University of
Konstanz

International Workshop on Nanomaterials for Energy Conversion, Emerging Photovoltaic and Optoelectronic Technologies (NEEPO-19)

Jointly organized by
National Centre for Physics (NCP), Islamabad
&
University of Konstanz, Konstanz Germany
Monday 07.10.2019 – Wednesday 09.10.2019

Venue: National Centre for Physics, QAU Campus, Islamabad, Pakistan.

Contents

Introduction

Renewable and cost-effective energy supply is one of the biggest challenges which has impact on human and global environment. The solar energy conversion technologies are entering a new regime with novel device architectures, new materials and feasibility of hybrid structures in the devices. Organic-inorganic perovskite materials have attracted the interest of the scientific community primarily due to the remarkable power conversion efficiency greater than 24% achieved within seven years, since their inception. However, despite the high efficiency, the stability of these devices is still a challenge, so that investigations of physical processes that can help overcome this setback still need to be explored.

The workshop topics will mainly cover the fundamentals of hybrid photovoltaic & optoelectronic devices, their physics, processing & characterization techniques and stability of third generation solar cells. Moreover, advanced topics such as emerging concepts in photovoltaics, the role of interfaces and charge transfer dynamics will be also part of the workshop. The aim of this workshop is to gather scientists and engineers working in the relevant fields to discuss progresses, challenges, and future directions of emerging concepts in the field of photovoltaics and optoelectronics.

The technical sessions in the workshop will comprise of plenary lectures, starting with the basics and leading to advanced concepts. Discussions and poster sessions will provide the opportunity to get involved in collaborative work on contemporary research problems.

Committees

Advisors

Dr. Hafeez Hoorani (NCP)	Dr. Sara Qaisar (NCP)
Dr. S. K. Hasanain (COMSTECH)	

Coordinators

Prof. Lukas Schmidt-Mende (Uni. Konstanz, Germany)	Dr. Muhammad Sultan (NCP, Islamabad)
Dr. Azhar Fakhruddin (IMEC, Belgium)	

Technical Committee

Dr. Safeer Ahmed QAU	Dr. Naila Jabeen NCP
Dr. Ghulam Hasnain QAU	Dr. Shahzad Abu Bakr NCP

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Dr.Muhammad Arshad NCP	Anila Iqbal NCP
Abida Saleem NCP	Hafeez Ullah Jan NCP
Haris bin Nazar NCP	Muhammad Asjad NCP
Iqra Khalid QAU	Taimoor QAU

List of speakers and fields:

International		
Prof. Lukas Schmidt-Mende*	Uni. of Konstanz, Germany	Hybrid and perovskite solar cells
Prof. Shengzhong Liu	Shaanxi Normal Uni, China	Perovskite solar cells and optoelectronic devices
Prof. M. Khaja Nazeeruddin*	EPFL, Switzerland	Developments and prospects of Perovskite solar cells
Dr. M. Adib Ibrahim	Uni.i Kebangsaan Malaysia	Novel Nanostructures for Photovoltaic Devices
Dr. Azhar Fakharuddin*	IMEC Belgium	Perovskite based optoelectronic devices
National		
Prof. Dr. Ahmed Shuja	IIUI, Islamabad	Recent developments in the field of Photovoltaics and optoelectronic devices
Prof. Muhammad Hassan Sayyad	GIKI, Swabi	Commercialization of next generation solar cells
Dr. Azhar Iqbal	Quaid-I-Azam University, Islamabad	Ultrafast charge transfer dynamics
Dr. M. Zahir Iqbal	GIKI, Swabi	Two dimensional materials and their application
Dr. Safeer Ahmad	Quaid-I-Azam University, Islamabad	Water splitting
Dr. Saifullah Awan	NUST, Islamabad	Physics of metal-oxide semiconductors
Dr. Khurram Joya	KFUPM	Functional nanomaterials for energy applications
Dr. Zafar Hussain Ibupoto	University of Sindh, Jamshoro	Metal Oxide Nanostructures for energy applications
Dr.Muhammad Usman	GIKI, Swabi	GaN-based light-emitting diodes
Dr. Shahzada Qamar Hussain	CIIT, Lahore	Advanced light scattering techniques for thin-film solar
Dr. Naveed Zafar Ali	NCP,Islamabad	Energy conversion
Dr. Abdullah	QAU	Development of techniques.

* Video Lectures.

Program and Lecture Schedule of "International Workshop on Nanomaterials for Energy Conversion, Emerging Photovoltaic and Optoelectronic Technologies (NEEPO-19)" (Tentative**)

	8:15 - 9:15 am	**9:20 - 10:30 am**	**10:30 - 11:00 am**	**11:00 am - 11:45 pm**	**11:45 - 1:00 pm**	**1:00 - 2:00 pm**	**2:00 - 2:55 pm**	**2:55 - 3:45 pm**	**3:45 - 4:00 pm**
Monday 07/10/18	Registration	Inauguration + Keynote lecture (K1)	Group Photo + Tea break	K-2 (M Ibrahim)	I-1, I-2, C1 Hassan, Khurram,	Lunch	K-3* (Nazeer)	I-3, C2 Qamar Abid	Tea
Tuesday 08/10/18	**8:30 - 10:30 am** I-6, I-4, I-5, C-3 Zaheer, Zafar, Saifullah, Aftab (C3)		**10:30 - 11:00 am** Tea break	**11:00 am -1:00 pm** I-13, C-5, C-6, I-8 Usman, Abdur-Rehman, Aisida, K-5* (Azhar),		**1:00 - 2:00 pm** Lunch	**2:00 – 3:00 pm** K-6* (Lukas)	**3:00 – 4:00 pm** Poster presentation + Tea	**4:00 - 7:00 pm***** Excursion
Wednesday 09/10/18	**8:30 - 10:30 am** I-9, I-10, I-16, C-4 Naveed, Safeer, Naeem, Akbar		**10:30 - 11:00 am** Tea Break	**11:00 am - 1:00 pm** K-2, I-12, I-14, C-2 Adib-2, Azhar, Adbullah, Saifullah		**1:00 - 2:00 pm** Lunch	**2:00 - 3:00 pm** Discussions	**3:00 - 3:40 pm** **Closing + Certificates**	**3:40 – 4:00 pm** **Tea**

K: Keynote lecture, **I**: Invited talks, **K***: Online video talks by foreign **f**aculty, C: Contributed talk.
** Tentative plan. For latest technical program please consult the webpage of the workshop (http://www.ncp.edu.pk/neepo-2019.php) and notice boards at venue.
*** Symposium dinner will be on 8^{th} Oct. 2019, 7:30 pm advanced registration for workshop dinner is compulsory by 4;00 PM on 7^{th} Oct 2019**.**

Invited Talks:

K-1 Prof. Dr. Ahmed Shuja (IIUI): Revisiting the Materials, Devices and Systems Matrix for Applications in PV Solar and Optoelectronics

K-2 Dr. M. Adib Ibrahim (Uni.i Kebangsaan, Malaysia): Novel Nanostructures for Photovoltaic Devices

K-3 Prof. M. Khaja Nazeeruddin* (EPFL, Switzerland): Developments and prospects of Perovskite solar cells (to be finalized)

K-4 Prof. Shengzhong Liu (Shaanxi Normal University China): High efficiency Perovskite solar cells and optoelectronic devices

K-5 Dr. Azhar Fakharuddin* (IMEC, Belgium): Light from perovskite crystals

K-6 Prof. Lukas Schmidt-Mende* (Uni. Konstanz, Germany): Perovskites - Defects and Interfaces

I-1 Prof. Muhammad Hassan Sayyad (GIKI): Commercialization of next generation solar cells

I-2 Dr. Khurram Joya (KFUPM): Functional nanomaterials for energy applications

I-3 Dr. Shahzada Qamar Hussain (CUI Lhr): Advanced light scattering techniques for thin-film solar

I-4 Dr. Zafar Hussain Ibupoto (Uni. Sindh, Jamshoro): Metal Oxide Nanostructures for energy applications

I-5 Dr. Saifullah Awan (NUST): Physics of metal-oxide semiconductors

I-6 Dr. M. Zahir Iqbal (GIKI): Two dimensional materials and their application

I-9 Dr. Safeer Ahmad (QAU): Synthesis and Electrochemical Characterization of Hematite Based Electrodes for Water Splitting

I-10 Dr. Naveed Zafar Ali (NCP): Conceptual design of novel framework materials for Fuel Cell technology

I-12 Dr. Azhar Iqbal (QAU): Ultrafast charge dynamics at interface of hybrid materials

I-13 Dr. Muhammad Usman (GIKI): GaN-based light-emitting diodes

I-14 Dr. Abdullah (QAU): Water splitting: design strategies challenges and way forward

***Video lectures**

Contributed Talks:

C-1 Dr. Abid Ali (CIIT, Lhr): Cobalt-Selenide Decorated Carbon Nanotube Fibers: A Versatile Approach towards Overall Electrochemical Water Splitting

C-2 Dr. Muhammad Saif Ullah (PINSTECH): Performance and Uniformity Improvement in Ultrathin Cu(In,Ga)Se2 Solar Cells with a WOx Interlayer at the Absorber/Transparent Back-Contact Interface

