropriate electron transport and hole transport layers (ETL/HTL) and electrode contacts. The solar cell analysis is in progress.

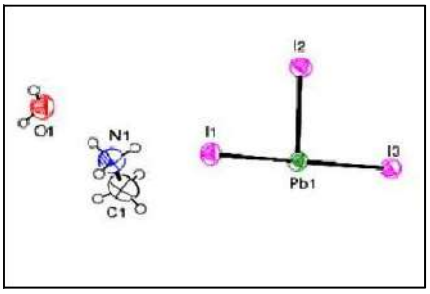

Figure 1: As-grown single crystal of $MAPbI_3$, Figure 2: ORTEP diagram of $MAPbI_3.H_2O$, Figure 3: Samples for I-V measurement

Paper ID: P-5006

Area: Photovoltaic Devices

Interfacial passivation by mono-ethanolamine in planar perovskite solar cell

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AZO is a potential replacement for the conventionally used TiO_2 as an electron transport layer (ETL) in low-temperature solution processes in hybrid perovskite solar cells (PvSCs). However, the defects and energy-band mismatch at the ETL/perovskite interface accelerate the interfacial carrier's recombination, leading to a decrease in the fill factor (FF), and current density (J_{SC}). To address this issue, a thin interfacial modification layer of monoethanolamine (MEA) not only reduces the energy barrier between AZO, and perovskite for accelerating the charge transfer but also passivates the uncoordinated Pb2+ defects on the perovskite interface. Due to the synergistic effect of charge extraction promotion, and trap density passivation, the champion PvSCs exhibit a higher value of PCE of 8.25 % with a current density (J_{SC}) of 22.59 mA/cm^2 , and FF of 46.55% compared to the PvSCs without MEA passivation (PCE=6.62%, J_{SC}=20.01mA/cm^2 , FF=44.07%), and the device maintains 70% of its topmost PCE after 720h under ambient atmosphere. This interface engineering based on MEA provides a feasible and novel strategy to fabricate the PvSCs with improved efficiency, and stability of planar PvSCs.

Keywords: Interfacial modification, monoethanolamine (MEA), AZO-ETL, planar perovskite solar cell.

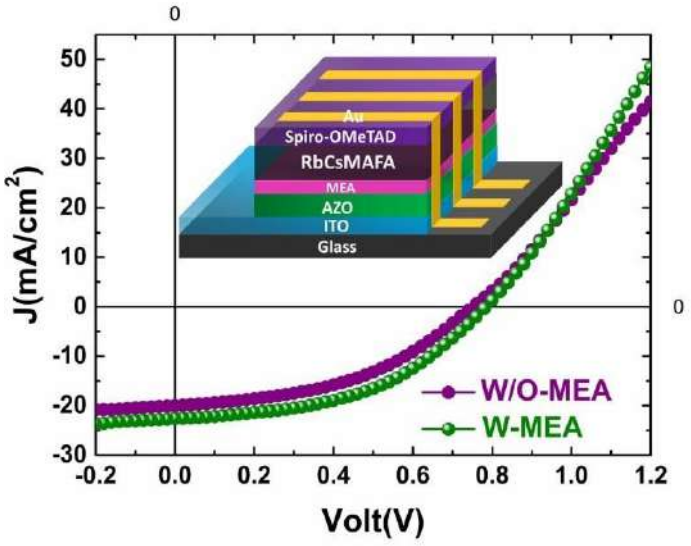

Figure1: Light-illuminated J-V curve of the PvSCs

Paper ID: P-5007

Area: Photovoltaic Devices

Design and Modeling of planar 2D nanostructured intermediate reflector layer for Light Management in tandem solar cell

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The crystalline silicon (c-Si) solar cells, currently occupy 85% of the world PV market is reaching to saturation in efficiency near to theoretical upper limit, called Shockley–Queisser limit (SQ limit) of 29.1% (Eg = 1.1 eV). A 3rd generation high efficiency tandem solar cell, made by stacking two cell in series e.g. a c-Si heterojunction cell (SHJ) as the bottom cell and a high bandgap polycrystalline (i.e., Perovskite or CIGS or Si QD) cell as top cell, has the potential to surpass this efficiency limit. However, the polycrystalline top cell demands a planar surface to grow defect free, instead of textured Si surface, used in conventional high efficiency c-Si solar cells. This results in a current loss in the tandem solar cell. To overcome the losses due to a planar bottom cell, a light management study has been done in the tandem solar cell. Here, our design includes a planar 2D nanostructured layer similar to 2D grating, incorporate Topologically Flat but optically rough (TFOR) surface, called a TFOR layer, and a DBR (distributed Bragg reflector) in the intermediate region (between top and bottom cell) of the tandem solar cell for light management, also called an intermediate reflector layer (IRL). The IRL layer has to be designed in such a way that it reflects the visible light from 300-650 nm to the top cell and transmit light from 650-1100 nm to bottom cell, in addition to scattering of light to increase path lengths.

In this work, we report on the optical simulation using Finite-Difference Time-Domain (FDTD) method to optimize the IRL layers. The silicon and transparent conducting oxide (TCO) materials have been used in TFOR in a chess-like design, and in DBR, to provide high refractive index contrast. Further, the optical simulations have also been performed on Perovskite (300nm)/Silicon (60µm) tandem cell, with and without an IRL layer. The absorptance and photocurrent measurements have been done for both top (Perovskite) cell and bottom (c- Si) cell. An increase in photocurrent is found in the top cell with the IRL layer, and a current-matched condition is achieved with a current value of 16.1 mA/cm^2 (top cell) and 15.985 mA/cm^2 (bottom cell) in the tandem cell.

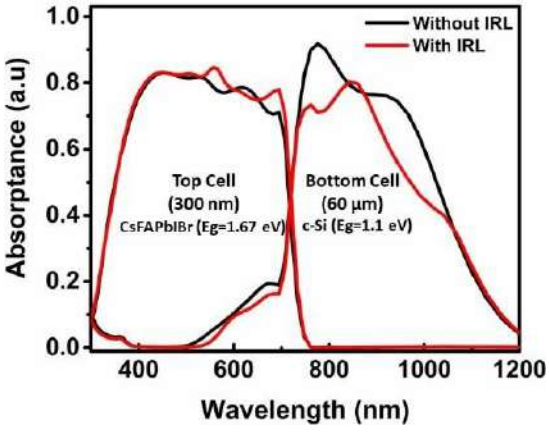

Figure 1. Shows the absorption spectrum in top and bottom cell of Perovskite/Silicon tandem solar cell.

Paper ID: P-5008

Area: Photovoltaic Devices

SnS quantum dot hybrid solar cells on TiO_2 nanorods

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Tin monosulfide (SnS), is emerging as a potential candidate for use as absorber material in the development of solution-processable solar cells at a lower cost. The Successive Ionic Layer Adsorption and Reaction (SILAR) method is utilized in the fabrication of SnS quantum dots for use in Quantum dots hybrid solar cells with a structure; Glass/FTO/TiO_2 nanorod/SnS Quantum Dot/P3HT/PEDOT: PSS/Ag structure. Titanium dioxide (TiO_2) nanorods are utilized for light trapping and electron transport , are produced on FTO-coated glass using a hydrothermal process. It is characterized by XRD and SEM to be crystalline TiO_2 nanorod with 500 ± 100 nm in diameter and a length of 8.5 ± 0.5 micrometers with a crystallite size of 42nm. SnS quantum dots are synthesized on the nanorod's surface, and the SnS layer is optimized through various SILAR cycles of deposition. To make the solar cell, a series of layers are deposited on top of SnS quantum dots (i.e., P3HT [poly (3-hexylthiophene)] layer (by spin coating), PEDOT: PSS layer (by spin coating), and metal contact (silver layer by thermal evaporation)). Furthermore, P3HT is used as a hole transport layer, and PEDOT: PSS is used as a buffer layer, which facilitates the passage of holes from P3HT to Ag. The current-voltage test (I-V test), scanning electron microscopy (SEM), EDX, and ultraviolet- visible (UV-Vis) spectroscopy is employed to characterize the SnS QDSSCs. The existence of TiO_2 and SnS elements in the sample was revealed by EDX data, supporting the effective synthesis of SnS quantum dots (QDs). The Dark I-V carve of this structure is showing Shockley's nature. Which indicates p-n junction forms here. Making extremely effective solar cells will be possible with the help of this arrangement.

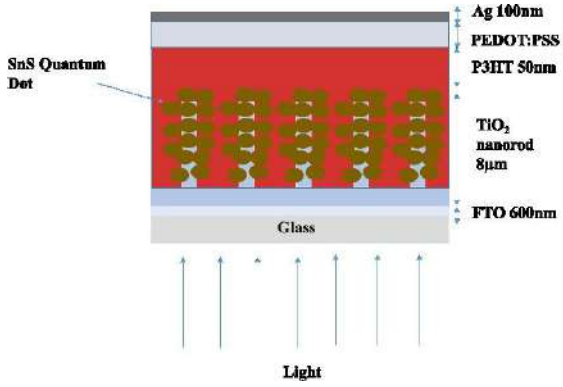

Figure 1: Structure of the Device

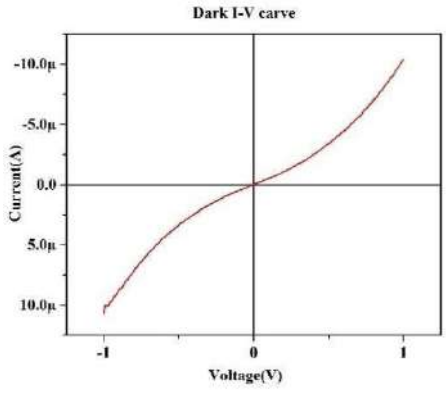

Figure 2: Dark IV showing Shockley's nature

Paper ID: P-5009

Area: Photovoltaic Devices

Synthesis and characterization of SnS Quantum Dot for Quantum Dot Solar Cell

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Tin sulfide (SnS) is one of the important chalcogenide materials as it has a very high absorption coefficient ($>10^4$) among all nontoxic chalcogenide materials. SnS QDs were prepared by the colloidal synthesis process. By the addition of TOPO (Trioctylphosphine oxide) to SnS, the size of the QDs was controlled and it was confirmed by the high-resolution transmission electron microscopy (HRTEM) study. In the preparation of QDs, TOPO surfactant acts as an effective ligand around the SnS particles, not only to protect the particles from ambient but also to keep them separated. HRTEM study (Figure 1) of the QDs reveals their sizes around 4 ± 2 nm which is less than Exitonic Bohr's radius of SnS (7 nm). Selective area diffraction pattern (SADP) confirms the crystalline nature of the material and the inter- planar distance was found to be ~0.329 nm. Powder X-ray diffraction studies also show some crystalline peaks at 120, 111, and 141 planes at the respective Bragg's positions. Crystalite Size of QDs from the XRD data (≤2nm) is less than HRTEM image which means some part of the nanoparticals is Crystalite. The photoluminescence study exhibits an emission peak of around 764 nm (Figure 2) corresponding to 1.62 eV which is higher than the band gap of bulk SnS (1.3eV). The optical band gap from UV-Vis spectroscopy is also higher (~1.8ev) than the band gap of bulk SnS and higher than PL emission wavelength. The band gap value obtained from both UV-Vis. and PL, which is higher than bulk SnS, clearly confirms the Quantum Confinement of SnS QDs. And some inter band energy state are also there from where emission is coming. Based on the above results, it is suggested that SnS QDs are formed and it will be potentially suitable for efficient QD solar cells.

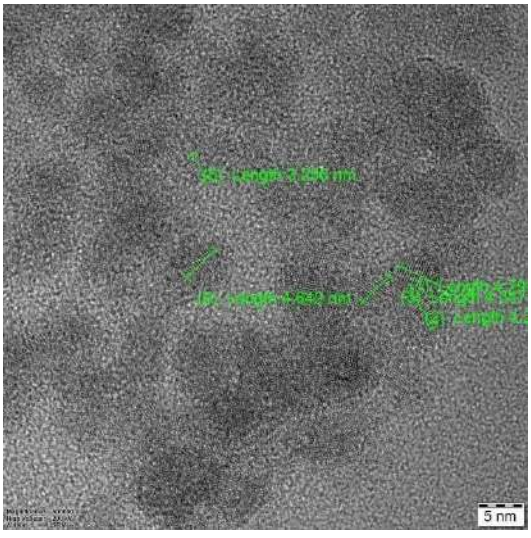

Figure 1. HRTEM Image of SnS QD'S

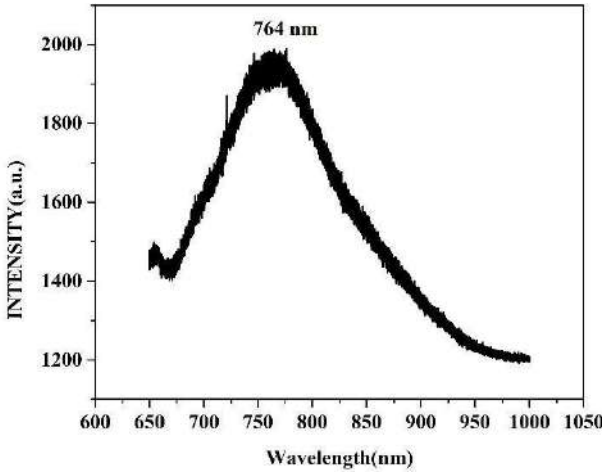

Figure 2. PL curve of SnS QD'S

Paper ID: P-5010

Area: Photovoltaic Devices

Effect of Cu-doping in ZnTe thin films as buffer layer for CdS/CdTe solar cells

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Cadmium telluride (CdTe) is a II-VI group binary semiconductor material with high absorption coefficient~10^5 cm $^{-1}$, direct bandgap ~1.45 eV, and long minority charge carrier diffusion length. Development of stable and low resistive back contact is required for the fabrication of efficient CdS/ CdTe solar cells. CdTe material has a higher electron affinity (4.5 eV), therefore a high work function metal (Au or Pt) comparable to that of CdTe (5.7 eV) is required to produce a good ohmic back contact on p-type CdTe. Due to the non-availability of high enough work function metal, the best solution to overcome the contact problem is incorporation of heavily doped p-type interface layer prior to the metallization. ZnTe and Cu-ZnTe films are used as buffer layer in CdTe solar cells due to their high absorption coefficient of the order of 10^4 cm $^{-1}$, low electron affinity 3.53eV, and direct band gap of 2.2eV. ZnTe and Cu-doped ZnTe thin films have been synthesized by an electrodeposition technique on FTO substrate using three electrode systems in aqueous solution with solution pH 2.5.The reaction mechanism has been studied by cyclic voltammetry to identify the deposition potential of thin film is found close to -0.9V versus Ag/AgCl reference electrode. The effect of annealing and Cu-doping on the structural, compositional, morphological, optical and electrical properties of as deposited and annealed thin film have been characterized by various characterization technique. After annealing the crystallinity and grain size was found to be enhanced remarkably. The improvement in the conductivity upon Cu doping is proposed due to the incorporation of Cu atoms in the ZnTe crystal structure. XPS analysis was carried out to determine the chemical state of Zn and Te. The survey scan and core-level spectra confirmed the peaks associated with binding energies of Zn,Te,Cu,O, and C. The current-voltage characteristics exhibit the nearly ohmic nature of ZnTe thin films. The capacitance-voltage measurements were performed to determine the carrier concentrations and flat band potentials. The ideality factor and carrier concentration obtained for the samples illustrate that the highly conducting p-type ZnTe and Cu:ZnTe buffer layers are developed.

Paper ID: P-5011

Area: Photovoltaic Devices

Stable halide perovskite solar cells based on low-temperature solution-processed SnO_2 ETL

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The stability of halide perovskite solar cells is a big issue in the commercialization roadmap. SnO_2 is an efficient electron transport layer (ETL) to improve the halide perovskite solar cells (PSCs) device's stability as well as power conversion efficiency (PCE) in the ambient environment. The ETL's physical characteristics, such as charge injection, band alignment, defect states, morphology, and associated interfacial properties, are important for photovoltaic performance. Superior characteristics of the SnO_2/$MAPbI_3$ include suppression of mid-gap defect states, massive electron carrier injection, and band alignments that may improve the device performance. Due to the high bandgap (~ 3.6 eV), SnO_2 shields against UV exposure. The bulk electron mobility of SnO_2 is good for low- temperature fabrication. In this work, we synthesized low-temperature spin-coating solution-processed SnO_2 with different precursors. The SnO_2-based PSCs reached 9.97% PCE and achieved long-term stability (2000 hr.) in the ambient environment. This study of low-temperature solution-processed SnO_2 ETL is a good approach to the commercialization of planar PSCs.

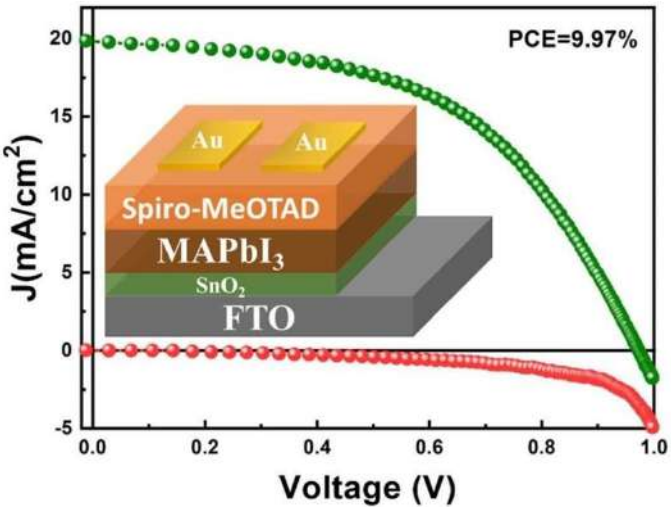

Figure 1: Current-voltage characteristic of the$SnO2/MAPbBI3$ based perovskite solar cell

Paper ID: P-5012

Area: Photovoltaic Devices

Low-Cost Fabrication of Single Chalcogenide $CuInGaSe_2$ Sputter Target and its Thin Films For Solar Cell Applications

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Copper $indium_{(1-x)}$ $Gallium_{(x)}$ Diselenide (CIGS) layer for (x=0.3) was optimized for low cost developing CIGS solar cells. For depositing the CIGS thin-film layer by RF-sputtering technique, single quaternary chalcopyrite CIGS sputter target was fabricated by High energy Ball Milling followed by a cold press vacuum sintering process (Figure 1 a-c). CIGS thin-film layer has been deposited at 10, 15, and 20 mTorr deposition pressure and 125, 150, and 175 W RF-Power. The effect of Rapid thermal annealing was studied under different annealing profiles. It was found that CIGS thin-film layer deposited at 15 mTorr, 150 W, and annealing for 250 °C results in a smooth surface however the grain size is very small. Further, the Rapid Thermal Annealing (RTA) process of CIGS film-annealed under a two-step annealing process [400 °C (2 mins) + 550 °C (8 mins)] possesses a sharp and intense X-ray peak. Physical, optical, elemental, and microstructural topographical analyses of CIGS thin film were analyzed. Optimized CIGS thin film was used as an absorber functional layer in the fabrication of CIGS solar cells and draws a 2.23 % conversion efficiency. EDAX (Figure 2), GIXRD, SIMS, SEM (Figure 1 d), FESEM, and I-V characteristics of the device were investigated for in-depth phase formation, elemental distribution, microstructural, and performance analysis.

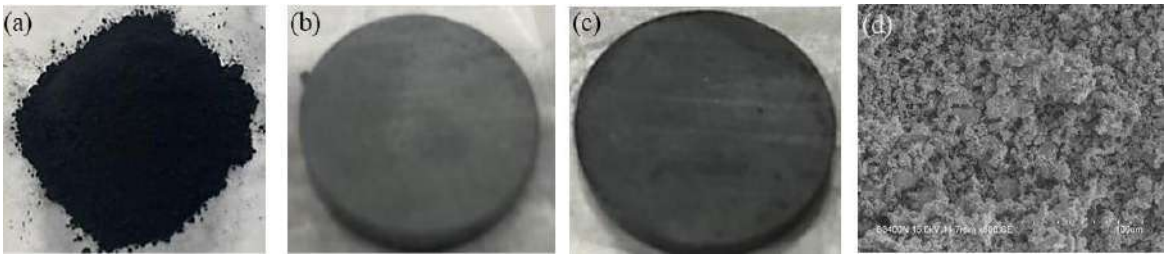

Figure 1: Photographic image (a) Ball milled CIGS powder, (b**)** cold press, (c) vacuum sintered CIGS target at 500 °C for one hour, and (d) its SEM image.

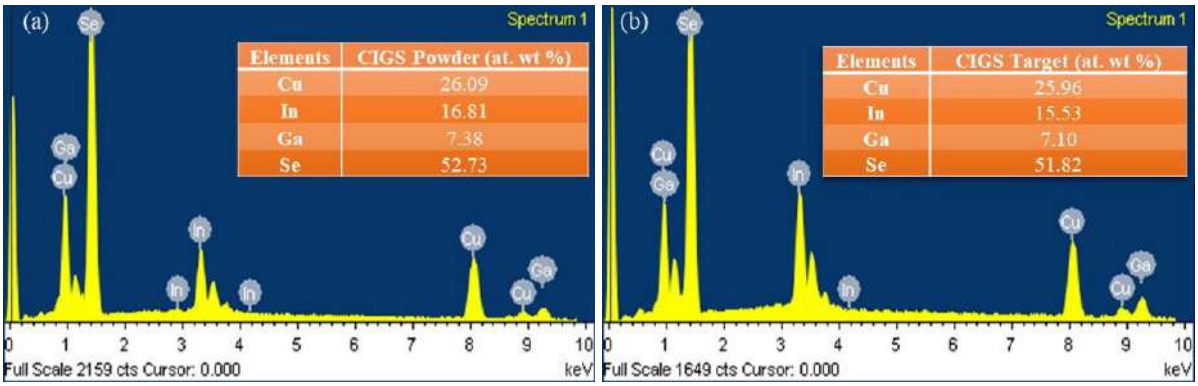

Figure 2. EDAX of (a) Ball milled CIGS powder, (b) vacuum sintered CIGS target at 500 °C for one hour.

Paper ID: P-5013

Area: Photovoltaic Devices

Assessment of thermal annealing on structural, electrical, optical and surface topographical features of titania thin films for solar cells

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Titanium dioxide or titania (TiO_2) has profoundly attracted the academia and industries due to its unique physical and chemical characteristics and diverse applications from solar cells to photocatalyst. The titania films have different roles in CdTe, perovskite, dye sensitized and organic solar cells as window/buffer layer, electron transport layer, photoelectrode etc. In order to further improve the stability and performance of these solar cells, the advancement in properties of titania films is essential which can be done by thermal annealing. The present work reports an assessment on thermal annealing induced structural and electrical features/properties of e-beam evaporated titania films which are annealed in range of 100-500ºC for one hour. XRD analysis reveals a phase transformation from amorphous to crystalline beyond 300°C. Electrical measurements unveil the ohmic nature and increment in resistivity for annealed films vis-à-vis to pristine. The assessment shows that titania films annealed at 500ºC have crystalline nature (with improved crystallinity) and ohmic nature, thus, these could be recommended for window and electron transport layer applications in solar cells.

Keywords: *Titania films; E-beam evaporation; Buffer layer; Crystallinity; Solar cell.*

Paper ID: P-5014

Area: Photovoltaic Devices

Device Simulation of $CH_3NH_3PbI_{3-x}Cl_x$ based mixed halide perovskite thin film solar cells

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Perovskite solar cells are an emerging area of study in thin-film photovoltaics due to their low cost and environmentally friendly fabrication. In this paper, the numerical simulation of FTO/CdS/$CH_3NH_3PbI_{3-x}Cl_x$/CuI/Au device performance was investigated using solar cell capacitance simulator (SCAPS-1D). Here, Chloride (Cl) doped methyl ammonium lead iodide i.e. $CH_3NH_3PbI_{3-x}Cl_x$ is used as perovskite light absorber layer because of its good thermal stability and film quality. It is a mixed halide perovskite which has tunable bandgap property. In this present solar cell configuration CdS is used as buffer layer and CuI as hole transport layer (HTL). The effect of absorber layer thickness, operating temperature and different HTL's were also analyzed on device performance. Before optimization the proposed structure achieves a PCE of 13.62%, FF of 86.69%, J_{SC} of 11.80 mA/cm^2 and V_{OC} of 1.33 V. By varying the thickness of the absorber layer from 0.1-1.0 µm ,the optimum thickness was found at 0.7 µm. In addition to this different HTL's CuI, Spiro-OMeTAD and Cu_2O were used in simulation and CuI gives best results compared to others. With optimized parameters, the proposed device achieves a PCE of 27.19%, FF of 87.88%, J_{SC} of 23.86 mA/cm^2 and V_{OC} of 1.29 V. These optimized results will be used for the fabrication of an $CH_3NH_3PbI_{3-x}Cl_x$ perovskite (mixed halide) thin film solar cell.

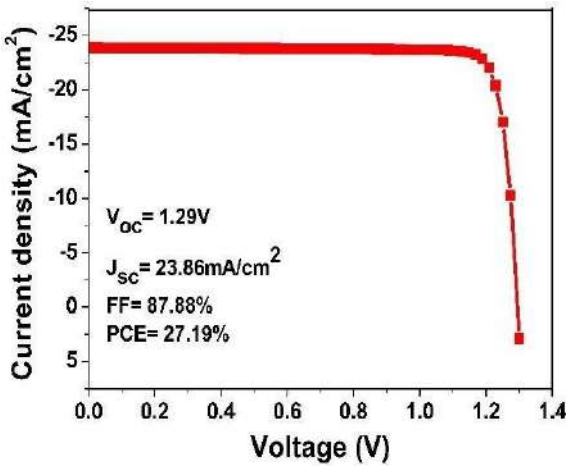

Figure 1: PCE of $CH_3NH_3PbI_{3-x}Cl_x$ based mixed halide perovskite solar cell having efficiency of 27.19% with CuI as HTL

Paper ID: P-5015

Area: Photovoltaic Devices

Fabrication of efficient single side MoO_{3-x}/n-Si(c) heterojunction solar cells

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Efficient solar cell requires effective charge carrier selective contacts (CSC) to allow transport of photogenerated charge carriers. Transition metal oxides (TMO) are actively explored CSC. TMO like Vanadium Oxide (VO_x), Tungsten Oxide (WO_x) and Molybdenum Oxide (MoO_x) are explored as hole selective contact in silicon heterojunction solar cells because of high work function and wide band gap. Among all TMO, molybdenum oxide is the extensively used hole selective contact in organic or inorganic solar cells. In this work, single sided Ag/Al/c-Si(n)/MoO_{3-x}/ITO/Ag heterojunction solar cell is fabricated. A systematic study is carried out on optimisation of each layer like selection of back electrode, optical and electrical properties of transparent conducting oxide (i.e. ITO here) and MoO_{3-x} which acts as hole selective contact. Optimisation of layers has improved the device performance from open circuit voltage (V_{oc}) - 455 mV, short circuit current density (J_{sc}) - 28.14 mA/cm^2 and efficiency (Ƞ) - 3.84 % to V_{oc} - 539 mV, J_{sc} - 35.69 mA/cm^2 and Ƞ - 11.05 %. Solar cell parameters of fabricated devices are listed in table 1. Further tuning of electrical and optical properties of MoO_{3-x} films are in process to improve the device performance.

Table 1: Calculated solar cell parameters for fabricated MoO_{3-x}/c-Si(n) solar cells.

Sample name	Voc (mV)	Jsc (mA/cm^2)	FF	Ƞ (%)
n$pMoO_{3-x}$_3	455	28.14	0.30	3.84
n275MoO_3_2	391	45.71	0.48	8.66
n275MoO_3_3	517	39.71	0.49	10.17
n275MoO_3_20	539	35.69	0.57	11.04

Paper ID: P-5016

Area: Photovoltaic Devices

Deposition and characterization of low-pressure RF sputtered Al_2O_3 and its application on hydrogenated amorphous silicon thin film solar cell

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In this current work, RF sputtered Aluminium oxide film deposited at low pressure was characterized and used as an electrical passivation layer as well as an antireflection coating in PIN and NIP type hydrogenated amorphous silicon (a-Si:H) thin film solar cells respectively. Because of the simplicity, availability, and good deposition rate, the RF sputter technique could be preferred over the conventional atomic layer deposition technique, which is a comparatively complex one. The film was deposited at 6×10^{-3} mbar chamber pressure with a substrate temperature of 200° C and subsequently annealed at 350° C for one hour. Different types of characterization techniques like FESEM, EDAX, XRD, AFM, UV-VIS-NIR spectroscopy, and CV were performed to analyze the deposited sample. The negative fixed charge present in the deposited film was measured to be 0.92×10^{12} cm^{-2}, and it is capable of providing electrical passivation, especially when it is deposited over a p-type material. Also, the antireflection property of Al_2O_3 is very effective when applied at the top of a solar cell. The application of RF-sputtered Al_2O_3 was studied on both PIN and NIP type solar devices. The efficiency of the PIN device when Al_2O_3 is applied just below the p-type layer is enhanced from 2.6 % to 2.9 %, and that for a NIP structure, when applied at the top, enhances from 2.6% to 4.3 %.

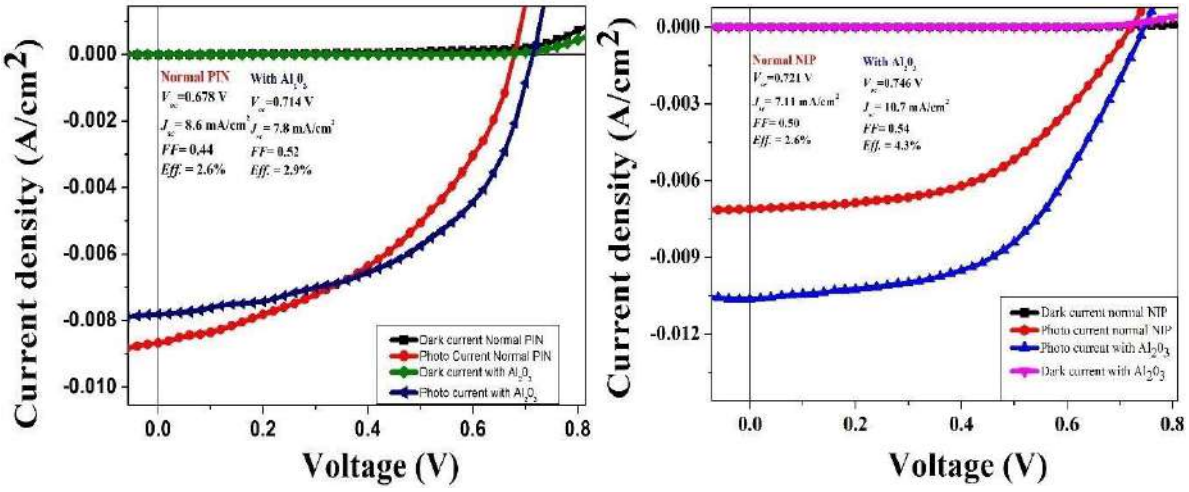

Fig. 1: J-V characteristics of PIN and NIP cells with and without Al_2O_3.

Paper ID: P-5017

Area: Photovoltaic Devices

Excellent silicon surface passivation of industrial type n-type CZ Si (111) by Al_2O_3 layers deposited by thermal ALD process for application in carrier selective contact solar cells.

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c-Si based carrier selective contact solar cells are achieving high efficiency with a crucial step of silicon surface passivation, reducing the electronic recombination losses occurring at the interface of Si and the passivation layer. The ultrathin passivation layers of Al_2O_3 are deposited by atomic layer deposition (ALD), known for its conformance and homogeneity. ALD is an attractive technique for low-temperature depositionof layers required for the development of c-Si carrier selective contacts and passivation. The deposition temperature is fixed at 200 °C, which lies in the ALD window for Al_2O_3 films. In this study, deposition of Al_2O_3 films is done by thermal ALD process where the growth per cycle of the films is calculated to be 0.1±0.01 nm using spectroscopic ellipsometry. Al_2O_3 films were deposited on n-type CZ- Si (111) (Ω cm) wafers of thickness 170 μm after processing with saw damage removal, standard RCA clean, and HF dip. Post deposition annealing was done in N_2 and forming gas environments at various temperatures to probe the passivation quality. A monotonic improvement was obtained with annealing in such an environment, reaching an excellent lifetime of about 1.24 ms (measured by WCT-120 Sinton lifetime tester) at a minority carrier concentration of 1×10^{15} cm^{-3} for samples annealed in forming gas environment at 310 °C. This is an excellent value for an industrial type Cz wafer with a measured bulk lifetime of only ~2ms. The corresponding effective surface recombination velocity obtained is 3.7 cm/s. An implied open circuit voltage (iV_{OC}) of 0.704 V is achieved for the same. These results demonstrate that the passivation obtained here is of device quality for CZ Si wafers and facilitates the development of high-efficiency Si heterojunction solar cells.

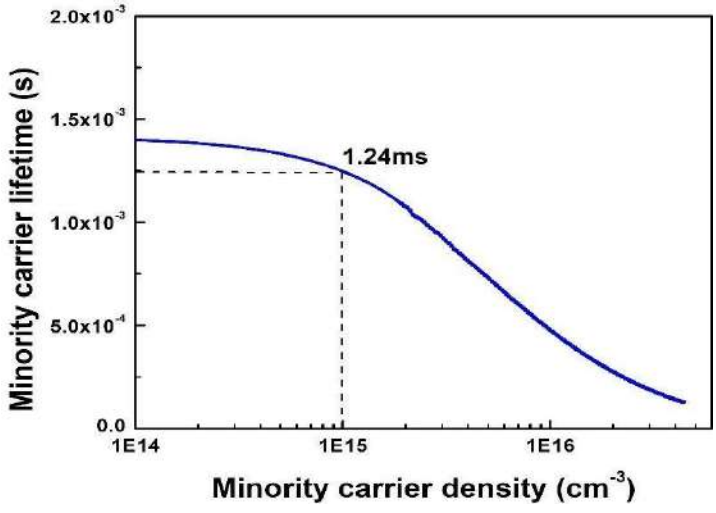

Figure 1. Minority carrier lifetime as a function of minority carrier density of n-type CZ Si (111) after Al_2O_3 deposition and post-deposition annealing.

Paper ID: P-5018

Area: Photovoltaic Devices

Direct-coated SnS and SnS_2 films prepared from the same precursor complex in different solvents

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ABSTRACT

SnS and SnS2 are prospective and promising non-toxic materials for the photovoltaic devices with added advantages of abundant availability on Earth [1]. On the other hand, SnS2 is being considered as a potential non-toxic buffer layer [2] for solar cells. Ink based coating methods for thin film solar cells are emerging as popular non-vacuum means for fabrication of thin films because of technical simplicity, high utilization of materials and amenability to large area. In this paper we report drop-casted SnS and SnS2 films on glass from inks prepared by dissolving 1:1 molar ratio of SnCl2 and thiourea (TU) to form complex in methanol (MEI) and ethylene glycol (EGI). Films were deposited on glass by drop-casting followed by drying, thermolyzing and heating. Fig. 1 & 2 shows the X-ray diffraction (XRD) of EGI and MEI films that were found to be Orthorhombic SnS and Hexagonal SnS2 respectively. Raman spectrum revealed the signature lines at 315 cm-1 for SnS2 and at 180 and 224 cm-1 for SnS as shown in Fig. 3 that confirmed the formation of the pure films. However, EGI-precursor films yielded SnSx films with mixed phases of SnS2 and SnS while heated from 300 to 340 oC. Further, pure SnS films were obtained at 360 oC and above. On the other hand, MEI produces SnS2 at and above 200 oC. The direct band gaps of SnS and SnS2 films are 1.42 and 2.4 eV, respectively. The SnS films were n-type and photoconducting with conductivity, mobility and electron concentration of 1-2 S/cm, 2 m2/V.s and 1018 cm-3, respectively. The SnS2 films were n-type and good photoconductor with conductivity, mobility and electron concentration of ~10-5 S/cm, 0.6 cm2/V.s and ~1014cm-3, respectively. The formation of SnSx films were explained on the basis of thermal decomposition of Sn+2 -TU complex in air. It is interesting to note that SnS and SnS2 films were deposited from inks formulated from same Sn+2-Tu complex in ethylene glycol and methanol as solvent [3].