C-3 Dr. Muhammad Aftab, Akram (NUST): Hierarchical Mesoporous Nanostructures of Ternary Metal Oxides for Energy Storage Applications

C-4 Eng. Akbar Qureshi (BZU): Enhanced Performance of Plasmonic Dye Sensitized Solar Cell due to Synergistic Combination of Copper doped TiO2 Photoanode and rGO/Iron Hybrid Nanomaterial as a Low Cost Counter Electrode

C-5 Dr. SAMSON, Aisida (University of Ibadan): High energy induced semiconductor ZnO nanodevices for space technology

Dr. Naeem Ahmad (IIUI): High elechtrocatalytic activity and low charge transfer resistance (RCT) in Single and alloy Cobalt-Nickel Nanowires /Polypyrole ($Co_{0.1}Ni_{0.1}$/Ppy) nanocomposites-based counter electrodes

Abdur-Rehman Anwar (GIKI): Role of polarization field on degradation of the internal quantum efficiency by analytical formulation of GaN-based light-emitting diodes**.**

Biographies of the speakers

Invited Speakers (International)

1. Prof. Shengzhong Liu

Prof. Shengzhong Liu received his MSc in Chemistry from Lanzhou University in 1986 and his PhD from Northwestern University, USA in 1992. Upon completing his postdoctoral research at Argonne National Laboratory in 1994, he joined high-tech industrial research, most notably on solar cells with Solarex/BP Solar and United Solar Ovonic. Professor Liu's research focus includes nanomaterials, thin film materials, photovoltaic materials and solar cells. His major outcome in basic research are published in scientific journals, including Science, Nature, Science Advances, Nature Communications, Advanced Materials, Energy & Environ. Sci., Physics Review X etc., with several of them being enlisted in ESI's "most cited paper" and "hot paper" lists. Many of his major inventions and patents have been converted into commercial technology and products. In 2011, he accepted a full-time professorship by Shaanxi Normal University and Dalian Institute of Chemical Physics in 2012. He is now the director of Shaanxi Engineering Lab for Advanced Energy Technology, Shaanxi Key Laboratory for Advanced Energy Devices and Institute for Advanced Energy Materials, Shaanxi Normal University and Associate Director of Solar Energy Department, Dalian National Laboratory for Clean Energy. He is also an Editorial Board Member for Scientific Report; International Advisor and Guest Editor for Journal of Energy Chemistry.

2. Prof. Lukas Schmidt-Mende

Dr. Lukas Studied physics at RWTH Aachen and Universität Heidelberg from 1993-99. From 1999-03, he did his PhD under supervision von Prof. Sir Richard Friend, Department of Physics, University of Cambridge, UK.He did Postdoc In 2003-05in Michael Grätzels Group at the EPF Lausanne, Switzerland (as Emmy-Noether fellow funded by the German Research Foundation (DFG)).He was Marie-Curie and Royal Society University Research Fellow at the Materials Science Department, University of Cambridge, UK in the Device Materials Group from 2005-07.From 2007-2011 he served as Professor (W2) at the Ludwig-Maximilians University Munich (LMU)Since 2011 he is serving as Professor at the University of Konstanz, Department of Physics.Since 2017 Director of Studies in Physics at University of Konstanz.

3. Prof. M. Khaja Nazeeruddin

Prof. Nazeeruddin current research at EPFL focuses on Perovskite Solar Cells and Light-emitting diodes. He has published more than 639 peer-reviewed papers, ten book chapters, and inventor/co-inventor of over 75 patents, which are well cited 90'047 with an h-index of 139 having an average citation of over 142. Google Scholar h-index is 160, and total citations are 112'012. His group has developed layer-by-layer growth of 3-dimensional and 2-dimensional perovskites yielding solar to the power conversion efficiency of 22.5% certified at Newport calibration PV lab earlier this year. His group has earned worldwide recognition and leadership in perovskite solar cells as evidenced by Times of higher Education selection ***as "the top 10 researchers in the world working on the high impact perovskite materials and devices". This recognition is based on the accumulated results and impacts generated between 2014 and 2018*** (https://www.timeshighereducation.com/data-bites/top-universities-and-researchers-perovskite-solar-cell-research#survey-answer).

He is elected to the European Academy of Sciences (EURASC), and Fellow of The Royal Society of Chemistry. According to ISI listing, he is one of the most cited chemists in 2014, 2015, 2016, 2017 and 2018, and one of the 20 scientists identified by Thomson Reuters as The World Most Influential Scientific Minds 2015, 2017, and 2018 from all scientific domains.

https://clarivate.com/hcr/wp-content/uploads/2017/11/2017-Highly-Cited-Researchers-Report-1.pdf
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http://gmf.epfl.ch/
https://twitter.com/GMF_EPFL
https://www.linkedin.com/feed/
https://www.researchgate.net

4. Dr. M. Adib Ibrahim

Dr. M. Adib Ibrahim is an Associate Professor / Senior Research Fellow at the Solar Energy Research Institute (SERI), Universiti Kebangsaan Malaysia (UKM). He has joined as Research Fellow in SERI since 2007. He has 10 years semiconductors industry experience before joining education sector. Currently, he is holding a post as Deputy Director of SERI since June 2018. His research interests are solar cells, biophotovoltaic cell, catalysis, energy management and conversion. He has published many publications in WoS and Scopus indexed journals related to research and development on novel type of transparent conductive films and oxide; quantum dots and silicon solar cells as well as nanostructured materials for novel structure photovoltaics device. He is also involved as an external and internal examiner for postgraduate studies as well as reviewers for several indexed journals such as Renewable and Sustainable Energy Reviews, Solar Energy, International Journal of Hydrogen Energy and Journal of Materials Science.

5. Dr. Azhar Fakharuddin

Azhar Fakharuddin holds a PhD in Advanced Materials from the Universiti Malaysia Pahang where he worked on nanomaterials for dye-sensitized solar cells. He has also been attached to the Centre for Hybrid and Organic Solar Energy of the University of Rome Tor Vergatta to carry on his research in perovskite solar cells and modules. He was Alexander von Humboldt Postdoctoral Research Fellow at the Department of Physics of the University of Konstanz, Germany where he worked mainly on interface engineering of perovskite solar cells and also its long-term stability. He is currently post-doc fellow at IMAC where he is working on the optoelectronic devices based on perovskite materials. His research interests also extend to investigation of the charge kinetics in organic solar cells, light emitting diodes.

Invited Speakers (National)

1. Prof. Dr. Ahmed Shuja

Prof. Shuja is the *Advisor to the Rector & President*, International Islamic University (IIU), Islamabad, *Founding Executive Director* of the Centre for Advanced Electronics & Photovoltaic Engineering and the *Principal Investigator* of Islamic Development Bank's Funded International Research Grants, namely, *Advanced Electronics Laboratories Project* and *Photovoltaic Energy Engineering* Labs. He is also the *Proponent & Focal Point* of *US Department of Energy's Users Facility Access Agreement* with International Islamic University and Govt. of Pakistan's *PSDP* support grant to the Centre. Prof. Shuja is also Visiting Professor at James Watt School of Engineering at University of Glasgow, UK. Prof. Shuja holds MS and Ph.D. in Electrical & Electronic Engineering from Sweden and UK; respectively. Besides serving in EU/UK and USA during his professional career; he previously remained the Dean of Faculty of Engineering & Technology at IIU, Islamabad and Executive Director of Centre for Emerging Sciences, Engineering & Technology, Islamabad. Currently; He is also the Member Board of Governors of three universities in Pakistan. Dr. Shuja developed a *pioneering teaching and research program*, in Pakistan, in the area of Advanced Electronics in year 2007. Dr. Shuja's research group studies the *engineering of circuits, devices & system for next-generation electronics/optoelectronics*, *sensing, energy and photonics applications* with cross-disciplinary convergence. The Centre originated and developed by Dr. Shuja is house to over 300 scientific projects with world-class research facilities including Pakistan's first Class-100 clean room facility for the development of micron- and sub-micron devices. As guest scientist and visiting professor, Dr. Shuja maintained very close collaborative linkages with some of the world's most renowned scientific facilities including the *Lawrence Berkeley National Laboratory*, Department of Energy, USA. Higher Education Commission of Pakistan has also focused and highlighted Dr. Shuja's contributions in its official newsletters in February 2011, May 2015 and August 2016. Dr. Shuja instituted and chaired several international conferences and national workshops in Pakistan and had been a plenary/keynote speaker in numerous national and international conferences and colloquia. Dr. Shuja has led tangible projects developing both physical and academic infrastructures, facilities, departments, faculty, Centers etc. covering the financial, strategic and planning aspects. With a track record of winning several competitive projects funded both on national and international level; Dr. Shuja has supervised over 50 graduate (MS and PhD) students and published numerous international research communications including the book chapters, impact-factor journal papers and peer-reviewed international conference proceedings. Dr. Shuja is also member of various national level committees and has a track record of working closely with national and international bodies for the initiation, approval, execution and accreditation of institutions, academic and research programs, and devising the policies and strategies in Science and Technology arena.