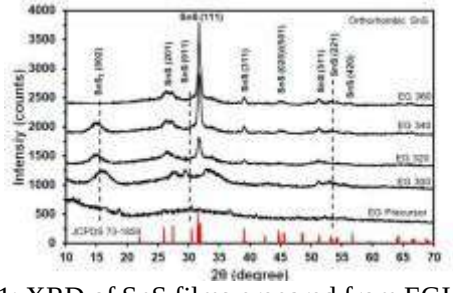

Figure 1: XRD of SnS films prepared from EGI

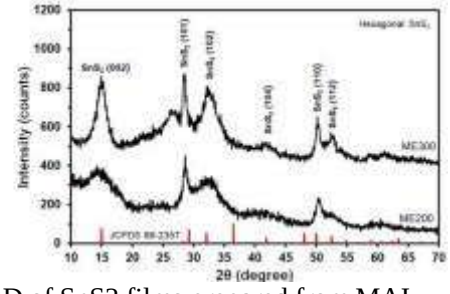

Figure 2: XRD of SnS2 films prepared from MAI

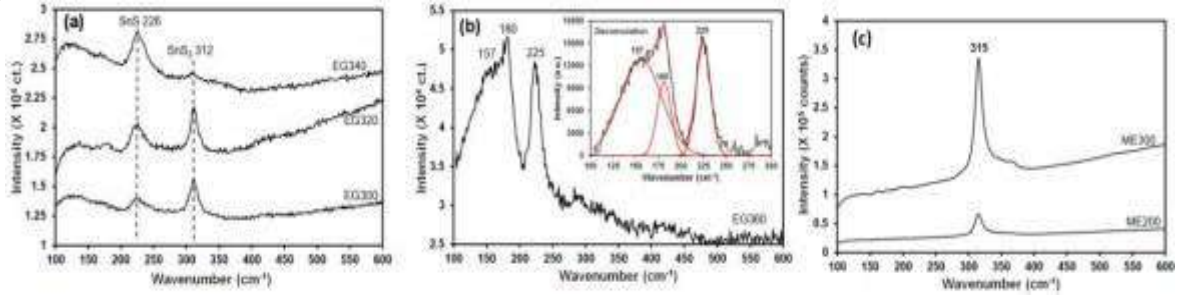

Figure 3: Raman spectra of SnS films prepared at different temperatures (a) EG300, EG320 and EG340 and (b) EG360 (Inset shows the deconvoluted peaks), (c) SnS2 films prepared at 200 and 300◦C.n-crystalline solids

Paper ID: P-5021

Area: Photovoltaic Devices

Effectiveness of the front and rear grids as a result of silicon solar cell metallization patterns: A study using Griddler simulator

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ABSTRACT

This study aims to investigate the effects of front and rear grid metallization patterns on silicon heterojunction (SHJ) solar cell efficiency. Using the Griddler 2.5 PRO simulator, it was discovered that the front grid metallization design and geometry have a stronger impact on the electrical parameters short circuit density (Jsc), open circuit voltage (Voc), fill factor (FF), and efficiency (η) of silicon-based solar cells. Griddler 2.5 PRO is designed to evaluate various cell types, improve cell manufacturing, and to obtain better understand of the limiting variables that affect the solar cell characteristics both under conventional laboratory test circumstances and in the field. The finiteelement method (FEM) is used in solar cell modelling to approximate the cell plane as a dispersed network of resistors and diodes. It also has an inbuilt interface for creating H-patterns and back metal grids. The number of metal fingers used for grid pattern optimization ranged from 80 to 130, with finger widths ranging from 10 to 60 m, and the number of busbars utilized on the front and back side metal grids of solar cells varied from 1 to 5. For efficiency and fill factor optimization, a variety of styles (straight, rectangular pad tapered, round pad, digital, two split, and three split) and shapes (straight, pointed, digital, appolo, and wine bottle) were explored. The front and rear contact resistances were kept constant during these simulations to get the best efficiency and fill factor. A silicon solar cell with 115 fingers (front and rear finger sheet resistance are 3 mΩ/□) and four
busbars, as well as two split style and straight shapes, was designed with a finger width of 25
microns. This study found it to be one of the most efficient silicon solar cells modelled, with a fill
factor and efficiency of 80 % and 19.55 %, respectively, which is noteworthy for a planar solar cell

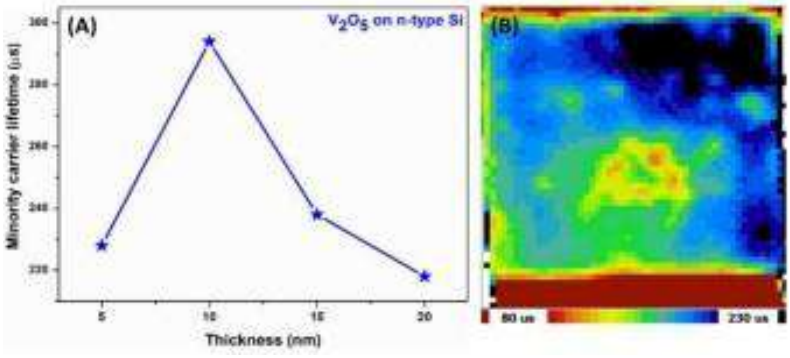

Figure 1: (A) The minority carrier lifetimes are affected by thickness. (B) Lifetime mapping of a 10 nm thick V2O5 film

Paper ID: P-151

Area: Photovoltaic Devices

Air annealing evolution to physical characteristics of Cd0.85Zn0.15Te thin films: Absorber layer applications to solar cell devices

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ABSTRACT

The II-VI ternary chalcogenide Cd1-xZnxTe is considered as a vital absorber material for the development of single-junction as well as multi-junction solar cell devices since it not only overcomes the problem of appropriate contact which lacks in CdTe based devices but enables band gap tunability too. Also, plummeting the surface and native defects in Cd1-xZnxTe thin films is crucial for obtaining unadulterated and omogeneous
films. Accordingly, presented work is endowed with significant insights on upshot of air annealing on physical properties of resistive heating based thermally evaporated Cd0.85Zn0.15Te thin films which are annealed at 200°C, 300°C and 400°C. Structural studies revealed the supremacy of (111) and (220) orientations of zinc blende cubic phased Cd0.85Zn0.15Te and grain growth with heat treatment. The direct optical energy band gap (Eg) is attained within range 1.62-1.89 eV. The current-voltage (I-V) measurements demonstrated Ohmic (linear) character of deposited films and topographical features portrayed hill-like topographies. Morphological images divulged small-spherical shaped and large-stone shaped grains and compositional analysis depicted the presence of Cadmium, Zinc and Tellurium peaks validating the successful deposition of Cd0.85Zn0.15Te films. The attained results connote that maximum grain growth, highest absorbance and optimum energy band gap of 300°C air annealed Cd0.85Zn0.15Te films make these fitting absorbers for single junction and tandem solar ell
devices concerned.

Keywords: Cd0.85Zn0.15Te thin films, Resistive heating evaporation, Annealing, Physical properties, Absorber layer.

Paper ID: P-5024
Area: Photovoltaic Devices

An analysis of absorber thickness variation and ideality factor at different levels of conduction and valance band offset

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ABSTRACT

The potential of Perovskite solar cells (PSCs) is witnessed by the research community within a decade of its emergence. The leading PSC to date has high power conversion efficiency (PCE) of 25.8%. All the efficient PSCs incorporate toxic Lead (Pb), which creates hindrance in the market acceptance of the cell. Inorganic lead free PSCs are extensively being studied as clean and green sources of energy. The issue with lead free PSCs can be minimized by overcoming the performance gap. This work, we analyse CsSn0.5Ge0.5I3 based PSC. We study the the photovoltaic (PV) parameters by varying absorber layer thickness at different levels of conduction band offset (CBOs) and valance band offsets (VBOs). We further study the phenomena of Ideality factor (IF) considering various defect densities at different levels of conduction band offset (CBOs) and valance band offsets (VBOs).

Keywords: Lead free, Perovskite solar cells, Ideality factor, absorber thickness variation, and band offset

Paper ID: P-5025

Area: Photovoltaic Devices

Annealing effect on Structural, optical and morphological properties of CdTe thin film onFTO substrate

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ABSTRACT

The effect of annealing temperatures on cadmium telluride (CdTe) layers produced by two electrode electrodeposition from a non electrolyte aqueous solution has been examined. The samples electrodeposited at 1.5 V were annealed at 250℃ and cooled down at room temperature. The Quenched sample performs better than the as-deposited and naturally cooled samples. Annealed sample indicate the growth of a cubic polycrystalline crystal structure with increased crystallinity of cdte material. The structural, optical, and morphological properties of the sample were investigated using X-ray diffraction (XRD), UV–Visible spectrophotometry (UV-Vis), scanning electron microscopy (SEM), and energy dispersive X-ray analysis (EDX) techniques. The XRD analysis showed that the little change in (220) and (311) peaks was for annealed layers compared to the as-deposited material. The energy band gaps of 1.44 eV for annealed film and for as- deposited film 1.53 eV as shown in Figure 1. The samples exhibited the required optical property for fabricating CdS/CdTe solar cells according to UV-Vis spectrometric measurements for CdTe layers. The SEM shows grain growth after annealing the sample, while, the EDX shows the effect of growth voltage on the atomic composition of CdTe layers. The findings suggest that the annealing conditions have a major impact on CdTe sample properties and quenched films may be the best absorber layer for thin film solar cell applications.

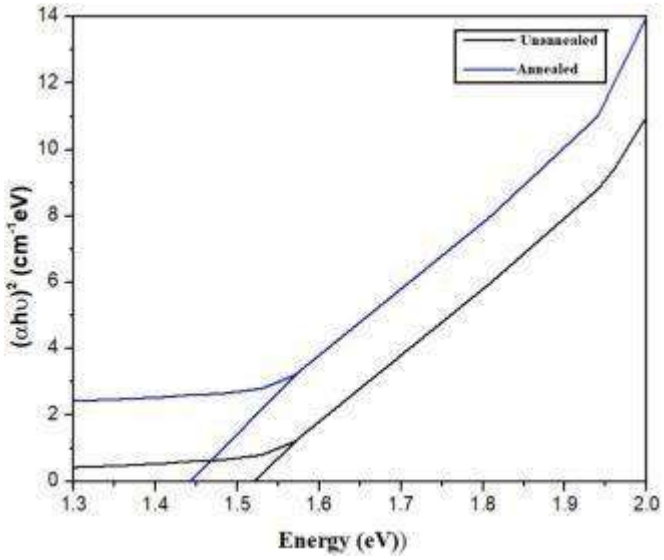

Figure 1: Tauc's Plot of CdTe thin films

Paper ID: P-154

Area: Photovoltaic Devices

Detailed investigation to attain high-performance lead-free La_2NiMnO_6–based double perovskite solar cells with different electron transport materials: Theoretical approach

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ABSTRACT

Perovskite solar cells (PSCs) have undergone significant advancements, but the commercialization of these devices is still constrained by some key bottlenecks including the toxicity of metal lead, the stability of the active layer against humidity and UV radiation, and the short durability of perovskite. In light of these difficulties, it becomes crucial to investigate the substitution of lead-based PSCs with an appropriate perovskite. In the recent past, lead-free double perovskite materials have drawn enormous interest among the scientific community due to their exceptional magnetic, dielectric, optical, and electrical characteristics.

In the present work, we carried out a detailed investigation of La2MnNiO6 – based double PSCs by employing different organic and inorganic electron transport layers (ETLs) namely PCBM, IGZO, ZnOS, and SnS2with Cu2O as hole transport layer (HTL). A comparative analysis of four different device architectures has been performed with planar n-i-p device architecture i.e. glass substrate/FTO/ETLs/LF-double perovskite/Cu2O/Au using drift-diffusion simulation by SCAPS-1D software. Furthermore, to enhance the device performance, the impact of the absorber layer thickness (100 nm - 1000 nm), operating temperature (300 K - 400 K), charge types of defects and defect density (1x1014 cm-3- 1x1019 cm-3), parasitic resistance i.e. series resistance (RS) and shunt resistance (RSh), and capacitance-frequency analysis on the cell performance have been studied. From the simulation results, it was observed that both organic and inorganic ETLs work best with the La2MnNiO6 with the highest efficiency of 19.03% attained by the architecture employed PCBM and ZnOS as ETLs. Besides, the efficiency attained with the other two architectures consisting of IGZO and SnS2 as ETL were 18.84% and 18.72% respectively at 300 K. The findings suggest that the systematic investigation of the materials and the appropriate selection of materials characteristics help to develop an efficient and stable PSCs. The simulation results reported here will definitely aid new knowledge in the development of low-price, and competent DPSC.

Paper ID: P-155

Area: Photovoltaic Devices

Effect of Ionic Migration in Triple Cation Based Perovskite Solar Cells Performance

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ABSTRACT

Perovskite solar cells have shown remarkable progress in recent years with rapid increases in conversion efficiency.[1] Recently, due to the rapid advancement of organic-inorganic mixed halide perovskite solar cells (PSCs) in the past one decade, the efficiency has reached beyond 25%. [2] However, the ionic migration acrossthe active layer under the external biasing (forward and reverse) is poorly understood, which is the main cause of hysteresis in the PSCs (figure 1). [3] To observe the change in the performance of PSCs under the forward and reverse scan due to the ionic migration, SCAPS-1D software is utilized. Here we have performed both experimental and numerical simulation for Cs0.05(FA0.83MA0.17)0.95Pb(I0.83Br0.17)3 perovskite-based solar cells. This study also observed that ionic movements are responsible for trap states, which decrease the mobility of charge carriers resulting in higher series resistance in different scan directions. Higher resistance changes the fill factor, which is reflected in hysteresis (Fig. a, b). Hence, the current study correlates with the experimental and simulation study and reveals the detrimental effects of ionic migration in perovskite solar cells.

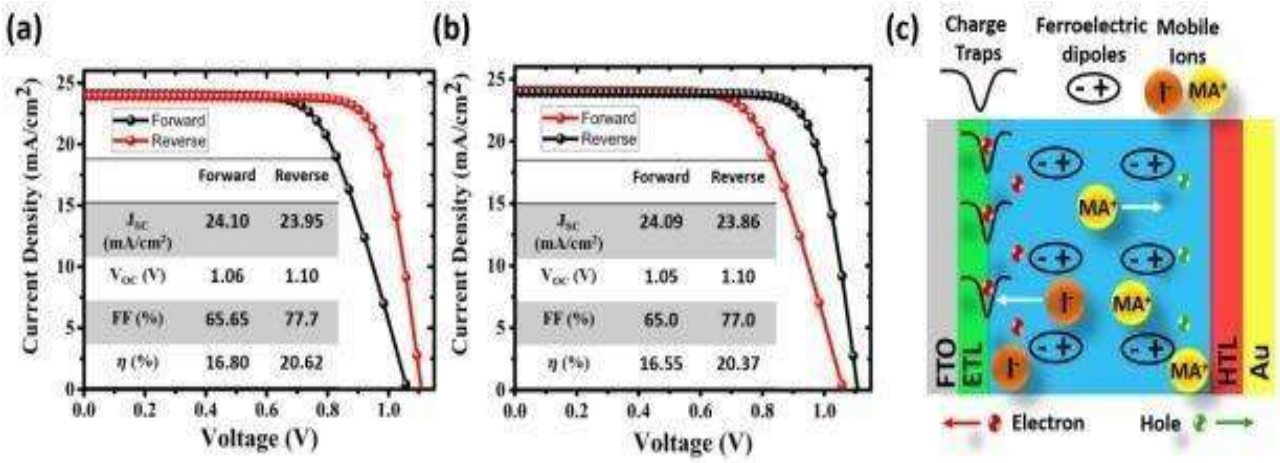

Figure 1: (a) Simulated J-V data, (b) Experimental J-V data, and (c) Ionic migration inside the active layer and charge traps at interface

Paper ID: P-5029

Area: Photovoltaic Devices

Low-temperature synthesized SnO_2 electron transport layer for perovskite solar cells

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ABSTRACT

SnO2 has come up as excellent electron transport (ETL) material in perovskite solar cells. It has several edges over TiO2, the traditional electron transport material. SnO2 possesses a high bulk electron mobility of ~250 cm2 V-1s-1, which promotes faster electron transfer; a wide bandgap of ~4 eV, which reduces the parasitic absorption; UV stability. In addition, SnO2 thin film can be processed at low temperatures. In this work, we have synthesized SnO2 thin film for ETL in PSCs by low-temperature steam annealing method. Various synthesis parameters, such as annealing time, precursor concentration, annealing temperature and spin coating speed, are systematically varied to find the optimum synthesis parameters. The optimum parameters are foundto be 0.1 M precursor solution with HCl, spin coating speed of 5000 RPM, and steam annealing at 125 °C for 1hr. From the SEM and AFM images, it is evident that the as-synthesized SnO2 ETL is uniformly deposited allover the FTO substrate. In addition, the ETL is thin, which retains the texture of the FTO film beneath it(Figure 1). Thin but uniformly covered ETL is highly desirable to reduce the series resistance but improve theshunt resistance. Perovskite solar cells are fabricated using the steam annealed SnO2 ETL under ambient conditions with the device structure of FTO/SnO2/perovskite/spiro-OMeTAD/Au. The highest efficient cell achieves the power conversion efficiency of 12.58%, with JSC of 23.13 mA/cm2, VOC of 0.81 V, and fill factor of 67% (Figure 2).

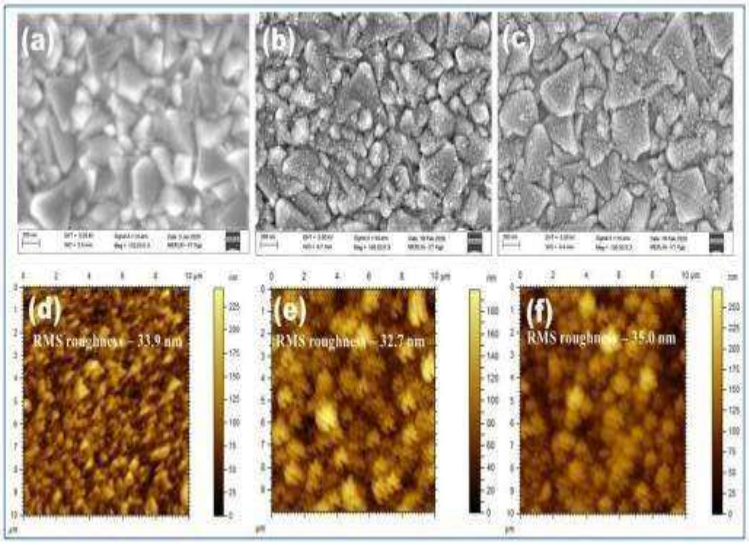

Figure 1. SEM image of bare FTO (a) and optimized steam annealed SnO2 thin film fabricated using 4000 RPM (b) and 5000 RPM (c). AFM image of bare FTO (d) steam annealed SnO2 thin film fabricated using 4000 RPM (e) and 5000 RPM (f).