2. **Dr. Safeer Ahmed**

Safeer Ahmed, completed his PhD in 2008 from Quaid-i-Azam University (QAU) Islamabad and appointed as Assistant professor on TTS in 2009. He did post-doctorate from the University of Bath, UK in 2012-13. His major research field is Electrochemistry. Few years back he also started work in the field of photovoltaics; with main focus on the synthesis and electrochemical and photo-electrochemical characterization materials for their use in energy applications. So far he has produced 05 Ph.D. and 32 M.Phil. students and published more than 60 research articles. He is a regular member of International Society of Electrochemistry (ISE) since 2013 and Life member of the Chemical Society of Pakistan (CSP).

3. **Prof. Muhammad Hassan Sayyad**

Prof. Dr. Muhammad HassnSayyad received his MSc degree in Physics with specialization in electronics in 1982 from Government College University, Lahore, Pakistan and PhD in Applied Physics from Dublin City University, Ireland in 1994. Currently, he is Professor of Physics at Faculty of Engineering Sciences, Ghulam Ishaq Khan Institute of Engineering Science and Technology, Topi, Swabi, KPK, Pakistan. Prof. Sayyad's research interests are in the areas of organic electronics, organic photonics, energy harvesting technologies, amplified stimulated emission and laser ablation. He has made great contributions to the strengthening of research and development activities in Pakistan. He has supervised several MS and 12 PhD students in multi-disciplinary areas, published over 80 papers and participated in numerous international conferences as invited speaker. He has established international collaborations with the University of Malaya, University of Auckland, Virginia Tech, Cambridge, Brown State University and McGill University.
Currently, in collaboration with Prof. Qiquan Qiao, Center for Advanced Photovoltaics, South Dakota State University, USA, he is doing research on the (1) design, calculation, synthesis and characterization of broad spectrum absorbing dyes, (2) development of novel carbon nano fibers as an inexpensive alternative to Pt counter electrodes, (3) use of solid-state hole transport materials to replace liquid electrolytes, and (4) fabrication, optimization and testing of dye sensitized and Perovskite solar cells

4. **Dr. Azhar Iqbal**

Dr. Azhar Iqbal has completed his PhD in Chemistry from University of Warwick, United Kingdom and post-doctorates from Lund University, Sweden and Nanyang Technological University of Singapore in Physical Chemistry and time-resolved spectroscopy techniques. He worked an Assistant Professor and recently been promoted to associate professor of Chemistry in Quaid-i-Azam University of Islamabad, Pakistan. He has published more than 35 research articles in highly reputed journals with accumulative impact factor of > 125. He has been recipient of Best Young Research Scholar Award of the year-2017 by HEC and also recipient of more than 15 million PKR grants form HEC and other funding agencies. He is holding the first ever time-resolved fluorescence setup in his laboratory, in Pakistan. He has supervised 2 PhD and 18 MPhil students and currently 5 PhD and 5 MPhil students are working in his supervision

5. **Dr. M. Zahir Iqbal**

Mr Zahir Iqbal holds a post doctorate degree from Georgia State University, USA. He holds a PhD in physics degree from Sejong University, South Korea with title "Quantum transport and spin tunneling in two-dimensional layered heterostructures". He holds another PhD degree in Computational and Applied Physics (PhD) From University of Universitat Politècnica de Catalunya (UPC), Spain with title "Structural and electrical characterization of doped graphene and carbon nanotube networks". Currently he is working as Assistant Professor at Faculty of Engineering Sciences, GIK Institute of Engineering Sciences & Technology, Pakistan and as Adjunct Professor at Centre of Excellence Solid State Physics, University of Punjab.

His areas of interests are Energy Devices, Electronic Devices, Optoelectronics, Quantum Electronics and Spintronics

6. **Dr. Saifullah Awan**

Dr. Saif ullah Awan is currently working as Associate Professor at Department of Electrical Engineering, NUST, Islamabad. He holds Ph.d degree with the title "Study of ferromagnetic and ferroelectric behavior in Li/Co doped ZnO nanoparticles and thin films". His research interests are Understanding the physics of nano-materials at low dimensions (2D, 1D, 0D) for the fabrication of nano-electronics devices to enhance their performance at low cost. His fields of interests are NanoSciences, Nanotechnology, Nano-electronics, Condensed Matter Physics, Solid State Physics and electronics, Semiconductor Physics, Materials Physics, Bio Physics, Photovoltaics and Renewable energies.

7. Dr. Khurram Joya

Dr. Khurram Joya is an active Researcher, Scientist, Teacher, Innovator, Mentor, Speaker, Research-Coach, Trainer and a Traveler. Dr. Joya holds multiple faculty positions at Chemistry Department, UET-Lahore and at Chemistry Department, King Fahd University of Petroleum and Minerals (KFUPM-KSA), Saudi Arabia.
Dr. Khurram Joya was born and raised in Lahore - Pakistan. Dr. Joya had a PhD from Leiden University - The Netherlands, and 4 postdocs, and experience/expertise of working at the best universities and top research institutions in the world. Dr. Joya has 65+ high impact research publications, with an h-index of 19 and over 250 impact factor, inventor of about 15 patents, and contributed to three books and 06 journals cover-highlights. After his MSc and MPhil in Applied Chemistry from UET-Lahore, he moved to Netherlands pursuing his PhD at Leiden University (2007-2011). Meanwhile, he had few research visits at TU-Delft Netherlands, TU-Eindhoven Netherlands, University of Zurich Switzerland, University of Uppsala Sweden, KTH Sweden, ICIQ Spain, University of Szeged Hungary, University of Manchester UK, MIT USA, and UNT USA. After his PhD, Dr. Joya joined Max-Planck Institute, Germany in 2012 for his postdoc research on an EU project. In the meantime, he also obtained a Research Falorization Award from TBSC-Netherlands and then moved to The Netherlands. Later in 2013, Dr. Joya then joined KAUST, KSA for another researcher position and DTU-Denmark in 2016. Dr. Joya's research is focused on Molecular and Functional Nanoscale Materials, Functional Surfaces and Thin Films, Organometallics, Electrocatalysis, Photo-Electrocatalysis, Electrochemical Sensors, Spectroelectrochemistry, Biomass Conversion and Dye-Solar Cells.

8. Dr. Zafar Hussain Ibupoto

Dr Zafar Hussain Ibupoto, was born on 2nd February 1980 in Sindh, He obtained his M.Ss form Shah Abdul Latif University Khairpur mirs 2001. Dr. Ibupoto joined cadet college sanghar as a chemistry lecturer in 2003. Later in 2005 he joined Sindh University Jamshoro as a research associate. In 2008, he was confirmed as lecturer in Physical Chemistry. In 2010 he left for PhD at Linkoping University Sweden. He obtained his PhD on March 2014 and he published more than 80 research articles during PhD which is a record at the higher education institute of Sweden. He obtained his PhD on synthesis of metal oxide nanostructures, their characterization and their electronic applications. In 2015 he went for Postdoc at Changchun institute of applied chemistry Chinese academy of science under presidential fellowship. He promoted as an associate professor in Physical chemistry at Sindh University jamshoro. In 2016 he left for second postdoc at Lulea University of Technology under wallenbery fellowship. He returned to Pakistan in 2018 and resume his position at Dr. M.A. Kazi Institute of Chemistry University of Sindh Jamshoro. His current research domains on the synthesis of wide range of metal oxides for energy and biomedical applications. He is authored and coauthored for more than 140 research articles with aggregated impact factor more than 500. He has produced one PhD and 8 MPhl students. Currently he is supervising 7 PhDs and 6 MPhl students from different public Universities in Sindh.

9. Dr.Muhammad Usman

The author received his Bachelor of Science in Electrical Engineering with major in telecommunications in 2007 from NWFP University of Engineering & Technology, Pakistan. He has worked in the telecommunication industry of Pakistan from 2008 to 2012 as Executive Engineer. Meanwhile he completed his Master of Science degree in Engineering Management from University of Engineering and Technology, Taxila and Centre for Advanced Studies in Engineering, Islamabad, Pakistan in 2011. In 2015, he completed his doctoral studies in the field of Electronics & Communication with majors in characterization of inorganic light-emitting diodes from Hanyang University, South Korea. Currently, he is working as Assistant Professor in Ghulam Ishaq Khan Institute of Engineering Sciences & Technology, Pakistan. He is also a member of prestigious professional societies such as Institute of Electrical and Electronics Engineer (IEEE), IEEE Photonics Society, IEEE Young Professionals, IEEE Nanotechnology Council and Optical Society of America (OSA). The author has also served as a reviewer for various national as well as international research projects, research papers and student grants. He also has several research articles published in reputed international refereed journals. Last but not the least, he is a pioneer of the GaN-based light-emitting diode research in Pakistan.

10. Dr.Shahzada Qamar Hussain

Dr. Shahzada Qamar Hussain is working as Lecturer in department of Physics at COMSATS University Islamabad, Lahore campus Pakistan. Dr. Hussain completed his doctor degree in energy science from well know Sungkyunkwan University, Suwon South Korea in 2018. His Ph.D. dissertation title was "Efficiency improvement methodologies for thin film silicon and crystalline silicon solar cells". He worked for various advanced light scattering schemes to improve the current density and efficiency of the thin film solar cells. He also worked for the various transparent conductive oxides (TCOs) films like AZO, ITO, ITO:Zr films with high transmittance and high mobility for the improvement of performance in silicon heterojunction solar cells. Recently, Mr. Hussain is involved in the project of hole and electron based carrier selective contacts for silicon heterojunction solar cells and published various SCI research articles. Dr. Hussain completed his M. Phil degree in Physics (Laser Spectroscopy) from Quaid-e-Azam University Islamabad in 2006.

11. Dr.Naveed Zafar Ali

Currently working as senior scientist national centre for physics Pakistan. Dr. Naveed holds a phd degress in "max planck institute for solid state research stuttgart germany (mpi-fkf)". He was a postdoctoral fellow at max planck society, Germany from march 2012 till nov. 2012_he was a postdoctoral fellow at humboldt university berlin &federal institute for material research berlin adlershof germany.

Abstracts

High Efficiency Perovskite Solar Cells

Shengzhong (Frank) Liu,[1,2*] Dong Yang[1], Yucheng Liu[1], Kui Zhao[1], Zhiwen Jin[1]

[1] *Key Laboratory of Applied Surface and Colloid Chemistry, Ministry of Education, Shaanxi Key Laboratory for Advanced Energy Devices, Shaanxi Engineering Lab for Advanced Energy Technology, School of Materials Science & Engineering, Shaanxi Normal University, Xi'an 710119, P.R. China*

[2]*Dalian National Laboratory for Clean Energy, Dalian Institute of Chemical Physics, Chinese Academy of Sciences, Dalian 116023, P.R. China*

A new type organic-inorganic hybrid perovskite has appeared to be a wonder material for its excellent optical absorption, long range charge-carrier diffusion and apparent tolerance to defects. In the last few years, it has been emerged as a primary candidate material for various photovoltaic, optoelectronic and photoelectronic applications. In just a few years, its solar cell efficiency has been improved from 3.8% to >24%. Moreover, the solar cell fabrication processes based on the planar architecture have been particularly enthusiastic thanks to their low temperature fabrication and compatibility with a range of substrates. Comparing solution deposition with vacuum deposition, the vacuum processes for thermal co-deposition and sequential deposition of $PbCl_2$ and CH_3NH_3I materials are recognized as efficient means to prepare perovskite film with good uniformity and high surface coverage. A vacuum deposition process has been developed to fabricate high efficiency perovskite solar cells with high stability using alternating layer-by-layer vacuum deposition. The new deposition process allows us to relax the strict deposition monitoring and control measures, while realizing superior uniformity in film morphology, surface coverage and smoothness, together with crystalline phase purity.

For the high efficiency perovskite solar cells, the power conversion efficiencies for the planar device is as high as 22.4%. More importantly, we have developed a superior low temperature modified SnO_2 material for ETL and transferred the cell fabrication process onto lightweight flexible polymeric substrate. The highest cell efficiency achieved was over 20%, it is also the highest efficiency among the flexible perovskite cells reported. Meanwhile, the devices show very good stability over long term exposure in ambient with very low degradation. After a representative cell was exposed in ambient lab condition for a year, its final cell efficiency is as high as over 95% of its initial efficiency with its degradation accounts for only smaller than 5%. Further analysis on the stability of the perovskite solar cells will be discussed. We have also developed a series of single-crystalline perovskites with superior stability and optoelectronic performance.

References

1. D. Yang, R. Yang, X. Ren, X. Zhu, Z. Yang, C. Li, S. Liu*, Advanced Materials, http://dx.doi.org/10.1002/adma.201600446.
2. D. Yang, R. Yang, J. Zhang, Z. Yang, S. Liu, C. Li, Energy Environ. Sci. 2015, 8, 3208.
3. D. Yang, Z. Yang, W. Qin, Y. Zhang, S. Liu, C. Li, J. Mater. Chem. A 2015, 3, 9401.

Stable perovskite solar cells by compositional and interface engineering

Mohammad Khaja Nazeeruddin

The Group for Molecular Engineering of Functional Materials, Ecole Polytechnique Fédérale de Lausanne, CH-1951 Sion, Switzerland.

Perovskite solar cells (PSC) are a new paradigm in renewable energy because of their high efficiency reaching over 24% in less than 10 years.[1,2] The high efficiency of perovskite solar cells is due to their excellent optoelectronic properties, which were optimized by various cations and anions with different ratios. Another advantage of perovskite solar cell is their simple fabrication through solution-processing methods, either in n-i-p or p-i-n configurations.[3,4] The perovskite absorbing layer consisting of methylammonium lead (II) iodide ($MAPbI_3$) is intrinsically unstable at elevated temperature due to methylammonium cation release. Therefore, compositional engineered cations and anions perovskite [$FA_{0.8}MA_{0.15}Cs_{0.05}PbI_{(3-x)}Br_x$] developed with solvent engineering method to reach over 22% efficiency.[5] However, despite the impressive high efficiency achieved at laboratory scale devices, their long-term stability and performance still need to be improved in order to make PSC a viable technology. In recent years, strategies using mixed composition and 2-Dimensional perovskite materials have been developed towards stable device performance.[6] In this talk, we present layer by layer deposition of 3-Dimensional and 2-Dimensional perovskites and the novel charge transporting materials.

References

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Prospects and Challenges of Perovskite Type Transparent Conductive Oxides in Photovoltaic Applications – Materials and Synthesis

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Transparent conductive oxides (TCOs) have been used in a wide variety of applications as sensors and electronic displays and for solar harvesting for the past decades. Many studies have been conducted to improve the properties of materials for TCOs. The properties that make a TCO effective are high transmittance and low resistivity. The current commercialized TCO is indium tin oxide (ITO), which has excellent transmittance and lower resistivity than other TCOs such as zinc oxide. Indium is expensive as its availability is becoming more limited over time. As such, studies to find an alternative material to ITO are continuing. Perovskite-structure materials are a candidate material with acceptable optoelectronic properties. Perovskites have a wide band gap of ~3.0 eV and high transmittance along with exceptionally low resistance. A perovskite can be made into a transparent conductive oxides (TCO) and with doped materials that reduce its resistivity while maintaining high transparency it. Perovskites can be synthesized in many methods, which are solid state reaction, sol-gel, pechini and hydrothermal methods. However, each of the methods does have their own set of drawbacks to consider. The deposition method of perovskite material onto its substrate is also important since there are also several film deposition methods available for a perovskite.

Development of Eco-Friendly Semiconductor Nanocrystal In Quantum Dot Sensitized Solar Cell

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Recent study showed the cadmium and lead Quantum dots (QDs) are commonly use for the synthesis of QD sensitizers because of high potential in light harvesting in visible region along with particle size tuning properties. However, these QD materials are highly toxic and easily disintegrate that leads to heavy-metal accumulation in the interface precursors. It is significant to investigate eco-friendly semiconductor material quantum dot that have wide photo-response in the solar spectrum as well as eliminate the hazardous precursors. Thus, the aim of this study is to explore the possibility of high optical absorption through multiple exciton generation in the eco-friendly semiconductor as sensitizer materials. Furthermore, formation of eco-friendly QD as sensitizers through single technique of deposition may not achieve of high-power energy conversion. There are several eco-friendly materials are discussed including Indium Sulphide ($CuInS_2$), Silver Indium Sulphide ($AgInS_2$), Silver Sulphide (Ag_2S) where the different techniques of deposition were applied. The deposition techniques are used to form QDs such as Successive Ionic Layer Adsorption and Reaction (SILAR), hot injection, hydrothermal and solvothermal. The incorporation of semiconductor nanocrystals with quantum properties that can enhance optical absorption is at the forefront of photovoltaic research. The expected outputs include new wide band gap sensitizer materials, which contain bifunctional molecular linker to the quantum dot surface.

Light from perovskite crystals

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Halide perovskites appeared as a top choice for a range of optoelectronic devices. Quantum efficiencies of their light emitting diodes (LEDs) are now at a par with established organic LEDs without additional light outcoupling. This remarkable performance stems from (i) their optoelectronic properties such as bandgap, lifetime of excited states, low defects density and their structural stability and (ii) efforts in device engineering to control charge injection/transfer and to obtain a charge balance within the emitter layer.

This talk provides insights into how tailoring of perovskite composition as well as device heterointerfaces allowed us to tune performance and operational stability of perovskite LEDs. Examples include most common three-dimensional perovskites (3D), mixed 2D/3D perovskite for green and near-infrared emission and all inorganic perovskite quantum dots. Only films with controlled optoelectronic properties, together with optimized device architectures, led to some state-of-the-art performance and stability in perovskite LEDsS.

Keywords: Energy transfer in perovskites, mixed halide perovskites, carrier lifetime, device stability, defects passivation.

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Revisiting the Materials, Devices and Systems Matrix for Applications in PV Solar and Optoelectronics

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This talk will provide an overview of the technologies based on the current research in materials, devices and systems for applications in PV solar and optoelectronics. The "*material-device-system*" matrix will be revisited in order to evaluate the research outcomes and their level of readiness for possible exploitation in industry. As this matrix is at the heart of research and development enabling the "manufacturable Frontier Technologies" meant to reshape the usage of transformative inventions on a commoner level, some interesting developments from the market leaders will also be discussed. Some of the promising work conducted in the Centre for Advanced Electronics & PV Engineering, on this account, will also be shared.