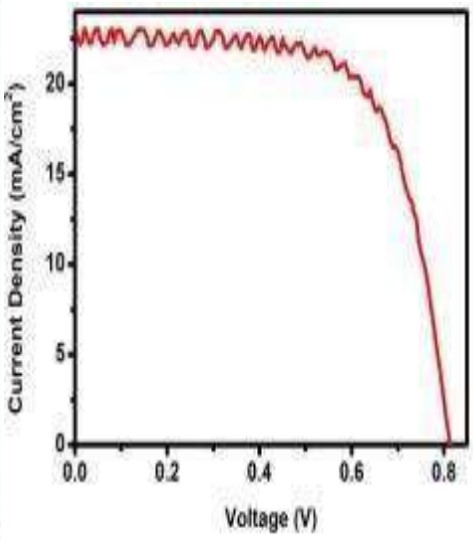

Figure 2. J-V curve of the best efficient cell using steam annealed SnO2, with power conversion efficiency of 12.58%.

Paper ID: P-5030

Area: Photovoltaic Devices

Interfacial engineering of $Cs_2AgBiBr_6$ based perovskite solar cell

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ABSTRACT

Due to its superior stability and benign properties, Silver-Bismuth based lead-free all-inorganic double perovskite solar cells (PSCs) have recently established their significance as a potential replacement for leadbased absorbers in PSCs. The interfacial imperfections (defects, voids non-uniformity, etc.) of various layers pose a serious threat to the device‘s efficiency and stability. In this view reducing the interfacial non-radiative recombination using bilayer between electron transport material (ETM)/perovskite interface is an effective approach to get improvement in open circuit voltage (VOC) and power conversion efficiency (PCE) in perovskite solar cells (PSCs). Additionally, interfacial engineering via insertion of an extra layer of suitable bandgap semiconductor materials at the interface of ETM/Perovskite has shown promising results. Herein, a very thin layer of WO3 was employed in FTO/SnO2/Cs2AgBiBr6/spiro-OMeTAD/Au based device structure to passivate the interfacial defects at SnO2/perovskite interface and analyzed the performance using SCAPS1D software. The extra layer facilitates improving the crystallinity of the absorber layer and also passivates the defects at the interfaces. A more precise energy level alignment [figure 1(a)] was discovered to be the major factor in the bilayer structured ETLs' resulting in high electron extraction and reduced interfacial recombination. Putting the suppressed defects values from the experimentally reported data at the interface, a significant enhancement in the photovoltaic performance has been observed. A PCE of 11.23 % and a VOC of 1.457 V were observed in without a bilayer-based device whereas PCE was improved up to 11.8 % and a VOC of 1.52 V after the application of the SnO2/WO3 bilayer. After the implementation of the bilayer, the improvement in VOC was 4.16% and in PCE was 4.98% [figure 1(b)]. Therefore, interfacial defects can be suppressed by utilizing bilayers at interfaces to improve the photovoltaic performance of PSCs.

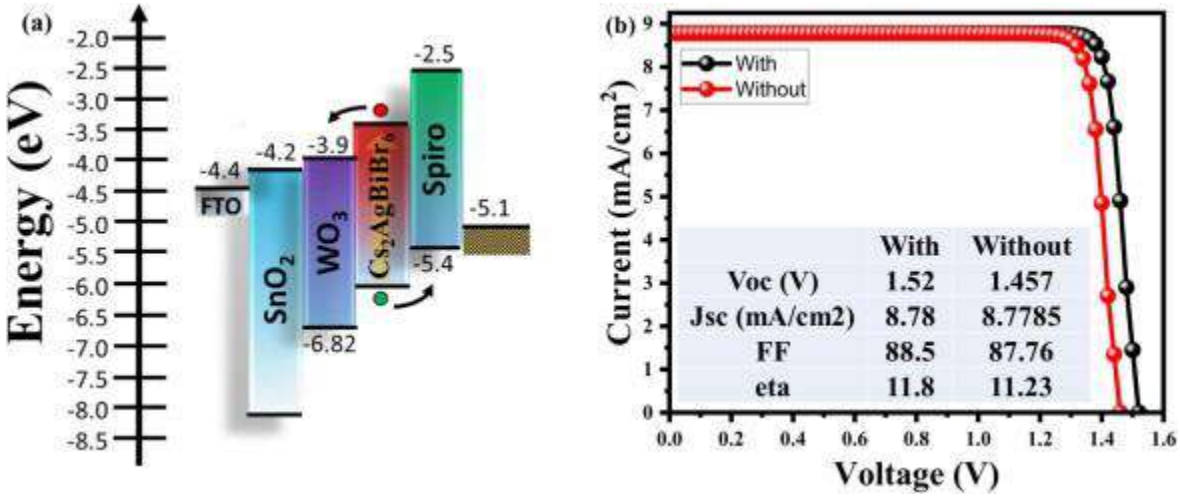

Figure 1: (a) Device architecture of PSC (b) J-V characteristic curve for with and without bilayer devices

Paper ID: P-5031

Area: Photovoltaic Devices

RF-sputtered high work function vanadium oxide thin films for heterojunction solar cells:Local probe-based studies

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ABSTRACT

Transition metal oxides (TMO) offer a wide range of work functions as a function of their growth technique. In particular, high-work-function TMOs, such as WO3, MoO3, V2O5, etc. are attractive as hole selective/extraction layer in various heterojunction solar cell technologies. Here, we report process parameter- dependent work function variation in vanadium oxide thin films prepared by reactive rf sputtering at room temperature under normal and oblique angle incidences. The morphological evolution of the films as a function of O2 flow rate and growth angle were examined by atomic force microscopy, whereas the work functions are measured using kelvin probe force microscopy. Other complementary characterisation techniques, such as UV-vis spectroscopy, XRD, four probe resistivity measurement and SEM were employed for a better understanding of the results. A 1 eV increase in work function from 4.6 eV to 5.6 eV is achieved by optimising the Ar: O2 flow ratio during deposition at normal incidence. Oxygen vacancies act as donors in the films, leading to an upward shift in the Fermi level. However, a decrease in the film work function is observed at even higher O2 flow rate, which deviates from the conventional understanding of reduced oxygen vacancy concentration with O2 flow rate. Further to this, oblique angle deposition with the optimised flow rate is found to yield high work function values as well. Film growth has found to evolve from rough characteristics towards smoother surface, finally leading to a nearly featureless type surface with increasing growth angle. The adopted film growth conditions (viz. oblique angle deposition, low deposition power) at room temperature would be promising for heterojunction solar cell technologies.

Paper ID: P-5032

Area: Photovoltaic Devices

S. Numerical exploration of BiI3 semiconductor using SCAPS-1D for promising photovoltaic applications

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ABSTRACT

The efficient harvesting of solar energy is by far one of the most important and promising solutions to tackle the impending energy crisis. Lead-based halide perovskites have emerged as a successful candidate for converting solar photons into electricity. But their commercialization is obstructed due to toxicity concerns associated with the lead content and stability issues in the ambient atmosphere. Thus, to mitigate these problems, in this work, for the first-time non-toxic bismuth-based BiI3 is investigated as a light absorber by the SCAPS-1D simulation program. To obtain the optimized device structure, various charge transport layers (CTLs) were considered and the device output was monitored at each step. The best electron transport layer (ETL) and hole transport layer (HTL) were found to be SnO2 and NiO respectively. Fig.1a shows the optimized device structure. Furthermore, the numerical simulations were carried out by varying the absorber thickness, defect densities, light intensities, operating temperatures, and parasitic resistances. The optimized device displays a significant power conversion efficiency (PCE) of 20.28% as illustrated by the J-V curve in Fig.1b. This study reveals that the performance of BiI3 as an absorber material can be significantly improved by proper choice of CTLs and control of defects.

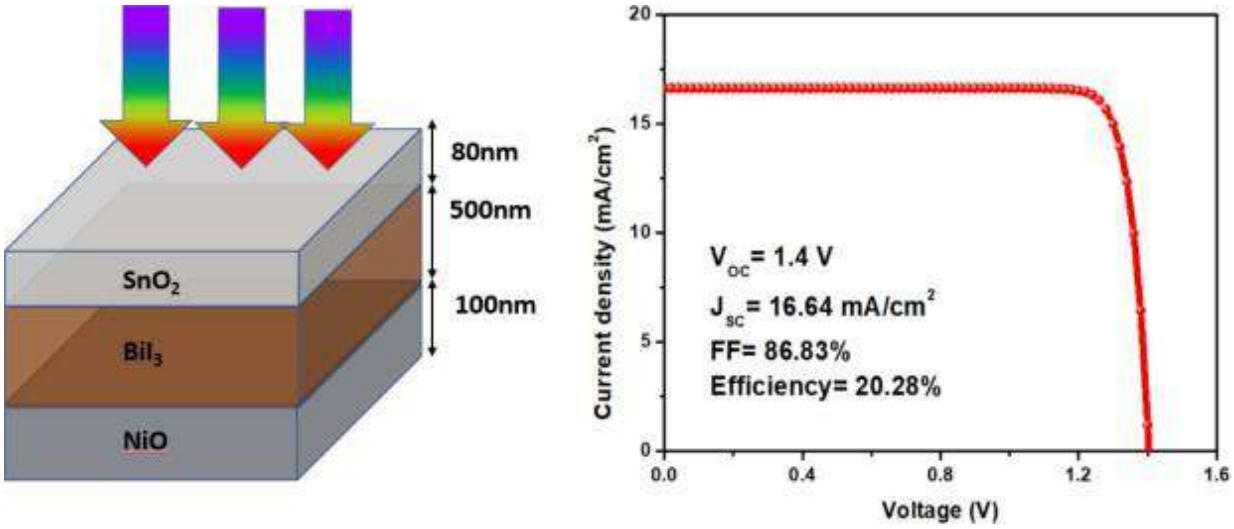

Figure 1: (a) Optimized device structure, (b) Cell parameters of the optimized device

Paper ID: P-5033

Area: Photovoltaic Devices

Impact of different transition metal ion on photovoltaic performance of TiO_2 based dye sensitized solar cells

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ABSTRACT

Titanium dioxide (TiO2) is a wide n-type band gap semiconductor material having its varied application in optoelectronic devices. Though it is a promising candidate for photovoltaic application to convert solar radiations to efficient energy but its performance is limited due to low mobility of porous TiO2 and its large bandgap reduces its spectral response. To improve the light harvesting properties of TiO2 nanomaterial, many transition metal are doped into TiO2 crystal structure which efficiently suppress the recombination of charge carriers and improving the absorption of light in the visible region. Here in this paper, we present the synthesis of different metal doped TiO2 compounds using wet precipitation method. Pure TiO2 and different doped nanopowders were characterized by XRD and UV- Visible Spectroscopy studies. Deposition of thin films were done using Doctor Blade Technique in order to improve the performance of dye -sensitized solar cell (DSSC). These films photovoltaic performance were studied using methylene blue as a dye. The effect of synthesized nanomaterials on the cell performance of DSSC were investigated by J-V curves. Furthermore, we have performed the electrochemical impedance spectroscopy analysis of formed DSSCs.

Paper ID: P-5034

Area: Photovoltaic Devices

Effect of thermal conductivity of gas used for sulfurization process on grain growth ofCZTS thin film for solar cell application: Ar Vs. N2

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ABSTRACT

Cu2ZnSnS4 (CZTS) is a well-known absorber layer which has proven its potential in thin film solar cell with a record efficiency of 11%[1]. The unique features of CZTS lies in its‘ high absorption coefficient of 104 cm1, an optimum band gap of 1.4-1.5 eV, natural abundance and its non-toxic constituents[2][3]. Despite these attractive properties of CZTS for light harvesting, performance of CZTS layer as an absorber depend on many factors like, defects, grain size, grain boundaries, energy states, optical and structural properties, etc. Properties of CZTS layer depends on its process parameters, like elemental ratio of precursor, annealing rate, temperature, annealing time, annealing environment, etc.

In this work CZTS layer of up to one micron thickness was prepared by sulfurization (annealing in sulfur vapor and N2/Ar gas) of a precursor prepared using magnetron co-sputtering of Cu, Zn and Sn on soda lime glass. Annealing environment was changed by varying the gas (Argon / Nitrogen) during the sulfurization process to study the effect of thermal conductivity of gas on CZTS layer and cell performance. Cells prepared using nitrogen gas sulfurization is found to be more efficient as compared to argon gas sulfurization. This has been discussed as a function of higher thermal conductivity of nitrogen gas which lead to the larger grain size and so higher short circuit current.

To confirm the effect of thermal conductivity of gas, separate experiments were performed where an independent thermocouple is placed on sample and data recorded with nitrogen and argon gas filled in the sulfurization chamber sequentially. It is found that the temperature on the sample was more in case of nitrogen gas and hence the bigger grain size was achieved.

A highest efficiency of ~5% has been achieved using nitrogen as annealing environment. Characterization of samples were done using XRD, SEM, EDX, Raman, Illuminated I-V measurements etc. These results will be presented and discussed in detail.

Paper ID: P-5035

Area: Photovoltaic Devices

Investigations on the effects of layer parameters and defect density of non-toxic SnSxbased solar cell

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ABSTRACT

Films of tin sulphides (SnSx) are of technological significance since they have the potential for utilization in variety of optoelectronic devices, specially, solar cells. SnS is a prospective candidate for earth-abundant and non-toxic absorber layer in thin film solar cells. On the other hand, SnS2 is being considered as a promising non-toxic buffer layer for solar cells. In this work, we investigate a numerical simulation of SnSx based solar cell using SCAPS-1D (Solar Cell Capacitance Simulator). The device structure of SnSx solar cell, that is SnS/SnS2/i-ZnO, was optimized for the layer parameters; such as thickness, defect density, etc. Results revealed that defect density and thickness of the layers are strongly influenced the power conversion efficiency (PCE) of the device. The defect density fewer than 10^{15} cm-3 and 3 um and 65 nm thickness of the SnS and SnS2 respectively shows high PCE of 23.29% with the Fill factor of 75.14 as shown in Fig. 1. These findings indicate the possibility to design, fabricate and enhance the performance of the environment friendly and non- toxic SnSx based thin film solar cells.

Keywords: *SnS; SnS2; Solar cell; PCE; SCAPS*

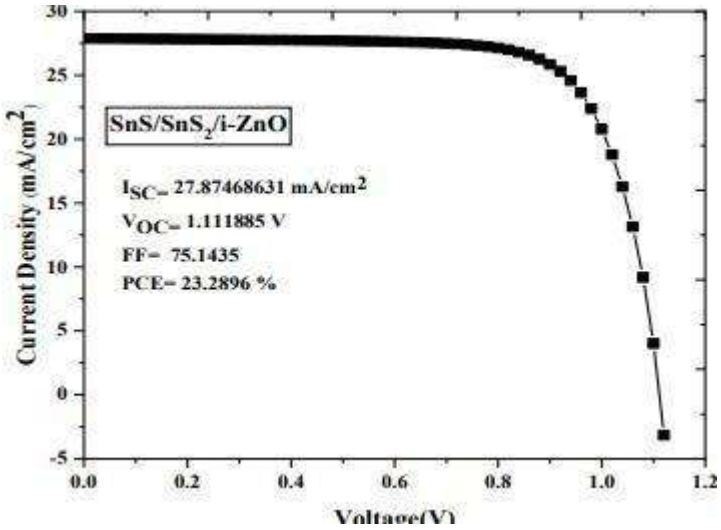

Figure 1: J-V characteristics curve of SnS/SnS2/ZnO photovoltaic devices.

Paper ID: P-5036

Area: Photovoltaic Devices

Machine Learning Assisted Bandgap Tuning to Develop Wide-bandgap Perovskites forSolar Cell Applications

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ABSTRACT

Now, machine learning (ML) methods are significantly increasing the research of Perovskite Solar Cells (PSCs) to discover new perovskite materials and overcome experimental limitations to develop high performance PSCs. Appropriate wide-bandgap perovskite materials need to be selected for the development of highly efficient and stable indoor solar cells, as well as the appropriate top cell absorber for tandem configurations. The permutation of different elements creates enormous material spaces, so choosing appropriate candidates from this pool is a huge task. Bandgap plays an important role in selecting appropriate Perovskite materials because it defines the compatibility of perovskite with the electron transport layer or hole transport layer as a whole. Here, 5 different ML algorithms are applied to train the bandgap prediction model and these are: Linear Regression (LR), Random Forest (RF), Support Vector Regression (SVR), Extreme Gradient Boosting (XGB), and Adaptive Boosting (AdaBoost). The good performances of the models are realized by high Pearson correlation coefficient (r) and small root mean square error (RMSE) value. Each of the algorithms presented good performance while XGB has given the best result with a high r value of 0.98548 and low RMSE of 0.0288 eV. For understanding the effect of every constituent ion in the bandgap value, correlation matrix based on r value is presented in figure 1(a). The bandgap has strong positive correlation with Cl and Br, while it has slight negative correlation with FA, thereby indicating the effect of each ion.