Metal Oxide nanostructures for energy applications

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Metal oxide nanostructures are a unique class of materials which play a great role in the development of electronic, and optoelectronic devices. Also, metal oxide nanostructures are found useful for the energy conversion and storage systems. We are presenting the recent results for metal oxide nanostructures on the all oxide solar cells, photo detectors and water splitting. We aim to investigate the fundamental mechanism for the metal oxide nanostructures in wide range of optoelectronic and renewable energy applications.

Synthesis and Electrochemical Characterization of Hematite Based Electrodes for Water Splitting

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Photoelectrochemical (PEC) water splitting is one of the efficient ways to use sunlight to produce hydrogen gas- and indirect solar energy resource. The status of H_2 as a stored form of future renewable energy is well established and marked as future green energy source with huge energy density of 120MJ kg^{-1}. However, so far, its generation from different sources, including water splitting, has not achieved a satisfactory status that can be commercialized on large scale. In the PEC process the key parameter is the catalytic material which determines the efficiency of the process. Among different photoelectro-catalytic materials hematite has many attributes that make it a good candidate for a photoanode including its low cost and abundance. This work describes the synthesis of pristine hematite (α-Fe_2O_3) and two composite electrodes namely; ZrO_2-Fe_2O_3 and TiO_2-Fe_2O_3 to be used as thin film photoanodes. The composite electrodes of α-Fe_2O_3 were made with varied amount of the referred oxides in five different compositions. The prepared films were characterized for their structural, morphological and optical characterization. This was followed by detailed electrochemical analysis including linear sweep voltammetry, photoelectrochemical (PEC) performance, electrochemical impedance measurements, incident photon to current efficiency (IPCE) and quantitation of H_2 gas produced as a result of PEC water splitting. The films were prepared by aerosol assisted chemical vapour deposition (AACVD) method and were found quite compact in flake liked structures with average particle size of 120nm and showed photocurrent density of 1.5mA/cm^2 with onset potential of 0.83V vs. RHE and 18% IPCE at 300 nm. The 30% ZrO_2-Fe_2O_3 photoanode showed a photocurrent of 2.98 mA/cm^2 at 1.23 V vs. RHE which is the highest value reported so far with this electrode. The 2% TiO_2-Fe_2O_3 photoanode showed maximum photocurrent density of 2.68 mA/cm^2 at 1.23 V vs RHE with 0.724V onset potential. The evident hydrogen generation was monitored through GC coupled PEC cell and among the three electrodes.

Ultrafast Time-resolved Spectroscopy: An Essential Tool to Understand Charge Carriers Generation and Recombination Dynamics in Semiconductor Low-dimensional Materials

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Semiconductor III-V, II-VI quantum dots (QDs) and perovskite materials demonstrate outstanding optical properties including wide color emission and long charge carriers lifetime enabling them highly suitable candidate for light-emitting diode (LED) and photovoltaic devices. Optical cascading mechanism has been observed in electrically emissive Ruddlesden-Popper (RP) perovskite series ($(C_8H_{17}NH_3)_2(CH(NH_2)_2)_{m-1}Pb_mBr_{3m+1}$). In a mixture of 3D formamidinium lead bromide $CH(NH_2)_2PbBr_3$ and 2D octyl ammonium lead bromide $(C_8H_{17}NH_3)_2PbBr_4$ perovskite (~0 - 80% 2D) an ultrafast energy transfer from donor 2D to acceptor 3D perovskite has been observed by using ultrafast femtosecond laser transient absorption and fluorescence spectroscopy techniques. Following excitation at 400 nm photo-bleaching signatures around 425 nm and 535 nm was observed for 2D and 3D perovskites films, respectively. In RP (20% 2D) perovskite, a very fast decay of 435 nm exciton and very fast rise (390 fs ± 90 fs) of 535 nm bleaching signal suggests very efficient energy transfer from higher bandgap “donor (2D)” to lower bandgap “acceptor (3D)” domain. In all-inorganic $CsPbBr_3$ perovskite nanocrystals (NCs) the control over the precursor concentration of CsBr helps to synthesize very bright and long radiative lifetime $CsPbBr_3$ NCs. In II-VI semiconductor QDs attached azobenzene (photo responsive) systems very fast charge/energy transfer has been demonstrated by time-resolved fluorescence measurements. Following excitation at 306 nm, the photo responsive azobenzene exhibits trans–cis isomerization. The photoinduced trans–cis transformation encourages charge/energy transfer from photoexcited QDs to the cis-isomer of the azobenzene molecular system, thus resulting in fluorescence suppression of QDs in QDs-azobenzene systems. Such findings suggest ultrafast spectroscopy methods, for instance, transient absorption and time-resolved fluorescence are essential to underpin the dynamic pathways of photoinduced charge carriers in low-dimensional semiconductor materials for optimization of optoelectronic devices

Trends and Innovations in Energy Storage Devices

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An upsurge in sustainable energy demands has ultimately made hybrid devices as one of the important choices for energy storage, owing to highly advantageous energy density, power density and long-life span. Supercapacitor comprises of high-power density but lacks high energy density in contrast the batteries have limited power density but greater energy density. An interesting strategy is adopted to combine high power density of supercapacitor and high energy density of batteries in a single device (supercapattery). This approach of the hybrid devices may provide high energy density with no compromise on high power density.

Advanced light scattering techniques for thin film solar cells

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Front transparent conductive oxide (TCO) films play a vital role in silicon based thin film solar cells (TFSCs) due to their high transparency, conductivity and excellent light scattering properties. We report various kinds of advanced light scattering techniques for the enhanced performance of silicon based TFSCs. Maskless large area randomly textured glass surfaces with various haze ratios were prepared by well controlling the ratio of buffered hydrofluric acid (BHF) and sulfuric acid (H2SO4). Inverted hemisphere textured (IHT) glass surface morphologies with high transmittance and variable haze ratio were prepared by wet chemical etching. It was observed that haze ratio of textured glass was dependent on feature size, etching depth and rms roughness. Multi-textured aluminum-doped zinc oxide (AZO) films were deposited on micro-featured textured glass (random and periodic) surface morphologies and showed high transmittance and haze ratio in visible-NIR wavelength region. Multi-textured AZO films deposited on various textured glass superstrates were employed as a front TCO layer for the fabrication of amorphous silicon (a-Si) TFSCs. a-Si TFSCs deposited on randomly textured glass showed short circuit current density (Jsc) =16.68 mA/cm2 with an efficiency of 9.79%. An efficiency of 9.61% with Jsc of 16.55 mA/cm2 was shown by a-Si TFSCs deposited on the periodic IHT glass superstrate. An enhancement of photocurrent from 15.64 to 16.55 mA/cm2 was observed for the a-Si TFSCs due to advanced light scattering.

Keywords: Light scattering, Maskless large area, Periodic textured glass, Multi-textured AZO films, Absorber layer, Amorphous silicon thin film solar cell

Light Emitting Diodes: From Basics to Applications

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Light-emitting diodes have extensive applications in various application ranging from energy-efficient solid-state lighting to displays (such as screens used in state-of-the-art mobile phones, computers and laptops). Many health applications of LEDs include ultraviolet curing, water purification and medical phototherapy. In addition, LEDs are gaining ground in the environmental applications such as air purification. In the areas such as instrumentation, sensing and counterfeit analysis utilization of LEDs is already a million-dollar industry. In this talk, an introduction to the basic physics of light-emitting diodes along with its applications and market analysis will be presented.

Conceptual Design of novel Framework Materials for Fuel Cell technology

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Fuel cells are of great importance among energy storage and conversion technologies, serving as electrochemical devices that convert chemical energy-fuels (e.g., hydrogen, natural gas, and methanol) into electrical energy for powering vehicles, stationary facilities, and portable appliances. There is a dire need to improve the fuel cell technology by developing new electrode catalysts along with the “development of novel electrolyte membrane” and ancillary components of fuel cell technology. In the first round of the talk, I will be talking about the concept of new ROTOR molecules and their role in achieving high proton conductivity as a substituent to NAFION membrane for PEM (proton exchange membrane) Fuel Cells. The preliminary focus would be to Spotify new kind of hybrid functional architecture materials for their application in Fuel Cell technology. Research endeavors in the pursuit of “Next Generation super-protonic solid acids proton conductors” having ideally incorporated ROTOR molecule that exhibits rapid reorientation of XO4 anion groups as the mechanism of proton transport. The aim would be to highlight new phosphate and silicate analogue to known sulfate and selenite solid acids with high conductivity and subsequently discuss methodologies to incorporate these functional guests rotor molecules into potential MOFs, that will facilitate proton conduction through well-defined crystalline MOF at wide-ranging temperature window. The second strategy, would be to tailor well defined MOFs architecture with commensurate pore size to achieve “high density hydrogen storage“ to accelerate fuel-cell-powered vehicles that require enough hydrogen to provide a driving range of more than 300 miles with the ability to quickly and easily refuel the vehicle. This will resolve the presently available storage options that typically require large-volume systems for hydrogen storage in gaseous form. The variety of materials-based hydrogen storage technologies, including sorbents, chemical hydrogen storage materials, and metal hydrides, with properties having potential to meet the current global hydrogen storage targets demands, besides the recent advancement in the use of MOFs based physical adsorbents that have attracted increasing attention as high density novel hydrogen storage materials for fuel-cell-powered vehicles will be discussed.

Performance and Uniformity Improvement in Ultrathin Cu(In,Ga)Se2 Solar Cells with a WOx Interlayer at the Absorber/Transparent Back-Contact Interface

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Thinning CIGSe absorber layer to less than 500 nm is desirable for reducing the cost per unit watt of PV-generated electricity and semitransparent solar cells based on such a thin absorber can be used in bifacial and superstrate configurations if the back electrode is transparent. In this study, a WOx layer deposited by thermal evaporation is inserted between the Cu(In,Ga)Se2 (CIGSe) absorber and the tin-doped indium oxide (ITO) back-contact to enhance the hole collection at the back electrode. A WOx interlayer with a thickness of 6 nm is found to be optimum because it causes a ~38% relative increase in the fill factor (FF) of a ~450 nm thick CIGSe-based device with respect to a similar device that does not contain a WOx interlayer. Increasing the WOx interlayer thickness ≥6 nm, while fixing the CIGSe layer thickness at ~450 nm, results in a decrease of the open-circuit voltage, short-circuit current density, and FF of the device. The degradation of the photovoltaic parameters in the case of the devices with a WOx interlayer thickness of 9 and 12 nm is primarily due to the emergence of a GaOx interfacial layer at the CIGSe/WOx junction.

Water splitting: design strategies (selected examples) challenges and way forward

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Solar-driven water splitting is deemed a viable option to produce sustainable hydrogen. One straightforward approach is to employ particulate photocatalytic systems, that retain their intrinsic activity and are competitive with fossil-fuel-derived hydrogen on a levelized cost basis. However, all the powder-based solar water-splitting systems tested thus far fall short on account of hydrogen production efficiency values required for practical applications. Functionally, in a typical particulate photocatalytic system, involves three key steps: (i) charge generation, (ii) charge trapping, interfacial electron exchange and (iii) subsequent surface chemical reaction that control the process efficiency. In the context of particulate photocatalysis, this work describes the photocatalytic properties and applications of semiconducting layered framework carbon nitride and selected nano metal oxides materials. Furthermore, by exploiting the band alignment strategy, the construction of carbon nitride isotype (type II) semiconductor heterojunctions and redox mediation to shuttle charges in metal oxides with the aim of suppressing the exciton recombination for the successful initiation of desirable redox processes (HCO2H, water splitting) are presented.

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Cobalt-Selenide Decorated Carbon Nanotube Fibers: A Versatile Approach towards Overall Electrochemical Water Splitting

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To acquire a sustainable energy society and clean environment, attention of the researchers is to develop cost-effective and highly active catalysts for energy conversion and storage devices. Water splitting is a promising route to achieve these goals. Here, we present carbon nanotube fiber electrode decorated with cobalt selenide nanoparticles as a highly efficient catalyst for overall electrochemical water splitting in alkaline media. Hydrothermally, one pot synthesized CoSe@CNTs exhibited high current density with lower value of overpotential. Tafel slope from the linear sweep voltammogram unveiled the excellent catalytic activity of the material with unique properties. Stability test at a certain value of overpotential confirmed the durability of the catalyst suggesting it to be a superior candidate for electrochemical water splitting.

Enhanced Performance of Plasmonic Dye Sensitized Solar Cell due to Synergistic Combination of Copper doped TiO2 Photoanode and rGO/Iron Hybrid Nanomaterial as a Low Cost Counter Electrode

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Plasmonic Dye-Sensitized Solar Cells (DSSCs) have gathered excessive consideration of researchers due to some versatile characteristics i.e. low cost, manufacturing ease and relatively proficient as compared to high module cost conventional silicon photovoltaic cells. However, to achieve maximum power conversion efficiency, researchers are focused on preparing a photoanode/cathode capable of harvesting maximum amount of light, enhanced dye absorption, reduced recombination reaction rate and improved electronic conductivity. In this research, we have synthesized copper doped TiO_2 (Cu-TiO_2) via hydrothermal technique while rGO-Fe_3O_4 by solvothermal technique without utilizing any harsh reducing agent. The as synthesized nanocomposites were characterized by SEM, EDS, XRD TGA, along with UV-Vis spectroscopic techniques to confirm their morphology, elemental composition, crystalline structures and their absorbance in visible portion of solar spectrum as well as their thermal stability. SEM analysis depicted that as synthesized nanocomposites had uniform granular grains ~50nm range while EDS analysis confirmed their elemental composition. Crystalline structure of above synthesized nanocomposites showed no impurity indication of crystallographic purity. TGA analysis confirmed the thermal stability of the samples over a wide range of temperature making them appropriate candidates for their usage in solar cells. UV-Vis analysis confirmed optical absorption due to LSPR effect. The dye-sensitized solar cells fabricated with Cu-TiO_2 as photoanode while rGO-Fe_3O_4 as a low cost counter electrode can exhibit a higher solar efficiency due to synergistic combination of both modified electrodes, LSPR of copper nanoparticles in semiconductor network and by excellent electronic conductivity of rGO in counter electrode than those fabricated with conventional titania and platinum respectively. Keywords: Cu-TiO_2, rGO-Fe_3O_4, Hydrothermal, Solvothermal, Dye sensitized solar cell.

Hierarchical Mesoporous Nanostructures of Ternary Metal Oxides for Energy Storage Applications

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Continuous efforts are being made by the scientific community to develop supercapacitors with high energy densities along with their intrinsic high-power density characteristics to make them suitable for practical use. Current work is focused on the development of high surface area hierarchically mesoporous nanostructures of ternary metal oxides. Due to their unique structure and morphology, the prepared electrodes exhibited excellent specific capacitance of above 2000 F/g with high cyclic stability of more than 5000 cycles at a discharge current of 1 A/g. Further asymmetric devices were assembled and tested with carbon-based materials as another electrode with high energy densities and cyclic stability. All the necessary material characterization such as XRD, XPS, SEM, TEM, SAED, EDX, etc. were also performed after synthesis stage. Current work present of the approaches to fabricate very high energy density next-generation energy storage devices for practical applications such as portable electronics.

High energy induced semiconductor ZnO nanodevices for space technology

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It is a misunderstanding that higher energy ion irradiation on nanomaterials has only detrimental effects on their properties. Recent research reveals that higher energy irradiation on nanostructure materials is favorable with advantageous effects. Light, medium, heavy ions, and high energy photons serve as a veritable tool to synthesized nanowires for these effects. In this article, experimental research on the impact of ion species and high energy photons irradiation on structured ZnO nanowires (ZnO-NWs) and at different ion energies (keV to MeV), ion fluences, and substrate temperatures are discussed. The study has revealed that ZnO-NWs structures were damaged at high irradiation fluence under room temperature. Moreover, the porous structures of ZnO-NWs are created by light ions irradiation at a higher temperature. It is noteworthy that the effect of these irradiation beams induced-cutting of ZnO-NWs and fabrication of nano-holes in ZnO-NWs valuable for nano-devices in space technology under harsh environment.

High elechtrocatalytic activity and low charge transfer resistance (R_{CT}) in Single and alloy Cobalt-Nickel Nanowires /Polypyrole ($Co_{0.1}Ni_{0.1}$/Ppy) nanocomposites based counter electrodes

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Dye sensitized solar cell (DSSC) is the cell that can give both the flexibility, easy fabrication process and transparency. Its efficiency is comparable to silicon solar cells but with a lower cost. The counter electrode (CE) is one of the most important components in dye-sensitized solar cells (DSSCs) playing an important role in the efficiency of energy conversion. In this work, we introduced a new kind of Pt-free counter electrode (CE) for dye-sensitized solar cells (DSCs). Polypyrrole (PPY) has extensively been investigated as an alternative CE material for DSSC because of its facile synthesis, high electrocatalytic activity, and good environmental stability The Cobalt-Nickle/Polypyrole ($Co_{0.1}Ni_{0.1}$/Ppy) nanocomposites, with low cost and simple preparation show good catalytic activity in tri-iodide reduction. The DSC composed of the Co-Ni/Ppy nanocomposite counter electrode having an acceptable energy conversion efficiency demonstrated low charge-transfer resistance and high efficiency. We measured the electro catalytic activity by replicating the Pt metal oxide by using $Co_{0.1}Ni_{0.1}$/Ppy nancompsite. AC electrodeposition was used to fabricate the nanowires and depositing on FTO glass by using Spin coating. We used X-ray diffraction technique for crystal structural, SEM for surface morphology, EDX for elemental analysis, Cyclic voltammetry for electro catalytic activity and Electrochemical impedance spectroscopy (EIS) for electrical diagnoses.