So, the bandgap of a mixed cation mixed halide perovskite can be effectively predicted by ML model and the suitable wide bandgap perovskites can be screened thereafter. Here, we have optimized FA0.75Cs0.25Pb(Br0.8I0.2)3 perovskite film in air ambient conditions. The selected perovskite material presented experimental bandgap of 1.676 eV which is very close to the ML predicted value (1.66 eV). For the preparation of the perovskite film, 1M solution using CsI, FAI, PbI2, and PbBr2 in 4:1 DMF:DMSO solvent was made. 300 µl Chlorobenzene antisolvent was dripped onto the spinning substrate at the 15th second of the last step of the three-step spin coating. Then the substrates were annealed at 140 0C for 30 mins. The obtained perovskite film presented large grain sizes with a smooth surface. The optimized FTO/TiO2/FA0.75Cs0.25Pb(I0.8Br0.2)3/spiro-OMeTAD/Au device has presented a moderate efficiency of 12.76% efficiency with a VOC of 1.09 V under 1 Sun condition (Figure 1(b)). It indicates that the optimized wide bandgap perovskite film will also perform well under indoor light spectrum or as top cell absorber for tandem solar cells. This work presents a route of developing highly efficient PSCs for particular applications, starting from selection of materials by ML-guided bandgap prediction strategy, optimization of the desired wide bandgap perovskite material, and fabrication of the devices intended for indoor applications

Keywords: *Perovskite solar cells, Simulation, $CH_3NH_3SnI_3$, MoO_3, SCAPS-1D.*

Paper ID: P-5037

Area: Photovoltaic Devices

Performance analysis of tin-based perovskite solar cell with MoO_3 as the hole transport layer

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ABSTRACT

In the present work, a solar cell structure $MoO_3/CH_3NH_3SnI_3/TiO_2$/FTO has been simulated in SCAPS-1D with absorber layer $CH_3NH_3SnI_3$, hole transport layer (HTL) MoO_3, electron transport layer (ETL) TiO_2 and window layer FTO. The parameters like thickness, acceptor density, defect densities of the absorber layer as well as HTL and working temperature of the device have been optimized. After optimizing the key parameters, the structure shows best output with Fill factor (FF) 79.17%, Open circuit voltage (V_{oc}) 0.85 V, short circuit current density (J_{sc}) 35.52 mA/cm^2 and efficiency (η) 24.02% at 283.60 K. The obtained results imply that the designed cell performs well at lower temperature region and the device can be implemented for commercial applications.

Keywords: *Perovskite solar cells, Simulation, $CH_3NH_3SnI_3$, MoO_3, SCAPS-1D.*

Paper ID: P-5038

Area: Photovoltaic Devices

A review of thin film solar cell technologies and challenges

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ABSTRACT

Thin film solar cells are favorable because of their minimum material usage and rising efficiencies. The three major thin film solar cell technologies include amorphous silicon (α-Si), copper indium gallium selenide (CIGS), and cadmium telluride (CdTe). In this paper, the evolution of each technology is discussed in both laboratory and commercial settings, and market share and reliability are equally explored. The module efficiencies of CIGS and CdTe technologies almost rival that of crystalline solar cells, which currently possess greater than 55% of the market share. α-Si is plagued with low efficiency and light-induced degradation, so it is almost extinct in terrestrial applications. CIGS and CdTe hold the greatest promise for the future of thin film. Longevity, reliability, consumer confidence and greater investments must be established before thin film solar cells are explored on building integrated photovoltaic systems.

Keywords: *Thin film solar cell, Amorphous silicon (α-Si),CdTe,CIGS*

Paper ID: P-166

Area: Photovoltaic Devices

Thin-Film Solar Cells: An Overview

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Abstract— Thin film solar cells (TFSC) are a promising approach for terrestrial and space photovoltaics and offer a wide variety of choices in terms of the device design and
fabrication. A variety of substrates (flexible or rigid, metal or insulator) can be used
for deposition of different layers (contact, buffer, absorber, reflector, etc.) using different techniques (PVD, CVD, ECD, plasma-based, hybrid, etc.). Such versatility
allows tailoring and engineering of the layers in order to improve device performance.
For large-area devices required for realistic applications, thin-film device fabrication becomes complex and requires proper control over the entire process sequence. Proper understanding of thin-film deposition processes can help in achieving high-efficiency devices over large areas, as has been demonstrated commercially for different cells. Research and development in new, exotic and simple materials and devices, and innovative, but simple manufacturing processes need to be pursued in a focussed manner. Which cell(s) and which technologies will ultimately succeed commercially
continue to be anybody‘s guess, but it would surely be determined by the simplicity of manufacturability and the cost per reliable watt. Cheap and moderately efficient TFSC are expected to receive a due commercial place under the sun.

Keywords— TFSC, PVD, CVD, ECD, plasma-based, hybrid

Paper ID: P-167

Area: Photovoltaic Devices

Synthesis and Characterization of Methylammonium Tin Iodide ($CH_3NH_3SnI_3$) absorber layer for photovoltaic applications

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ABSTRACT

In this work, a halide perovskite i.e. Methylammonium tin iodide ($CH_3NH_3SnI_3$) has been synthesized through chemical route. This synthesis route involves two processes: i) Formation of SnI_2, and ii) Formation of $CH_3NH_3SnI_3$. After synthesis of $CH_3NH_3SnI_3$ powder, thin films were deposited using doctor blade's technique. The compositional, structural and morphological analysis of SnI_2 powder, $CH_3NH_3SnI_3$ powder and $CH_3NH_3SnI_3$ thin films have been studied using EDXRF, XRD and FESEM respectively. The optical properties of the $CH_3NH_3SnI_3$ films were also studied using UV-Vis spectrophotometer. The characterization of the thin films shows an optical bandgap of 1.4 eV with broad absorption, ranging between 300 nm to 900 nm. The morphological study of SnI_2 powder shows rod-like structure with roughness average of 39.38 µm and that of perovskite powder and film shows flake-like structure with roughness average of 42.87 µm and 39.10 µm respectively. A new method of synthesis has been proposed. Also a brief characterization study of SnI_2 powder, $CH_3NH_3SnI_3$ powder and $CH_3NH_3SnI_3$ thin films have been done, in order to analyse the photovoltaic properties of the thin films.

Keywords: *Perovskite solar cells (PSCs), $CH_3NH_3SnI_3$, thin films, chemical route*

Paper ID: P-5041

Area: Photovoltaic Devices

Impact of thin layer of Copper on CdTe thin films

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ABSTRACT

The present paper focuses on the study of influence of copper incorporation in the CdTe films. CdTe absorber layers have been grown by thermal evaporation technique and CdS buffer layers have been deposited by Chemical bath deposition method. Copper incorporated CdTe films have been characterized by X-ray diffraction (XRD), Atomic force microscopy (AFM), Scanning electron microscopy (SEM), UV-Vis spectroscopy, Raman spectroscopy and Hall Effect measurements. XRD analysis illustrated that all the CdTe thin films were of polycrystalline nature possessing cubic structure showing sharp peak at (111) orientation, while the intensities of peaks varied from sample to sample with respect to copper incorporation in the CdTe films. SEM analysis demonstrated that maximum grain size and morphology were dependent on the incorporation of copper on buffer layer. From the AFM results it was observed that the surface roughness of CdTe thin films varied with respect to different copper incorporation in the thin films. From the Raman spectra analysis, it was observed that the intensities of A1, E1 modes of Te and TO modes of CdTe thin films varied with copper incorporated sample displaying maximum intensities of the shoulder peaks followed by other samples. From the optical properties of CdTe thin films it was demonstrated that bandgap of samples slightly decreased with higher copper amount. From the electrical properties of CdTe thin films it was observed that higher mobility and reduced resistivity were observed for copper incorporated samples. Thus, all these characterization results suggest that with controlled amount of copper incorporation these CdTe thin films possess the potential to be used as absorber layer for solar cells.

Keywords: *CdTe thin films, Copper incorporation, XRD analysis, SEM analysis, Raman spectra*

Paper ID: Q-6001

Area: Semiconductors for Quantum Technologies

Characterization of hybrid (CuPc and CdSe QDs) composite layers

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Semiconductor Quantum Dots (QDs) have proven the essential component in composites to tailor the various properties. We have reported the synthesis of cadmium selenide (CdSe) QDs by simple solvothermal route. The composite layers of copper phthalocyanine (CuPc) and CdSe QDs were prepared by spin coating and studied various properties. The synthesis of uniform, narrow size distributed CdSe QDs were confirmed by UV-Vis, and TEM images. The XRD pattern of CdSe composite represents cubic crystal structure with diffraction plane of (111), (220) and (311). The peaks associated with CuPc were observed at lower angles. A systematic clear enhancement in optical absorption of the visible region was directly proportional to the concentration of CdSe in the composite layer. The thermo-gravimetric analysis confirms a noteworthy enhancement in the thermal stability of composite layers in comparison with the pristine CuPc. The concentration of CdSe QDs in composite also controlled the surface morphology. The efficient charge separation between QDs and polymer is due to maximized interface between them which enhances the charge transport for the development of high efficiency hybrid solar cell devices.

Paper ID: Q-6002

Area: Semiconductors for quantum Technologies

Fabrication and Study of ITO/TiO_2/CdS:Fe Quantum Dot Heterostructure Rectifying Diode

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The field of single dot semiconducting electronics is growing remarkably fast since the last decade by improving device fabrication techniques. TiO_2 and CdS:Fe quantum dots (QDs) have been synthesized by hot-injection method. Samples are characterized by X-ray diffraction (XRD), Transmission electron microscopy (TEM). The optical absorption and band gap have been estimated from UV-Vis spectra. The photoluminescence spectra have been measured to study the luminescence properties, defect states, and oxygen vacancy present in samples. The ITO/TiO_2/CdS:Fe quantum dot heterostructures rectifying diodes were grown by spin coating and are studied by scanning tunneling microscopy (STM) at ambient temperature. Scanning tunneling spectroscopy (STS) has been used for investigation of rectification properties of single-dot diodes. The images reveal individual CdS QDs having a spherical shape with maximum diameter of 4 nm. The threshold voltage has been tuned from 1.62 eV to 0.33 eV which makes the diode useful for daily life electronics with low power consume.

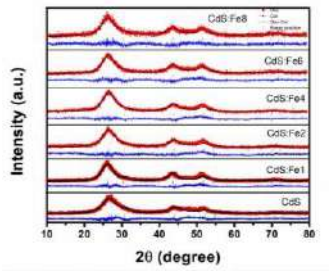
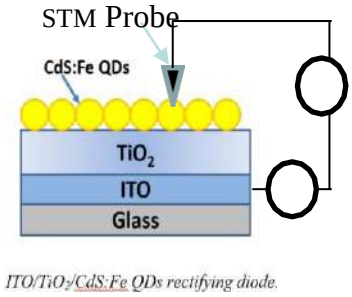


Fig. 1XRD patterns



ITO/TiO_2/CdS:Fe QDs rectifying diode.

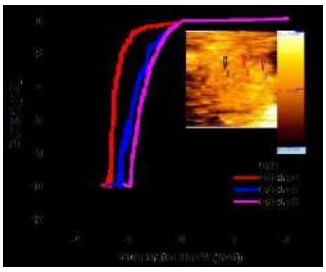


Fig.3.: Rectifying behavior

Paper ID: W-1001

Area: Wide band gap semiconductors

Optical and theoretical investigations of GeTeSe and $Te_{(0.9)}(GeSe_{0.5})Sc_{0.1}$ chalcogenide glasses for IR applications

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The study reports the optical parameters (%T, α, k, n, Eg) for thermally evaporated thin films of GeTeSe and $Te_{(0.9)}(GeSe_{0.5})Sc_{0.1}$ chalcogenide alloys. The samples were prepared using melt-quench technique and thin films were deposited using thermal evaporation technique under 10^{-5} mbar and at room temperature. X-rays diffraction (XRD) analysis was done structural investigation and amorphous nature was revealed. SEM and EDX measurements were done for surface morphology and element composition analysis respectively. Optical band gap (Tauc gap) was found to be more than ternary thin films and this increase has been explained by electronegativity of glassy alloys. Double beam spectrophotometer was used for UV-Visible spectroscopy in the range 200-2800 nm for studying absorption parameters, refractive index, bandgap, etc. The optical parameters data has been determined by using the Tauc's relation. The physical properties such as density (ρth), molar volume (Vm), compactness (δ) has also been calculated for the system. Conduction band and valence band positions have also been investigated and relation between refractive index (n) and Eg has been established. The results indicate that GeTeSe and $Te_{(0.9)}(GeSe_{0.5})Sc_{0.1}$ are suitable for various IR applications such as optical storage memory devices, sensors, etc.

Keywords: *Chalcogenide glasses, thin films, optical parameters, energy bandgap, optical storage devices.*

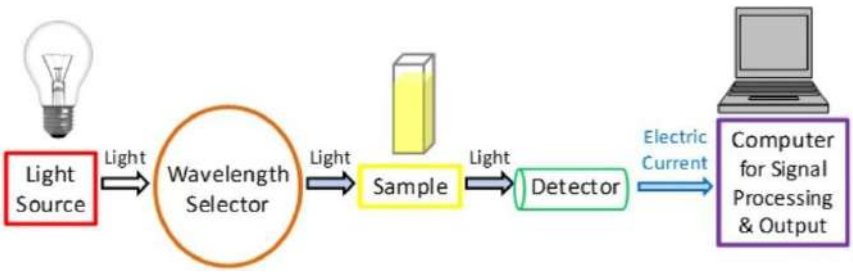

Figure 1: UV-Visible Spectroscopy schematic

Paper ID: W-1002

Area: Wide band gap semiconductors

Electrically Active Traps in Bipolar 10 kV 8 A Silicon Carbide (SiC) PiN Diodes

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4H-Silicon Carbide (4H-SiC) bipolar PiN diode rectifiers demonstrated ultra-high breakdown voltage (V_{BR} > 10 kV), high current handling capability (> 8 A), low reverse leakage current, and drift conductivity modulation, as compared to the well-developed 4H-SiC Schottky barrier diodes (SBDs). The concentration of the performance-limiting trap such as $Z_{1/2}$ (E_C – 0.67 eV) in the n-type 4H-SiC epilayer has been considerably reduced (< 5×10^{12} cm^{-3}) in recent years. The PiN diode structure integrates double p-type layers (p and p^+). The p-type 4H-SiC layer quality is sub-standard than the n-type. The periphery protection was realized by Al^+ ion-implantation (p^+). The ion-implantation-induced crystal defects introduce electrically active traps and affect the PiN diode characteristics via charge trapping. So, this work focuses on identifying the traps in the 4H-SiC PiN diodes by deep-level transient Fourier spectroscopy (DLTFS).

The 4H-SiC PiN diodes with a DC blocking voltage of 10 kV and a continuous forward current of 8 A were used for this study. The active area of the diodes is about 8.69 mm^2. The junction termination extension (JTE) technique was employed in the diode structure to mitigate the electric field crowding at the junction edges (p^+ periphery production), thus yielding theoretically anticipated on-state and off-state performance.

The forward voltage drop across the diode at 1 mA is ~2.6 V. It is found that negligible current flow occurs for low forward bias < 1.6 V, then the diffusion current governs the forward current up to 2.7 V, beyond that series resistance effect comes into the picture. The diode exhibits a low reverse leakage current < 0.5 nA at -200 V. It is noted that the forward voltage drop decreases with the temperature rise due to the increase in intrinsic carrier concentration, at the same time on-state current increases; thus on-state conduction losses reduce with temperature. The reverse I-V (0 V to -200 V) remains unchanged even at 150°C, signifying the effectiveness of 4H-SiC PiN diodes for the elevated temperature operation.

Figure 1 shows the capacitance-DLTFS spectra acquired at two different emission transients (T_E = 20.48 ms and 2.048 s). In our measurements, positive and negative DLTFS peaks correspond to electron trap (located below conduction band E_C - E_T) and hole trap (i.e. E_V + E_T), respectively. Three hole traps H1 at E_V + 0.16 eV, H2 at E_V + 0.3 eV, and H3 at E_V + 0.63 eV and two electron traps E1 at E_C – 0.19 eV and E2 at E_C – 0.67 eV are identified in PiN diodes using Arrhenius analysis. Among these, electron traps E_C – 0.19 eV (Ti) and E_C – 0.67 eV ($Z_{1/2}$) are omnipresent defects in the n-type 4H-SiC layer. The hole traps namely E_V + 0.16 eV, E_V + 0.3 eV, and E_V + 0.63 eV may be originated from the ion-implanted p^+ JTE region.

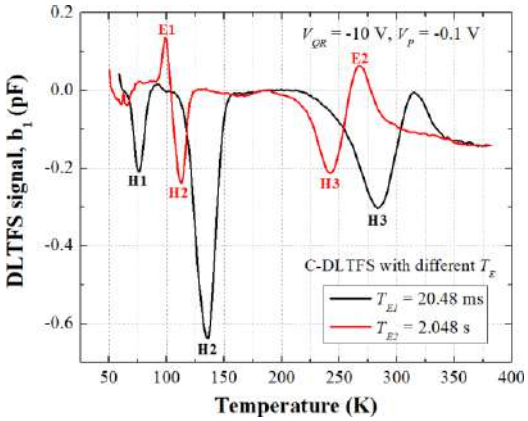

Figure 1: Capacitance-DLTFS spectra acquired at two different emission transients (*TE* = 20.48 ms, 2.048 s) reveal three hole traps H1, H2, H3, and two electron traps E1 and E2 in the 4H-SiC PiN diodes.

Paper ID: W-1003
Area: Wide bandgap semiconductors

Tuning the optical properties in Al-doped gallium oxide thin films deposited by RF/DC magneton sputtering

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Thin films of aluminium(Al)-doped gallium oxide are of vital importance in optical applications. Pure and Al-doped gallium oxide thin films were coated on glass substrate by RF/DC magneton sputtering method. Doping has been carried out at different time intervals since the last few minutes (5,10 and 15 minutes) of sputtering. Structural, morphological, compositional and optical properties of pure and Al doped gallium oxide films were studied. Thickness and refractive index of the films were investigated from spectroscopic ellipsometry (SE).X-ray diffraction patterns reveal that the films are amorphous in nature. SEM images show that the films exhibit grains of uniform size which are agglomerated for films with increasing dopant concentration and the elemental compositional studies of Al-doped gallium oxide thin films were confirmed using EDAX analysis. The UV-Visible spectrophotometric findings show that the transmittance of deposited films decrease with increasing dopant sputtering time and the optical bandgap of the films decreases from 5.03 to 4.97 eV.

Paper ID: W-1004

Area: Wide band gap semiconductors

Role of deposition parameters on optoelectronic properties of ITO thin films prepared by rf- sputtering technique

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Abstract

Transparent Conducting Oxides (TCOs) play an important role in optoelectronic devices. These materials are electrically conductive and have low absorption of solar spectrum in the visible region. Indium Tin Oxide (ITO) is widely used as a TCO electrode in solar cells due to its higher band gap (~3eV) and conductive nature. Here, optical and electrical properties of ITO thin films are studied by varying the process pressure and deposition temperature. ITO thin films are deposited on 1737 corning substrate using rf-sputtering by varying the process pressure from 9.3×10^{-3} mbar to 3.8×10^{-3} mbar and deposition temperature from 130°C to 200°C.