The $Co_{0.1}Ni_{0.1}$ nanowires show an FCC cubic structure measured from XRD. The $Co_{0.1}Ni_{0.1}$/Ppy CE has an ideal charge-transfer ability and electro catalytic activity toward I_3^- reduction. It is also observed that compared to the Pt electrode, all the fabricated CEs showed higher redox current density, likely due to the large catalytic active site toward the reduction of I_2 and I^{3-} ions. It is observed from data that (peak to peak potential) Epp values of the all nanowires/PPy based CEs were lower than that of Pt suggesting that the electrocatalytic activity toward the I-/I3- redox reaction were greater for CEs than Pt. The experimental CV analysis indicated that the CEs possesses better performance for the reduction of I^-/I^{3-} in DSSCs related to the Pt CE. The charge transfer resistance (R_{CT}) and cathodic current density for CoNi/PPy compsite is found to be 0.53 k.Ω.cm-2 and 19.7 $\mu A.cm^{-2}$ respectively which is much better than Platium. It is confirmed from all these measurements that CoNi nanowires/PPy based electrode has higher effiency, low preparation cost and low charge transfer resistance as compared to other conventional materials.

Role of polarization field on degradation of the internal quantum efficiency by analytical formulation of GaN-based light-emitting diodes

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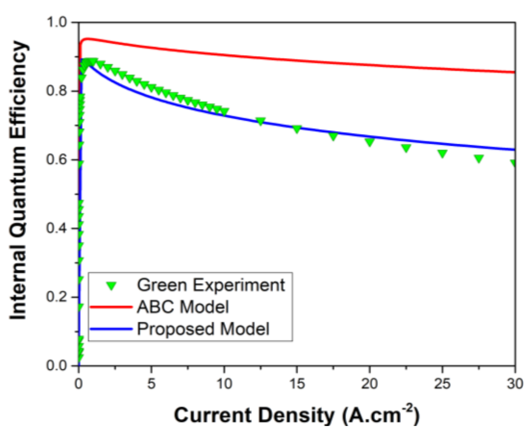
Gallium Nitride (GaN) has dramatically revolutionized the area of energy saving solid-state lightning due to their broad wavelength emission spectrum. But the major drawback in the development of solid-state lighting is degradation of efficiency at high current density. In this study we present the analytical model for better approximation of internal quantum efficiency (IQE) and light output power (LOP) by including the effect of polarization field, which has been absent in previous reported models i.e. ABC model. The effective volume in active region is reduced with increase of polarization field which directly degrades the confinements of carriers (electrons & holes) in active region. As a result, the probability of radiative recombination is reduced. Our proposed formulation for IQE and LOP shows good agreement with experimental results by using reported values of polarization field for blue and green InGaN LEDs.



Poster Abstracts

Surfactant-Assisted Hydrothermal Synthesis of Tin Disulfide (SnS2) using Single Source Precursor

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Berndtite or tin disulfide (SnS2) is a layered n-type semiconductor. It is earth abundant and environmentally friendly 2D material. The surfactant-assisted hydrothermal synthesis of SnS2 using single source precursors (SSPs) provides the control on phase, size and morphology of the nanostructures. Remarkably, this facile synthesis approach can be extended to the phase-controlled growth of the designed metal sulfide phases for desired metal sulfide nanostructures that are attractive candidates in advance energy applications.

Structural and Electronic Properties of Double Perovskites for Energy Applications

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The study of physical characteristics of lead free double perovskites A_2SnI_6 (A= Cs, Rb) have been done by DFT based on FP-LAPW+lo method. The lattice constant calculated from structure optimization by using Murnaghan equation are 12.06Å for Cs_2SnI_6 and 11.98Å for Rb_2SnI_6, closely matches with results available in literature. Using mBJ potential 1.09 eV and 1.15 eV are the calculated electric band gap value for Cs_2SnI_6 and Rb_2SnI_6 respectively.

Perovskite and Thin Film hybrid configuration to accomplish all thin film solar cells

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The combine preparation of perovskite materials and thin film has the potential to achieve high efficiency all thin film tandem solar cells. Thin film semiconducting materials and perovskite materials have tunable bandgaps and are better candidates for tandem configuration solar cells. In the present work we developed Al doped CdS thin films for n-type companion with p-type absorbent thin film and hole transport (HT) layer. An interconnecting layer (ICL) has a vital role to develop a consistent contact between two individual cells, indium tin oxide (ITO) will be used as ICL layer.

The Mn12-Acetate Molecule: A Magnetically Measurable Nano-Observatory for Hydrogen Production Reactions

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One of the challenges associated with understanding the reaction dynamics in nanostructures at ambient temperatures is that one needs spectroscopic measurement techniques that do not affect the structure or temperature of the nano-scale system as a chemical reaction proceeds. Here we discuss a computational approach that determines how magnetic properties of a nano system change during a chemical reaction [1]. In addition, we discuss how changes in the electronic structure impact the magnetic properties. Specifically, we investigate a model for de-hydrogenation of the water molecules attached to the well-characterized Mn12O12(COOR)16(H2O)4 molecule in both neutral and anionic states. We find the removal of the hydrogen atoms causes the charge states of the Mn atoms to change significantly which affects the exchange coupling between neighboring Mn atoms and the total charge of the Mn atoms. The primary focus of the talk will be on correlating changes in the Mn-atom charge states and electronic structure with the magnetic anisotropy of the molecule. The results have been determined through the use of the PBE-GGA density functional approximation and the NRLMOL electronic structure code.

Effect of Surface Recombination Velocity (SRV) on the Efficiency of Silicon Solar Cell

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Surface recombination velocity is an important parameter which strongly impacts the overall performance of the solar cell. A high surface recombination velocity causes the creation of dead layer. The rate of photo generated carriers reduces due to higher surface recombination velocity (SRV). The impact of front and back surface recombination velocities on the important characteristics (namely short circuit current (Isc), open circuit voltage (Voc), conversion efficiency (η) and fill factor FF) of solar cell were investigated by Personal Computer One Dimension (PC1D) simulation software. Higher recombination rate of carriers due to high SRV provide a detrimental impact on the Isc of solar cell. It was noticed that increase in surface recombination rate, the carrier starts to recombine at defected surface there by reducing the performance of the solar cell. The simulation results show that both internal and external quantum efficiency of solar cells reduces drastically with increasing the front and back SRV. The maximum efficiency is coming at FSRV of 100cm/s i.e. 16.33%

Design and Construction of a Solar Water Purification System with Graphene-Plasmonic Nanocomposite

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Availability of clean drinking water is a great challenge for communities all over the world. Production of clean water by utilization of solar energy from sewage and sea water has been considered a great alternative solution. Conventional solar water purification system has very low efficiency and high cost. Here we have extended a state-of-the-art solar water purification system by using graphene and plasmonic nanocomposite as an optimistic component to enrich the efficiency. We have synthesized the graphene plasmonic nanocomposite by using sol-gel technique and obtained in powder form. Synthesized Graphene-Plasmonic nanocomposite has been utilized in polluted water to design the water purification system. The nanocomposite has been combined with water in the presence of sunlight, it captive the polluted components and pure water converted into vapors, which have been collected on another chamber. We have attained the rate of purification 2.7 kg h-1 m-2 g-1 under the sunlight with 80% efficiency. Result shows that a suitable nanocomposite gives an ideal change in solar water purification system by using simple technique. The chemical composition, structural morphology and crystal structure of synthesized graphene plasmonic nanocomposite has been studied by energy-dispersive X-ray spectroscopy (EDX) and field emission scanning electron microscope (FE-SEM) and X-ray diffraction (XRD), respectively. So we have achieved pure drinking water from sewage and sea water under normal environmental conditions.

Synthesis of Cs-Doped TiO2 Nanoparticles to Improve the Stability of Dye-Sensitized Solar Cells

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DSSC is one of the most promising candidates for achieving efficient solar energy conversion because it is flexible, inexpensive and easy to manufacture. DSSCs are known to functioning well in low light or diffuse light conditions. Therefore, they are interesting for indoor use, where the ambient light may have different spectra. DSSC provides a technically and economically credible alternate concept in present days. The effect of additive on the performance of the dye-sensitized solar cell (DSSC) has been studied. Dye-sensitized solar cells based on titanium dioxide (TiO2) are highly efficient, longer carrier lifetime to conventional solid state photovoltaic (PV) devices based on materials such as cesium. The efficiency of Cs has increased the stability and surface area in DSSC. Dye-sensitized solar cell employing Cs-doped TiO2 has been increased efficiencies and stability of solar cells. Cs doped TiO2 nanoparticles has been prepared by sol-gel method. The compound samples has been characterized by X-ray diffraction (XRD), EDX, SEM and UV/Vis. The XRD patterns have indicated that the crystal structure still remains as anatase phase for the doped samples. Keywords: Cesium, TiO2 nanocomposite, Dye-Sensitized solar cell.