Two sets of series are prepared i.e.

(4) Process Pressure Variation

In this series, films are deposited at 150°C temperature, 7sccm Argon flow rate and 80W RF power for 30 minutes by varying process pressure. UV-Vis spectra show that ITO films have maximum transmission of ~90% in transparent region and band gap of ~3.70 eV. XRD data show sharp peaks, which represent that deposited films are compact and crystalline in nature. Thickness of films has increased and sheet resistance has decreased when the process pressure is decreased from 9.3×10^{-3} mbar to 3.8×10^{-3} mbar. Lower collision probability and higher mean free path of atomic species in the chamber at 3.8×10^{-3} mbar is the reason for obtaining higher deposition rate at this pressure. These results suggest that lower pressure is good for depositing ITO films. The deposition parameters, band gap, sheet resistance and thickness of ITO films are mentioned in table 1.

(5) Deposition Temperature Variation

In this series, only the deposition temperature is varied from 130°C to 200°C at 3.8×10^{-3} mbar pressure, keeping other parameters constant as mentioned in the previous section. ITO films prepared at all temperatures have shown crystalline nature. Thickness of ITO films have increased and sheet resistance is decreased as temperature is increased from 130°C to 170°C however decrease in thickness and increase in sheet resistance is observed when deposition temperature is raised to 200°C. All films have ~90% transmission in transparent region (400 nm – 800 nm). The deposition parameters, band gap, sheet resistance and thickness of ITO films are mentioned in table 2.

From these studies, it is concluded that ITO films prepared at 150°C temperature and 3.8×10^{-3} mbar pressure have shown good transparency (~90%), lower sheet resistance (11Ω/Sq) and good crystallinity. These optimized conditions will be used for fabricating solar cells.

Table 1. Deposition conditions for variation in pressure

Sample Name	Pressure (mbar)	Band gap (eV)	Sheet Resistance (Ω/Sq)	Thickness by Profilometer (nm)	Thickness by Swanepoel Method (nm)
SP861	9.3×10^{-3}	3.71	76	345	327
SP864	5.3×10^{-3}	3.73	23	538	555

SP865	3.8×10^{-3}	3.76	11	624	621

Table 2. Deposition conditions for variation in temperature

Sample Name	Substrate Temperature (°C)	Band gap (eV)	Sheet Resistance (Ω/Sq)	Thickness by Profilometer (nm)	Thickness by Swanepoel Method (nm)
SP867	130	3.73	17	592	528
SP865	150	3.76	11	624	621
SP868	170	3.63	10	630	643
SP769	200	3.71	15	598	581

Paper ID: W-1005

Area: Wide band gap semiconductors

Design Considerations to Enhance 2DEG Charge Density in δ-doped *β*-(AlxGa1-x)2O3/Ga2O3

HFET

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β-Ga2O3 based FETs have recently gained popularity due to its ultra-wide bandgap with high breakdown voltage, which results in high Baliga's Figure of Merit (BFoM)[1]. Development of *β*-(AlxGa1- x)2O3/Ga2O3 heterostructure FETs surfaced specifically to enhance the mobility due to 2DEG charge density. Higher 2DEG charge density is essential to improve the mobility. The current study focuses on design consideration involving various device parameters to enhance 2DEG charge density. Figure 1 shows the schematic of δ-doped *β*-(AlxGa1-x)2O3/Ga2O3 heterostructure consists of undoped *β*-(AlxGa1-x)2O3 layer of thickness d over bulk *β*-Ga2O3 layer. A thin sheet of dopant (δ-doping) has been placed at a spacer distance d_s from the interface, in *β*-(AlxGa1-x)2O3 layer. The undoped spacer layer above the heterojunction helps to improve mobility by reducing ionization scattering due to dopant layer. In this work, a unified analytical model is used to study the effect of variation of spacer thickness d_s, barrier thickness db, Al content (x%) and δ-doping density on 2DEG charge density. The unified model has been developed in continuation of our previous work of region-based 2DEG charge density[2], obtained using the Poisson's- Schrodinger(1) and Fermi-Dirac statistics equations(2)[3]. Figure 2 shows that, as we increase the spacer thickness (d_s), the 2DEG charge density decreases because of reduction of proximity of dopants from the heterointerface. This signifies the adverse effect of increasing spacer thickness on 2DEG charge density. Fig. 3 shows the effect of spacer thickness and doping density variation on 2DEG charge density. As the doping density increases, more 2DEG charge density gets accumulated. From this analysis, it can be concluded that there reduced spacer thickness and high doping density is conducive to enhance the 2DEG charge density.

$$n_s = \frac{\epsilon V_g'}{qd}\left(1 - \frac{V_{th}\ln\left(\frac{\beta V_g'}{2} + \alpha\left(e^{\beta V_g'} - \frac{\beta V_g'}{2}\right)\right) + \gamma_{nu}\left(\frac{C_0 V_g'}{q}\right)^{2/3}}{V_{th}\ln\left(e^{\beta V_g'} + \alpha\left(e - e^{\beta V_g'}\right)\right) + V_g' + \frac{2\gamma_{nu}}{3}\left(\frac{C_0 V_g'}{q}\right)^{2/3}}\right)$$

$$V_{off} = \emptyset_m - \frac{\Delta E_c}{q} - \frac{q n_\delta d_b}{\epsilon}$$

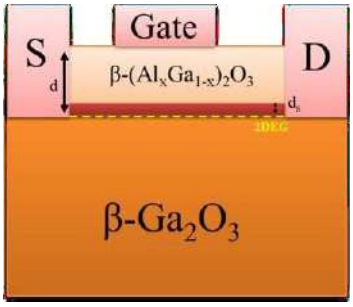


Fig. 1 Schematic diagram of β-(AlxGa1-x)2O3/Ga2O3 with spacer layer of thickness d_s

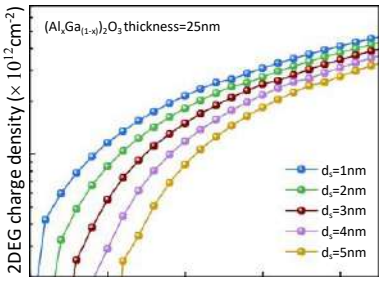
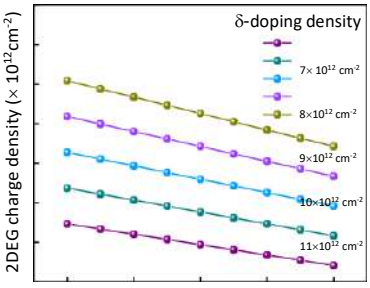


Fig. 2 Variation of 2DEG charge density with gate voltage for different thickness of spacer layer



Paper ID: W-1007

Area: Wide bandgap semiconductors

Investigation of near infrared reflecting properties of hydrothermally synthesized tungsten oxide nanopowders for cool roof coating applications

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Abstract

Tungsten oxide is one of the most promising n-type semiconductor material having wide tunable bandgap (2.5-3.7 eV) and have potential application as an energy conserving near infrared (NIR) shielding material. In this work, nanostructured hydrated tungsten oxides were synthesized using simple hydrothermal method and the samples were calcined at 300 °C, 600 °C, 700 °C, 800 °C and 900 °C for 1 hr. The thermal properties of the samples were characterized by thermogravimetric (TG) and differential scanning calorimetric (DSC) analysis. The structural, morphological, compositional and optical properties of the samples were characterized using X- ray diffraction (XRD), Raman spectroscopy, fourier transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM), energy dispersive spectroscopy (EDS), UV-Vis-NIR spectrophotometer and CIE L*a*b* color analysis. Structural analysis revealed that above 300 °C the nanoparticles completely oxidised to form crystalline monoclinic tungsten oxide. From the transmittance spectra, the samples calcined at 600 °C showed maximum NIR reflectance value of ~91% (at 1100 nm) with good color performance (L* = 70.21, a* = -4.28, b* = 22.47, h = 79.21, C* = 22.87), thereafter the NIR reflectance decreases. As the calcination temperature increases, the oxygen vacancies increases thereby polaron absorption and resonant absorption in the NIR region increases and NIR reflectance decreases. The present work provides new insight in to developing near infrared (NIR) reflecting tungsten oxide nanopowders to be used as environmental friendly cool materials for roofing in buildings with energy saving performance.

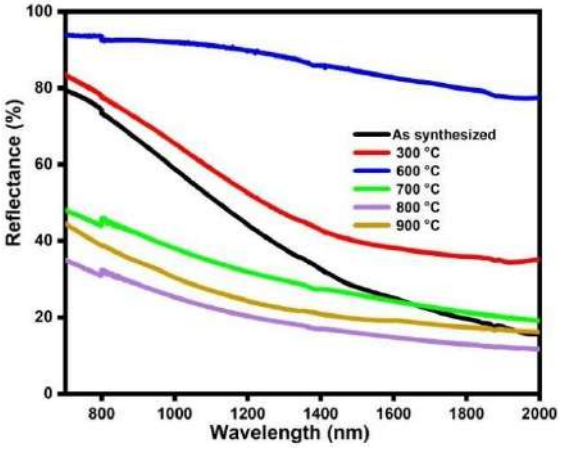

Figure 1: NIR reflectance spectra of as-synthesized and annealed samples.

Paper ID: W-1008

Area: Wide Band Gap Semiconductors / Semiconductor Device Modeling and Simulation

Investigation of Performance Enhancement of Recessed Gate Field-Plated AlGaN/AlN/GaN Nano-HEMT on β-Ga2O3 Substrate with Variation of AlN Spacer Layer Thickness

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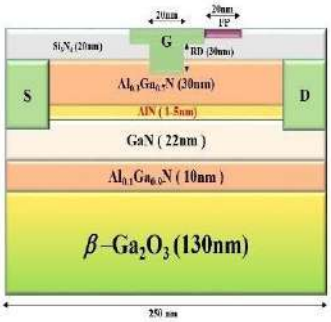
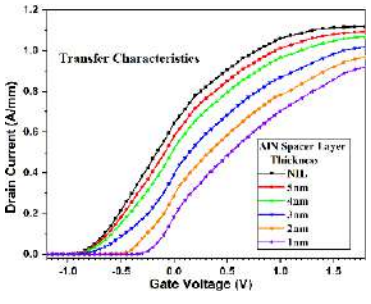
Group III-nitride compounds have aroused interest for the past couple of decades, not only because of their broad availability but also their unique characteristics. AlGaN/GaN HEMT is one of the most widely proven device that can be used in numerous nanotechnology applications due to its robust high power and high-frequency capabilities. However, more scientific innovations are required to produce high-performance, robust, and economical devices. The proposed III- Nitride Nano-HEMT is grown on **β-Ga2O3** substrate with a spacer layer between AlGaN and GaN layers. The study is conducted using the TCAD Atlas software.

GaN HEMTs, are developed on substrates like Si, Sapphire, and SiC, are suffering with lattice mismatch with GaN. When lattice discrepancy arises, traps development which cause a decrease in 2DEG density, raise the ON resistance, and nonlinearity at high power. The newly emerging material **β-Ga2O3** can be employed as a substrate for AlGaN/GaN HEMT due to its reduced 2.8% lattice mismatch with GaN. The **β-Ga2O3** substrates are excellent for RF & power electronics applications because of their low cost, high-quality native, and wide bandgap.

The major findings of this research demonstrate that the AlN spacer layer's large band off set, strong polarization field, and high barrier allow the increased concentration of the 2DEG, when it is introduced between AlGaN/GaN interface. Furthermore, the AlN layer moves the 2DEG distribution shifts from the surface, which diminishes interface scattering. AlGaN/GaN HEMT with an AlN spacer layer exhibits superior mobility, breakdown, and RF characteristics as compared to conventional HEMTs. Further, AlN thickness variation influences the polarization field and conduction band offset, which impacts the concentration and mobility of 2DEG.





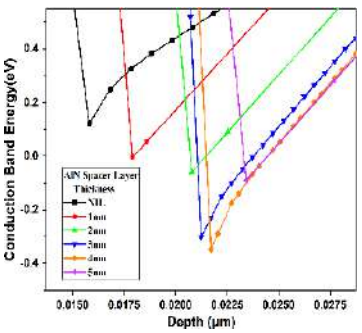
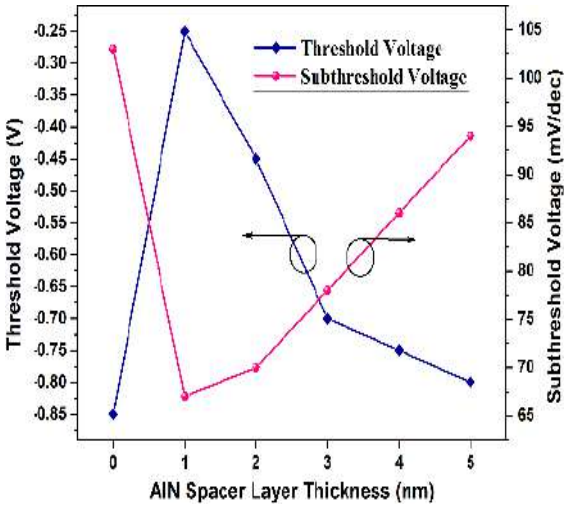


Figure 1: The proposed III-Nitride HEMT Figure 2: Transfer Characteristics Figure 3: Quantum well depth



on β-Ga2O3 substrate with AlN Spacer Layer

Figure 4: Threshold Voltage & Subthreshold Voltage Characteristics

Breakdown & RFCharacteristics

Table 1: Simulated results of transport Characteristics,

AlN layer thickness	**2DEG Depth (eV)**	**Electron Density (x 10^{19} cm^{-3})**	**Mobility ($cm^2v^{-1}s^{-1}$)**	**Breakdown Voltage (V)**	**Cut-off Frequency (GHz)**	**Maximum Frequency (GHz)**	
Without	0.0034	16.4	1145	118	192	248	
1nm	0.014	18.3	1241	145	305	424	
2nm	0.052	18.9	**1261**	149	**384**	**546**	
3nm	0.0886	19.1	1255	155	330	492	
4nm	0.303	19.8	1252	162	322	485	
5nm	**0.35**	**19.9**	1248	**168**	314	472	

Paper ID: W-181

Area: Wide Band Gap Semiconductor.

Influence of Reduced Graphene content on Dielectric, Optical Energy Band Gap, and I-V Characteristics of PVDF/PANI/RGO Nanocomposites

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Abstract

This analysis explores the significant enhancement in dielectric performance, I-V characteristics, optical energy band gap and thermal properties of reduced graphene oxide (RGO) based poly(vinylidene fluoride) (PVDF)/polyaniline (PANI) blend nanocomposites. The dispersion pattern of RGO and PANI phases in the bulk of PVDF has been analyzed from the photomicrographs obtained from the field emission scanning electron microscopy (FESEM) studies. The effect of ionic liquid (IL) such as 1-Butyl-3-methylimidazolium hexa-fluoro phosphate on the dispersion pattern of the PANI and RGO phases in the interface has also been analyzed from the photomicrographs obtained.The informative morphology recorded for the fabricated nanocomposite systems are correlated with the dielectric relaxation performance, optical energy band gap and *I-V* characteristics. The excellent dielectric properties such as high dielectric permittivity (ε'), adequate AC conductivity (ζ_{ac}), and required impedance (both real and imaginary) of the fabricated conductive nanocomposite systems have been explored in a wide range of frequency (1 Hz to 10^6 Hz) of the applied electric field. The effects of IL on the above dielectric properties are also explored and the result obtained particularly for ε' in presence of IL ensures the effortless polarization of the dipoles.The non-linear *I-V* characteristics behaviour indicates the disordered structure of crystalline RGO and PANI nano particulates separated by insulating and semicrystalline PVDF matrix. The shifting of the optical energy band gap towards lower photon energy on increasing the addition of RGO loading level obtained from the optical energy band gap study reveals the alteration of energy states in between the conduction band and valence band upon 0.25 wt% of RGO incorporation. The effect of RGO and IL on the thermal properties of developed nanocomposites has been explored using thermogravimetric analysis (TGA) and differential scanning calorimetry (DSC) techniques.

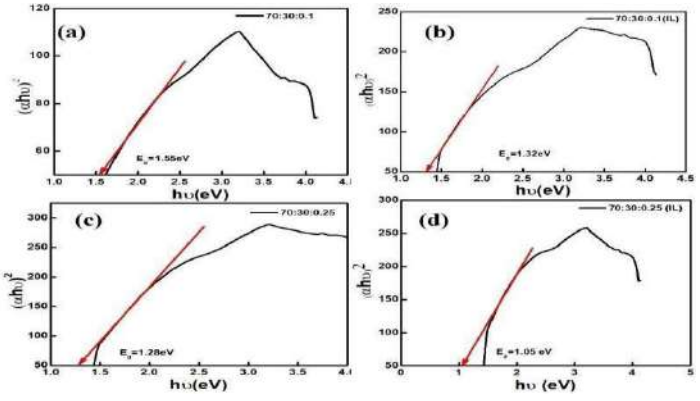

Fig.1 Optical Energy Band Gap of the Fabricated Nanocomposites

Paper ID: W-182

Area : Wide Bandgap semiconductors

Camelia Sinensis assisted Green synthesized Ag decoration on Ag doped TiO_2 : excellent Photocatalyst

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Abstract

A heterosystem Ag decorated Ag doped TiO_2 with UV–Visible-NIR light gathering quality was designed and synthesized by optimization of the different constituents of the heterosystems. Here Ag doped TiO_2 quantum dots were synthesized using solvothermal methods, then green synthesis method was employed to decorate the Ag nanoparticles on the Ag doped TiO_2. TiO_2 quantum dot exhibited band gap ~ 2 eV due to presence of defect related energy states between conduction and valence bands of TiO_2, it was narrowed to 1.75 eV in Ag doped TiO_2 by introducing Ag 4s energy states near the conduction band of TiO_2. Finally Ag decoration on the doped TiO_2 stimuluses the charge transfer between duo, lowers the band bap of the whole system near 1.57 eV. The Ag doped TiO_2 exhibited 60% photocatalytic efficiency toward degradation of safranin O (SO) dye under 60 mins white light illumination, as doped TiO_2 suffers recombination loss of photogenerated charges due to trapped states arising from highly concentrated defects in TiO_2 quantum dots. Prompt transfer of photogenerated electrons from Ag doped TiO_2 to Ag nanoparticles in the heterosystem reduces the recombination loss, as a consequence an ample of electrons are available at the surface of Ag nanoparticles, while holes are present at the surface of Ag doped TiO_2. That generates oxide and hydroxide super radicals on the aqueous system of photocatalyst, resulting 80% degradation of SO dye under 60 mins white light illumination. The photocatalytic activity of the synthesized heterosystem was also studied with different dyes Mordant Orange (MO), and Blue (DB) together with SO dye. DFT analysis of the geometrical- relaxed structure Ag doped TiO_2 and the heterosystem Ag-Ag doped TiO_2 supports the absorptivity tuning of experimentally obtained heterosystems. Broad absorption of the heterosystem was well explained by computed density of states (DOS) of the materials. Proper designing and synthesizing the hetero-systems explored a green, inexpensive UV–Visible-NIR photocatalyst for industrial waste management.

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Paper ID: W-183

Area: Wide band gap semiconductors

Realizing bright green luminescence in SrWO4:Ho^{3+} phosphors for solid state lighting

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The article reports the structural and luminescence properties of Ho^{3+} activated SrWO4 phosphors synthesized in microstructural form. The crystallization of the materials took place in a tetragonal structure following the space group I41/a. The detailed structural properties are visualised by performing the Reitveld refinement of the collected X-ray diffraction patterns. The characteristic infrared vibrational bands corresponding to the W-O and O-W-O stretching vibrations of $[WO4]^{2-}$ group are identified at 409 and 821 cm^{-1}. The oxidation states of the elements Sr, W, O and Ho are ensured by analysing their respective 3d, 4f, 1s and 4d high resolution XPS spectra. The photoluminescence excitation peaks for the phosphors are established at 348, 361, 398, 418, 452, 468, 474 and 487 nm in near-UV and blue ranges. The 452 nm is the strongest among all the excitation peaks. Hence, the excitation by 452 nm will yield the brightest luminescence. The photoluminescence emission spectra observed at 452 nm excitation are given in fig. 1. The luminescence performance is maximized by varying the amount of Ho^{3+} ions inside the lattice. The emission spectra of all the phosphors show five peaks at 487, 544, 617, 657 and 754 nm. The emission peak in the green region at 544 is much intense in comparison to all other emission peaks. Therefore, the green light is emitted by all the samples with good color purity. The maximum emission is revealed by the sample having 0.5 mol% Ho^{3+} concentration. At concentrations above 0.5 mol%, dipole-dipole interactions among very closely located Ho^{3+} ions result in luminescence quenching. The decay times of the electrons in the excited state corresponding to the 544 nm peak lie between 9.084 to 9.866 ms. The affirmative results promote the interest of researchers in SrWO4:Ho^{3+} green-emitting phosphors.

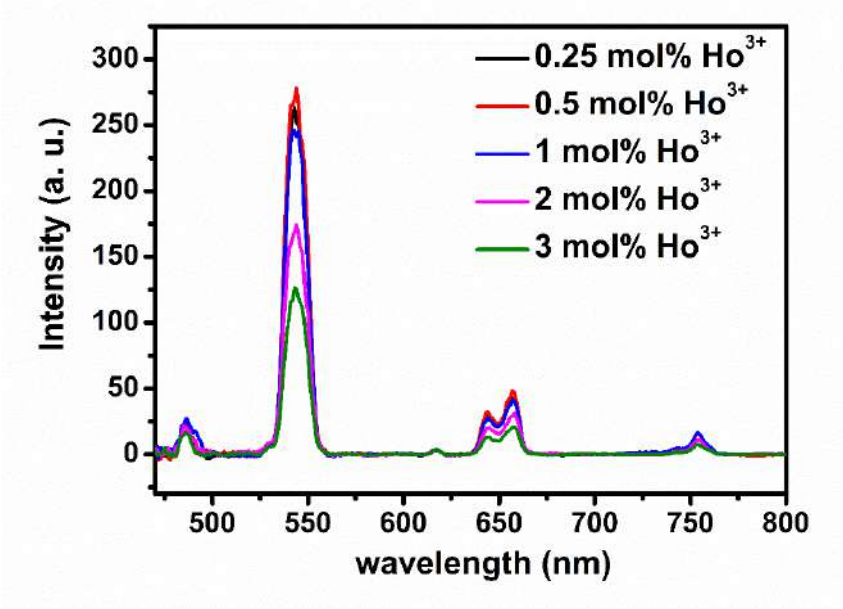

Figure 1 Photoluminescence emission spectra of SrWO4:Ho^{3+} phosphors with different Ho^{3+} concentrations

Paper ID: W-1013

Area: Wide band gap semiconductors

Synthesis of multipurpose KYF4:Ho^{3+}/Yb^{3+} upconversion nanoparticles for fingerprint detection, optical thermometry, and anti-counterfeiting applications

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This work reports the synthesis and upconversion study of hexagonal KYF4:Ho^{3+}/Yb^{3+} nanoparticles for latent fingerprint detection, optical thermometry, and anti-counterfeiting applications. The nanoparticles are synthesized in an oleic acid and 1-octadecane medium at 300^0C in an inert atmosphere via the thermal decomposition reaction method. The synthesized nanoparticles crystallize in the hexagonal phase and utilize an anti-stoke phenomenon called upconversion to show intense green and red emissions under excitation by near-infrared radiation (NIR) at a very low power density of 2.5 mW/cm^2. The UC spectrum is shown in figure 1. The intense green and red emissions at 538 nm and 657 nm are due to the transition from excited ^{5}F4 (^{5}S2) and ^{5}F5 levels to ground ^{5}I8 levels of Ho^{3+} ions. Excitation power-dependent spectra revealed the energy transfer mechanism in synthesized nanoparticles. The nanoparticles are very stable in various polar and non-polar mediums which is beneficial to prepare security inks for various anti-counterfeiting applications. Temperature-dependent UC spectra show excellent temperature sensing ability which could pave the way to preparing an efficient optical thermometer. The synthesized nanoparticle is tested for fingerprint detection and as security ink for anti-counterfeiting applications. The NIR illumination provided a clear bright image with good contrast in fingerprint and written words using nanoparticles.

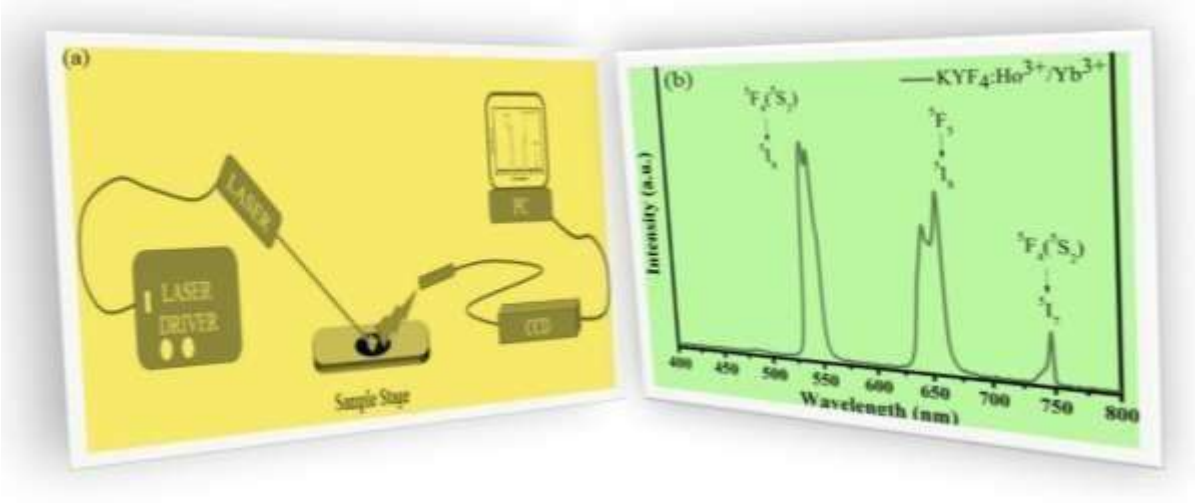

Figure 1. (a) Schematic of an experimental setup for UC emission study and (b) UC emission spectrum of synthesized KYF4:Ho^{3+}/Yb^{3+} nanoparticles.

Paper ID: W-1014

Area: Wide Band Gap Semiconductor.

Exploring the Effects of Ultra low loading level of Silver Oxide Nanoparticles on the Dielectric, I-V Characteristics and Optical Energy Band Gap of Thermoplastic Polyurethane and Poly-aniline Blend Nanocomposites

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Abstract

This study deals with the exploration of ultra low loading level of Silver oxide (Ag_2O) nanopartilces on the materials properties such as dielectric, I-V characteristics and optical energy band gap of theromplastic polyurethane (TPU) and Polyaniline (PANI) blemd nanocomposites. The nanocomposites with varying the loading level of Ag_2O nanoparticles have been fabricated using the most simplified solvent casting technique. The dispersion pattern of Ag_2O phase in the vicinity of the TPU and PANI matric has been observed from the high resolution transmission electron microscopic (HRTEM) analysis. The dielectric properties like dielectric permittivity (ε'), AC conductivity (ζ_{ac}), real and imaginary impedance (Z' and Z''), Nyquist plot etc., of the fabricated nanocomposites have been explored in a wide range of frequency of the applied electric field (1 -10^6Hz). The significant improvement in ε' with 3wt% loading level of Ag_2O is one of the outstanding findings of the today research work. The obtained I-V characteristics indicates the formation of dielectric materials with psudo-metallic behaviour. The decrease in optical energy band gap with addition Ag_2O ensures the suitability of the fabricated nanocomposites to be used construction of the solar cell. Dielectric properties ensures the suitability of the materials to be used in the construction of buffer layer of solar cell, fabrication of EMI shielding panels to be used in heavy electronics where the radiation leakage is very frequent.

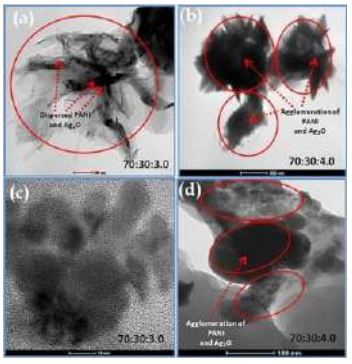

Fig.1 HRTEM photomicrograph of TPU/PANI?Ag_2O nanocomposites

Paper ID: W-186

Area: Wide band gap semiconductors.

Probing of Barrier Inhomogeneity at Metal/Ga_2O_3 Interfaces using Nanoscopic Electrical Characterizations

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In the present work, we have investigated the barrier inhomogeneity in metal/Ga_2O_3 interfaces by carrying out the nanoscopic electrical characterizations using conducting atomic force microscopy (CAFM). Vertical nanoscale Schottky barrier diodes (SBDs) were formed by using the full backside ohmic contact with front side Schottky contacts (SCs) using CAFM tips directly. The AFM tips were made of silicon nitride coated with Pt-Ir. Localized current-voltage characteristics of nanoscale Schottky contacts were performed at different random locations and modelled using thermionic emission current transport mechanism to find out the individual SBHs and ideality factors. The SBHs of individual nanoscale Schottky contacts reflected a distribution, which was suggestive of the presence of barrier inhomogeneities at the metal-semiconductor (MS) interface. The distribution of SBHs in nanoscale SCs was fitted with a Gaussian function, and a mean barrier height of 0.67 eV with a standard deviation of 35 meV was found. A high rectification of order of 10^4 was also observed. This study demonstrated the direct investigation of barrier inhomogeneity at nanoscale dimensions at the MS interface using CAFM techniques.

Paper ID: W-187

Area- Wide band gap semiconductor

Effect of bumped band edge structure on the electronic dispersion and some related properties of Tin Europium Telluride

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We studied the $k.\pi$ band dispersion of a six level double group basis including bumped band edge states for $Sn_{1-x}Eu_xTe$. The special significance of bumped structure adheres to the inversion of and basis states of pristine SnTe material at x=0.01 of Europium content in $Sn_{1-x}Eu_xTe$. We explored significantly the electronic properties like density of states (DOS), effective g-factor and effective mass for different ranges of Eu impurity with temperature. For bumped band (BB) structure ($0 \leq x \leq 0.01$) the behaviour was found to be opposite to that of normal band (NB) structure. We found, there is significant increase in DOS (30% at T=300K) at Fermi energy and effective mass with the increase in temperature for BB structure as compared to NB structure. The temperature range is considered from T=100K to 400K. The material $Sn_{1-x}Eu_xTe$ can be found suitable for thermoelectric power factor enhancement due to significant rise in DOS and effective mass in the concentration range with increase in temperature. The observed trends and results are in agreement with experimental findings whenever available.

Keywords: Bumped Band, band dispersion, DOS, Fermi energy, Effective mass

Paper ID: W-1017

Area: Wide band gap semiconductors.

Radiation hardness of gamma irradiated MOCVD grown β-Ga_2O_3 deep UV photodetectors

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Recently, β-Ga_2O_3 with large energy gap of ~4.9 eV has led to its probable usage in solar-blind photodetectors (SBPDs). β-Ga_2O_3 (1.1 μm) thinfilms were deposited on a c-plane sapphire substrate using MOCVD. The interdigitated electrodes of Ni/Au were deposited on the surface of β-Ga_2O_3 for fabricating metal- semiconductor-metal (MSM) SBPDs. 10^6 times the photo to dark current ratio (PDCR) was observed. The high responsivity of 71 mA/W with detectivity of 6.9×10^{16} Jones was calculated at 10 V. The Noise equivalent power (NEP) is estimated to be 1.6×10^{16} W/$Hz^{1/2}$ and the gain was estimated to be 360 at 10 V. Until 300 kGy of gamma dose, there was no change. However, at 500 kGy the changes are slightly significant compared to the pristine data. The PDCR value was estimated to be around the pristine value. The responsivity value was observed at 107 mA/W with detectivity value 9.1×10^{16} Jones was estimated at 10 V. The Noise equivalent power (NEP) was estimated to be 1.2×10^{16} W/$Hz^{1/2}$ and the gain was estimated to be 545 at 10 V. The rejection ratio (R260/R500) $\times10^6$) of the pristine device was found at 1.7 whereas it was decreased to 1.4 for 500 kGy dose. However, morphologically and in terms of device functioning, the deterioration was partially negligible.

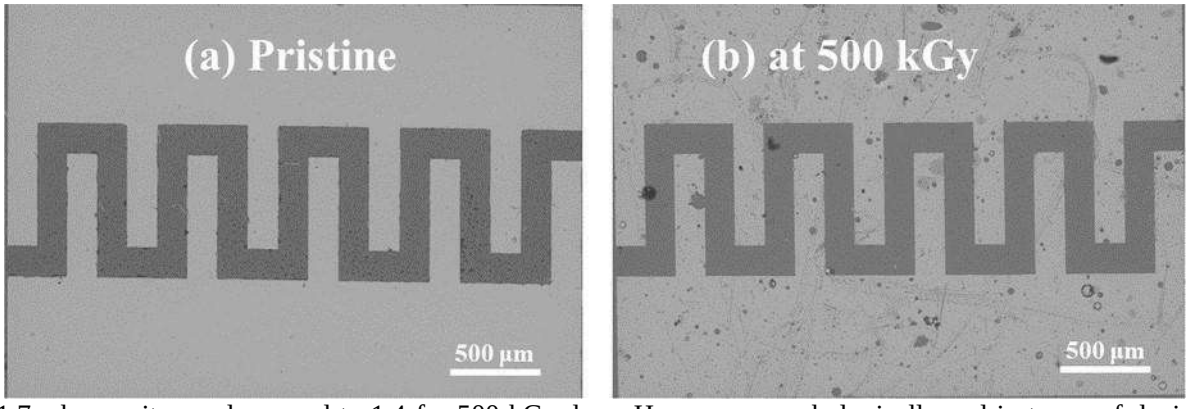

Fig. 1: (a) Pristine; (b) 500 kGy gamma dose β-Ga_2O_3 samples

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Paper ID: W-1018

Area: Wide band gap semiconductors

Impact of Ag and Au concentration on the electronic and optical properties of $LiNbO_3$: A DFT based calculation

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Abstract

In this study, density functional theory (DFT) was used to develop a theoretical analysis of the impact of silver (Ag) and gold (Au) on the electronic and optical properties of $LiNbO_3$ crystal at 8.33% of doping concentrations. In line with experimental evidence published in the literature, the findings showed that $LiNbO_3$ shows a non-magnetic semiconductor property. The 8.33% doping concentration of Ag and Au did not affect the semiconductor behaviour. But, compared to pure $LiNbO_3$, a substantial decrease in band gap energy was found. The findings of this study demonstrate the viability of using $LiNbO_3$ in various technical fields, such as spintronic. This can pave the way for additional studies and research into these materials.

Keywords: DFT, $LiNbO_3$, Ag doping, Au doping, electronic properties, optical properties

Paper ID: W-1019

Area: Wide band gap semiconductors

The Effect of Fe_2O_3 and MoO_3 content on DC Conductivity of Bismuth Borate Glasses

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Abstract: The standard melt-quenching technique was used to synthesise a heavy metal-based oxide glass series with the composition xM.(40-x) $Bi_2O.60B_2O_3$ (M = Fe_2O_3 and MoO_3). The amorphous nature of the present systems was estimated by XRD patterns. The SEM pattern has been used to study the microstructure of the sample. The effect of temperature on DC conductivity has been measured in the temperature range of 523-623K for the compositions. In this temperature range, the DC conductivity in Fe_2O_3-Bi_2O_3-B_2O_3 glasses is higher than the glasses containing MoO_3 content, has been observed that Fe_2O_3 is a better probe to generate non-bridging oxygens (NBOs) than MoO_3 content in the present study. Fe_2O_3-containing glasses exhibit a non-adiabatic polaron hopping mechanism, but MoO_3-containing oxide glasses exhibit an adiabatic mechanism.

Paper ID: W-1020

Area: Wide band Semiconductor

Synthesis, Characterization and properties of Calcium Copper Titanate by modified Solid State process

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Recent research has shown that the perovskite-related body-centred cubic material CaCu3Ti4O12 (CCTO) exhibit extraordinarily giant dielectric constant at room temperature ($\varepsilon \approx 10^4$ -10^5). Besides, these high dielectric constants were found to be nearly constant in the temperature range between 100 and 500K; which makes it even more attractive from the technological point of view. These properties are very important for device implementation and make CCTO a promising candidate for microelectronic applications (like decoupling capacitors, random access memories), microwave devices (for applications in mobile phones), antennas (for example, planar micro-strip antenna on CCTO substrate for 3-GHz operation. In the microelectronics device field, homogeneous and smooth thin films with colossal dielectric constant and with low dielectric loss are desirable. This study is aimed to examination of various properties of CaCu3Ti4O12 and compare with standard dielectric materials. CaCO3, CuO and TiO2 powders were taken with proper molar proportion. The mixture was mixed properly in agate mortar and then heat treatments were performed at different temperatures and also for different time duration. Experimental temperatures were 1000ºC and 1200ºC. Obtained materials were then sent to various tests such as XRD, FTIR, UV-VIS, SEM, FESEM, Dielectric Property and HR-TEM. By these tests we come to a conclusion that the properties like high permittivity of CCTO depends upon the particle size and powder morphology. The particle size and powder morphology of CCTO depends upon several processing parameter that are temperature, heating duration and atmosphere. Band gap was noted to be about 2.44eV. CCTO synthesized using mechano-chemical method high purity and close control of powder morphology, which will result in desired microstructure and dielectric behavior. Grain size was estimated to be in the range of 39-41nm by FESEM analyses.
Keywords: Perovskite; Phase, Morphology, Band gap, Dielectric etc

Paper ID: W-1021
Area: Wide band gap semiconductors

Linear synaptic potentiation and experience-dependent learning behaviour in tungsten oxide- based memristor

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Abstract

Two-terminal memristors have aroused immense research interest due to their potential applications in future no-volatile memory and artificial synapses in brain-inspired neuromorphic computing systems. However, achieving reliable synaptic functionalities at nanoscale, that is crucial to build realistic artificial intelligent machines, remains a significant challenge. Here, we demonstrate the excellent synaptic plasticity behaviours of rf sputter-grown amorphous tungsten oxide (WO_X) memristor synapses using *in-situ* conductive atomic force microscopy. The device reveals gradual conductance modulation (analogous to synaptic plasticity) under consecutive DC voltage sweeps and shows multi-level resistance switching in the current-voltage hysteresis curves. The device emulates diverse essential synaptic functions such as excitatory/inhibitory post synaptic current, long-term potentiation/depression, paired pulse facilitation, and spike rate dependent plasticity behaviour under identical pulse trains. The linearly potentiated synaptic weight modulation for the identical pulses is observed for different amplitude, width, and interval of the input voltage pulses and is presented as an invariant feature of the nanoscale artificial synapse. More importantly, the device exhibits the fascinating ―experience-dependent plasticity‖ behaviour where the synaptic plasticity is highly dependent on the frequency of the previous pulse train. In addition, the proposed nano-synapse demonstrates synaptic functions with ultra-low write currents (<20 nA) which eventually leads to ultra-low energy consumption (~30 pJ). Schottky barrier modulation at the metal/WO_X interface is discussed as the governing mechanism for synaptic properties, which is caused by local migration of oxygen ions under external electric field. The present study guides towards exploring synaptic plasticity at nanoscale and highlights the potentials of WO_X memristors to be a promising candidate for the fabrication of high- density electronic synapses for neuromorphic computing applications.

Paper ID: W-1022
Area: Wide band gap semiconductors

Tunable physicochemical properties of WO_X thin films prepared by varying angle of deposition

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*Corresponding Author: tsom@iopb.res.in

Abstract

In this work, we demonstrate a wide range of tunability in structural, optical, and electrical properties of WO_X thin films deposited on glass and *p*-Si substrates. At room temperature, radio- frequency magnetron sputtering technique is used to deposit WO_X films under various deposition angles (0°-87°) and having varying thicknesses (6-60 nm). From optical studies, it is revealed that band-gap of WO_X films increases with increasing growth angle, whereas, an opposite trend is observed with film thickness for the films grown at a particular angle of incidence. The effect of relative oxygen vacancy concentration on the work function and optical band-gap is thoroughly investigated using X-ray photoelectron spectroscopy (XPS) and Kelvin probe force microscopy (KPFM) analysis. Finally, current voltage (*I-V*) characteristics are measured to investigate the charge transport behavior across the WO_X/*p*-Si heterojunction. Overall, the present study provides useful insights into the correlated optical, electrical, and structural properties of WO_X thin films, which will be beneficial for designing emerging WO_X-based optoelectronic devices.

Paper ID: W-1023
Area: Wide band gap semiconductors

Defects study in few-layered hexagonal Boron Nitride using photoluminescence spectroscopy

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Hexagonal boron nitride (*h*-BN) is a layered two-dimensional (2D) material similar to graphene. Unlike graphene, which is considered as a semimetal, *h*-BN is an ultrawide band gap semiconductor with a bandgap of the order of ~ 6 eV. Because of its high thermal and chemical stability, *h*-BN is used as an encapsulator. Recently it has been found that *h*-BN has luminescence emission in FUV (far ultraviolet) , UV (ultraviolet), and visible range. Thus *h*-BN has potential applications as a light emitting diode in the FUV region. In this work, *h*-BN flake of size 10-15 μm was exfoliated on SiO_2/Si substrate with the SiO_2 thickness of 300 nm. The thickness of flakes varied from 80 to 90 nm. Photoluminescence spectra show peaks at 572 nm at room temperature corresponding to NV center defects states. Temperature annealing studies show that there is a significant increase in the intensity of the defect spectrum. These defects inherit the property of 2D quantum emitters. Different characterization techniques such as Atomic Force Microscopy (AFM), Raman Spectroscopy, Field Emission Scanning Electron Microscopy (FESEM), and Energy Dispersive X-Ray Analysis(EDX) have been utilized to study the exfoliated flakes. Annealing in different environments such as plasma, O_2, N_2, etc. can be used to study the luminescence defects. The luminescence emission corresponding to defects has application as a quantum emitter.

Paper ID: W-199
Area: Wide band gap semiconductors

Structure-property correlation of europium doped β-Ga_2O_3: An experimental and first-principle study

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*Corresponding Author: sudesna.roy@gmail.com

Abstract

In this work, the structure-properties correlation of Eu doped β-gallium oxides were studied by both experimental as well as first-principle study. The thin films were grown by the PVD co-sputtering method on a quartz substrate and analyzed further. The results showed that thin film fabricated were nanocrystalline structures with an average grain size of ~0.029 ± 0.005 μm, and preferably oriented towards the (-201) plane. The band gap energy (Eg) of intrinsic β-Ga_2O_3 measured from the Tauc plot shows a decreasing trend, as band energy gap decreases from 3.98 eV to 3.88 eV on Eu doping, while the optical transmittance doesn‘t show any effect. Further, a first-principal study was conducted, and the simulated result of the band structure of β-Ga_2O_3 on Eu doping, also follows the same decreasing trend as the experimental results. The band structure of intrinsic β-Ga_2O_3 reduces to 0.439 eV from 1.93 eV on Eu doping. The total and partial density of states (DOS) results suggested that the reason behind the decreasing trend of band structure of β-Ga_2O_3 may be due to the dominance of the 4f states orbital in the lower conduction band on Eu doping in the tetrahedral site. There was a redshift in the absorption spectra observed of intrinsic β-Ga_2O_3 on Eu doping, which improves the visible light absorption. It is suggested that co-doping with other rare earth metals may be able to tune the Eg and make it useful for monolithic and phosphor-free LEDs applications.

***Keyword**: First-principal study; β-Ga_2O_3; Eu doped β-Ga_2O_3; Electronic properties; Optical properties.*

Paper ID: W-200

Area: Wide Bandgap Semiconductors

Influence of Low Energy Xe^{8+} Ion Irradiation on Hafnium Oxide (HfO_2) Thin Films

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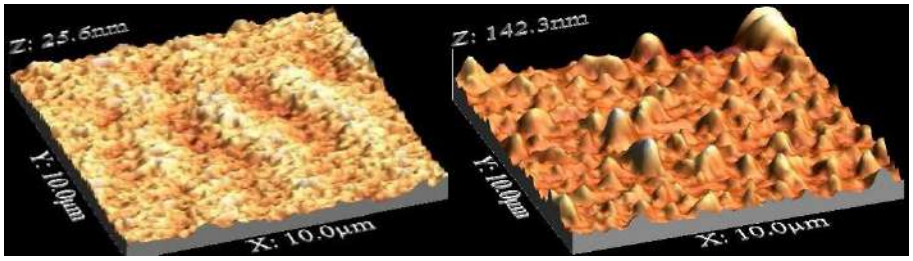
ABSTRACT

Changes in various properties of Hafnium Oxide (HfO_2) thin films, grown on Silicon (Si) substrate by 500 cycles of Atomic Layer Deposition (ALD) technique; having nominal thickness of around 50 nm were studied as a function of Low Energy Ion Beam (LEIB) irradiation. In this article, we have attentively studied 350 KeV Xe^{8+} LEIB irradiation defect induced modifications in HfO_2 thin films. The pristine and irradiated films were studied by various techniques. The substantial Root Mean Square (RMS) surface roughness variation as a function of Xe^{8+} ion irradiation was measured by Atomic Force Microscopy (AFM). Structural changes studied using X-Ray Diffractometer (XRD) revealed the change of state from amorphous to crystalline nature of the films. Systematic X-ray Photoelectron Spectroscopy (XPS) showed that the deposited films are highly oxygen deficient ($HfO_{x<2}$) and post irradiation a new carbon compound $C_xHf_yO_z$ is formed. Formation of the new compound leads to increased conductivity of the films and the existence of trapping sites in the irradiated samples decreases the carrier concentration.

Keywords: Ion Irradiation, XPS, ALD and Thin Films.



(a) (b)

Figure 1: 3D AFM images of (a) pristine and (b) irradiated samples.

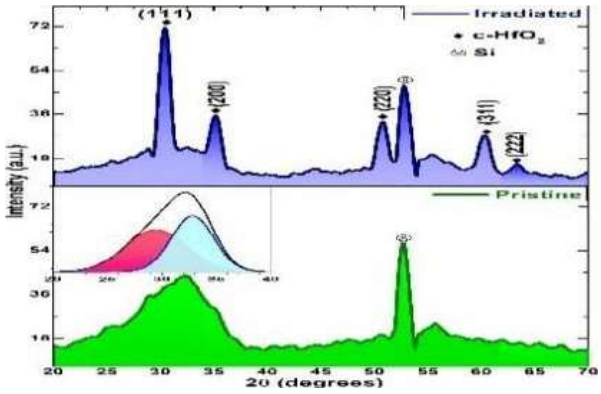


Figure 2: XRD spectra of pristine and irradiated HfO_2.

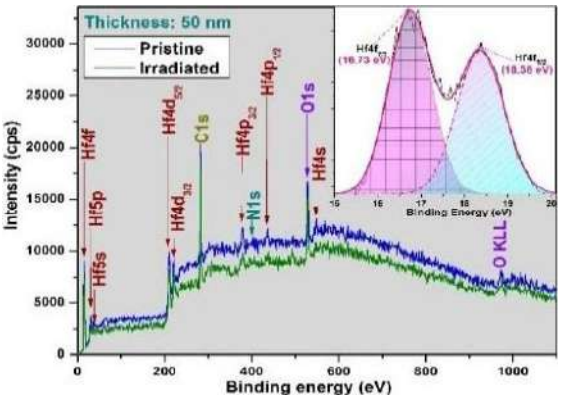


Figure 3: XPS survey scan of HfO2 film.

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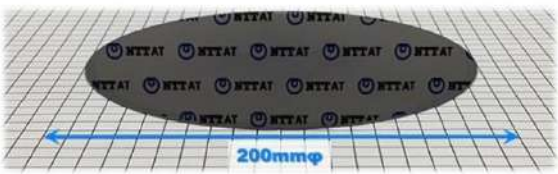

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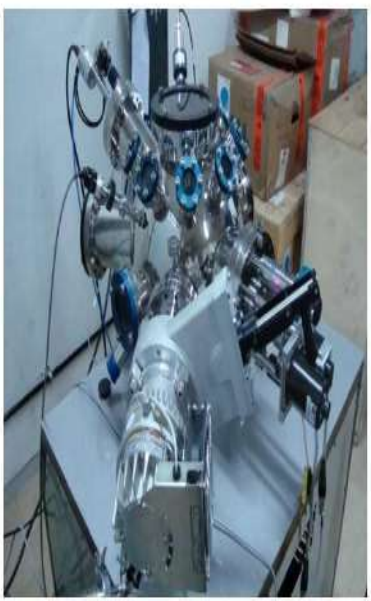

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Kalinga Institute of Industrial Technology (KIIT), a household name, one of the most sought after universities in India for professional education has become a case study. No other educational institution in India has grown in its scope and scale like KIIT has in a short span of time.

All over the world KIIT is being appreciated for its vision, top notch academics and steadfast commitment to community service. One would seldom imagine that such a prolific institution of monumental dimension was made by an unassuming humble being who had just Rs. 5000 in his pocket, dreams in his eyes and passion to eradicate poverty and hunger.

KIIT that started in two room rented apartment with 12 students and 2 teachers has grown to become one of the most promising widely acclaimed universities offering professional education to around 35,000 students from all over India and 65 countries across the globe.

With a vast 25 square kilometre academic township, 25 campuses, over 2500 eminent faculty and researchers, 15000 staff, a multi storey central library and libraries in each school, central research facility, 22 storey research and innovation wing, many auditoriums the largest being of 5000 capacity, 16 sports complexes, 15 food courts, rose garden, greenest campus in India, KIIT provides a holistic human development model that cannot be experienced anywhere in the world.

KIIT is known for three main pillars apart from experiential learning, excellent placement and world class infrastructure

- Student and Parent Friendliness
- Community outreach work
- Promotion of Sports

It has got all accreditations and affiliations by prestigious national and international bodies.

KIIT Deemed to be University has made a significant jump in the Times Higher Education 'World University Ranking' for 2023, being placed in the cohort of 601-800 as against 801-1000 in the previous year, surpassing all private institutions in India. Its ranking school wise is all very impressive with Computer Science Faculty being ranked in the cohort of 301-400 in the world.

KIIT has been accredited with A++ grade, the highest of its kind by the National Assessment and Accreditation Council (NAAC).

It has got prestigious accreditation for six of our Engineering courses by Accreditation Board for Engineering and Technology (ABET), USA and Institution of Engineering and Technology, (IET), UK.

It has been ranked 8th best University in the world in the prestigious Times Higher Education Impact Rankings 2022 for the impressive progress made in 'reducing inequalities' (SDG10). It has also been the top university for innovation among private institutions for two consecutive years.

The national ranking of 20th position by National Institution of Ranking Framework, NIRF, Ministry of Education, is exemplary in a short span of 25 years.

KIIT and KISS have tremendous contributions to the field of Sports. KIIT has nurtured and produced several Olympians who are pursuing their education at KIIT free of cost and are being wholeheartedly supported in all their endeavours in the field of Sports for which it has been adjudged as the best university for the promotion of sports by Sport star. KIIT and KISS are the nodal centres for FIFA Football For Schools Programme in Asia for the promotion of Football at the grassroots.

Alumni of KIIT have made their mark in respectable positions in academics, corporate organisations, Civil Services and Enterprise. Besides its huge impact on development of the state and city, KIIT has immense contribution towards art, culture, sculpture, rural development, literature and spiritualism.

KISS, Kalinga Institute of Social Sciences, the humane face of KIIT is a home for 70,000 indigenous children (30,000 alumni and 30,000 currently pursuing education in the campus and 10,000 students in satellite campuses) who are provided with accommodation, nutrition, holistic education, skills and sports empowerment fully free of cost. Recently, KISS has been conferred with UNESCO International Literacy Prize 2022, the most prestigious and highest of its kind for outstanding contribution to education and protection of indigenous language through its innovation.

All the achievements of KIIT have been possible because of its founder - Dr Achyuta Samanta. Everyone is hooked to the kernel called Dr. Achyuta Samanta. He steers the institute to growth. He is also the epitome of principles, discipline and hard work. The ethics of the institution is guided by his visionary leadership. His humility runs in the DNA of the Institution. He is the epitome of self-sacrifice, and selfless service. His life and work proves that to help fellow human beings one need not to be wealthy but to be good at heart that values the dignity of human life. Instead of basking on its past glory and exponential growth, KIIT Under the leadership of its founder looks forward to achieving greater heights in rankings, research and academics to become the University taking India ahead.

KALINGA INSTITUTE OF SOCIAL SCIENCES

A HOME FOR 20000 INDIGENOUS CHILDREN

KISS

The Kalinga Institute of Social Sciences (KISS) is a residential institution providing free education, accommodation , medical care, vocational, athletic & artistic training to 70,000 indigenous children. Of these, 30,000 students study at the main campus in Bhubaneswar, 20,000 are alumni and 10,000 are study at 10 satellite centres of KISS across Odisha. It has indirectly impacted over a million tribal children and youth. The students come from 62 different tribal groups within the region, of which 13 are Particularly Vulnerable Tribal Groups (PVTGs).

KISS was established in 1992 with the aim of using accessible, free education to empower children from marginalised communities. It has now grown to symbolise a revolution for tribal populations of India to eradicate poverty through education. In its course of existence for over 28 years, KISS has arrested dropouts, child marriage, gender based harassment, left wing extremism, proselytisation, ignorance and superstition on a massive scale with its peaceful intervention through education and empowerment. It has promoted awareness on the importance of education, girl child empowerment, upskilling and vocational empowerment, entrepreneurship and collaboration with the tribal communities as caretakers of the ecosystem and nature.

In 2017, KISS became the first exclusive tribal Deemed to be University in the world, and since 2015, it has been accorded Special Consultative Status by UN-ECOSOC. KISS proudly adheres to a 3E approach -Educate, Enable, Empower while ensuring that the model prioritises indigenous control of education, to preserve the culture, heritage and traditions of India's diverse tribal communities and fulfil the Sustainable Development Goals 2030 in its entirety.

Kalinga Institute of Industrial Technology (KIIT)
Deemed to be University
(Established U/S 3 of UGC Act, 1956)

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