Synthesis Of Zr/TiO2 Nanocomposite Via Facile Immersion Approach Highly Optimized Perovskite Solar Cell

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In recent years, enhancement in power conversion efficiency of Perovskite solar cells (PSCs) has been shown incredible progress, from reports of about 3% in 2006 to over 24% in 2019. It is accomplished that the 3rd generation PSCs technologies discussed here are well placed for major contribution to large scale energy production.Whereasthe commercialization of PSCs still faces obstacles in term of fabrication and stability. Perovskite solar cells convert the ultraviolet and visible solar light very efficiently into electricity; they may be excellent tandem partners to absorber materials such as crystalline Titania that convert lower-energy light. Recently perovskite compounds attracted great attention in research. The use of Zr/TiO2 increase the thermal conductivity in solar cell gained from solar radiation. Due to doping of Zr, stability and surface area of TiO2 nanocomposite has been increased.The objective of current work is to synthesis of Zr/TiO2 nanocomposites via sol-gel method for perovskite solar cells. A sequence of (Zr /TiO2) with various concentrations of Zr has been prepared by using titanium (IV) iso prop oxide and zirconium nitrateas precursors. Zr/TiO2 samples has been characterized by using these techniques e.g. X-ray diffraction (XRD), UV–Vis, SEM and EDX. The samples has been phase pure with the anatase structure in which XRD data hasindicate even after 5 mol % for doping of zirconiumin the crystal lattice of TiO2.The crystalline size decreased with increasing Zr substance. An increase in the field surface area has been also observed after doping of zirconium (Zr) on nano-Titania.

Facile sonochemical synthesis of strontium based mixed phase/Polyaniline composite material for potential application in supercapattery devices

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Among hybrid energy storage devices, supercapattery gained profound research interest due to its ability to give high energy density while maintaining the power density and cyclic stability. In this study, novel low-cost strontium/polyaniline based materials with multiple phases of oxides, carbonates and phosphate are successfully synthesized by controlled sonochemical method followed by calcination at various temperatures. The material with mixed particle-rod like morphology allows the synergistic contributions from its multiple phases during electrochemical charge storage process. The characteristic electrochemical behavior of materials reveals a “battery-type” nature of synthesized material with a high specific capacity of 196 Cg-1.. A thorough electrochemical performance of optimized material (on the basis of calcination temperature) is investigated as an electrode material in a sandwiched type asymmetric device. The supercapattery (SrP/PANI 50/50//AC) operates at 0 – 1.7 V in 1 M KOH and give a high specific capacity of 102 Cg-1 at 0.5 Ag-1 and retained 90 % of its value at high current density of 4.0 Ag-1. Furthermore, supercapattery offers a considerably high energy density of 56.1 W h kg-1 at a power density of 1940 W kg-1. In addition, the device well retained its specific capacity to 90 % after continuous 3000 charge/discharge cycles at 4 Ag-1. Strontium/polyaniline based materials with mixed phases could be proposed as an appropriate choice as an electrode material for hybrid energy storage devices.

Perovskite Solar Cell, The Most Recent Developments

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One of the most exciting developments in photovoltaics over recent years has been the emergence of organic−inorganic lead halide perovskites as a promising new material for low-cost, high-efficiency photovoltaics. In record time, confirmed laboratory energy conversion efficiencies have increased from a few percent to over 22%. Although there remains uncertainty as to whether materials with the required stability can be found within the associated material system and whether the presence of Pb in highly soluble form will limit commercial application, it is certain that these perovskite cells will remain the focus of concerted research efforts over the coming decade.

Applications of Doped Metal Oxide Nanostructures for Renewable Energy

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The poster will focus to find out alternative, reliable and compatible renewable energy resources to meet with the recent energy crises all over the world. This study plans to synthesize, characterize the various doped metal oxide nanostructures. Furthermore, these nanostructures will be characterized using XRD, SEM, EDX, UV-Visible Spectroscopy, FTIR. The functional characterization will be carried out by electrochemical techniques such as; linear sweet voltammetry, cyclic voltammetry, chronoameprometry, chronopotentiometry, and Electrochemical Impedance Spectroscopy. Finally, the device and battery fabrication will be carried out at the end of this proposed study.

It is a well-known fact that energy demand is highly increasing now a days, which folded over the world into crises. Therefore, it is very important and also a crucial job for the scientific community to find out the solution at its desired level. Up to this the world totally dependent to generate the energy by using fossil and nuclear means, these means of energy generation are very costly from economic as well as environmental point of view.

In this regard the research groups all over the globe are busy to find the solution of the energy crises by utilizing the alternative energy means. Presently they are looking to use of the abundant materials present on the earth. Recently, it has been repeatedly reported in the literature that some catalyst materials are being frequently used as a tool for generation of alternative energy. The materials which are being frequently used as a catalyst are facing a big challenge in the sense of reliability and compatibility.

As it well noticed, that nanotechnology is playing its vital role for the solution of number of complex issues in variety of field by utilizing the materials at their nano scale level. Since recent past the nanotechnologist around the world are working to find out economic and environmental friendly alternative energy system by using the metal oxide nanomaterials. These materials are being used for generation of energy by splitting the water molecule i.e getting Hydrogen and oxygen as sources of energy by means of oxygen evolution reaction (OER) or water oxidation reaction or using reversible process along with hydrogen evaluation reaction (HER) or oxygen reduction reaction (ORR).

This poster will focus on the applications of various metal oxide doped nanostructure for the splitting of water into oxygen and hydrogen for alternative energy applications.

Synthesis of copper iodide nanoparticles and their characterization: Inorganic hole transport material for perovskite solar cell

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Copper iodide (CuI) nanoparticles are very significant due to their numerous applications in various fields such as detection of mercury, cloud seeing, synthesis of organic compounds and many others. Copper iodide also recognized as cuprous iodide having band gap 3.1 eV. Copper iodide nanoparticles are being used intensively in energy related applications such as perovskite solar cells. Recently, cuprous iodide has been used as an inorganic hole conducting material (HTM) in perovskite solar cells. In this research work, copper iodide nanostructures were synthesized by using a low cost method in which copper sulphate, potassium iodide and sugar beet juice were used. Different samples were prepared by using different amount of sugar beet juice, i.e., without juice and with juice (5 ml, 100 ml, 15 ml, 20 ml). Various material investigation techniques such as X-ray diffraction (XRD), electron microscopy (SEM) and UV- visible spectroscopy were used in order to investigate crystal structural features, morphology, and optical properties of obtained copper iodide nanostructures. Crystallite size of the samples were calculated using Scherrer equation and found to be 46 nm, 43 nm, 41 nm, 40 nm, 38 nm respectively. SEM results showed it has triangular morphology. From UV- visible spectroscopy the maximum absorption peak was observed at 240 nm.

Development Of Reduce Graphene Oxide (RGO) Based Counter Electrode for Enhanced Performance Of Dye Sensitized Solar Cell.

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Energy consumption level is increasing day by day and it becomes very difficult to meet this demand using conventional energy sources. Researchers are working hard to tackle this issue using various approaches. One of these approaches is the efficient use of solar energy as energy from sun is the largest and the most promising carbon free energy source that can be converted into electricity by using solar cells. Since 1990, Dye-sensitized Solar Cell (DSSC) consisting of nanocrystalline structures is becoming a better alternate of commercialized silicon based solar cells because of its low-cost manufacturing, high efficiency and eco-friendly behavior. Counter electrode is an important component of DSSC. In the present work, Reduce Graphene Oxide (RGO) was prepared from graphene oxide. Graphene oxide was first prepared by improved Hammer's method. The samples were characterized using X-rays diffraction (XRD), scanning electron microscopy (SEM) for their structural and morphological investigations. XRD showed the pure phase of the Reduce Graphene Oxide (RGO) nanoparticles. Various parameters such as average crystallite size, lattice constants, unit cell volume and X-ray density were also calculated from the XRD data. The synthesized nano-particles can be used in the counter electrode of dye sensitized solar cells (DSSCs). There are many studies in which thin film of RGO on conducting substrate was used as counter electrode in dye-sensitized solar cells.

Preparation and characterization of Nickel oxide (NiO) nanoparticles as hole transport material for high-performance perovskite solar cells

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Nickel oxide nanoparticles are of vital interest due to their low cost and easy availability. Also, these have unique optical, catalytic, mechanical, electrical, magnetic, and heat conduction properties. Nickel oxide is an important cubic p-type semiconductor with a direct band gap of 3.6 eV to 4.0 eV. In the present research work, simple soft chemical route was used to synthesize nickel oxide nanoparticles. For sample preparation, Nickel chloride ($NiCl_2.6H_2O$) and Sodium hydroxide (NaOH) was used. For characterization of Nickel oxide nanoparticles, two techniques were used namely X-ray diffraction (XRD) and Scanning electron microscope (SEM) to study their structural and morphological properties respectively. XRD studies showed pure phase of Nickel oxide which confirmed the impurity free phase. Nickel oxide can be used successfully as a hole transport material for Perovskite Based Solar Cells (PSCs).

An efficient nickel sulfide nanocomposite catalyst with high density of active sites for the hydrogen evolution reaction in alkaline media

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Efficient hydrogen evolution reaction (HER) catalysts based on earth-abundant materials are highly vital to design practical and environmentally friendly water splitting devices. In this study, we present an optimized strategy for the development of active hydrogen evolution reaction HER catalyst using composite nanostructures of NiS and NiO. The composite catalysts are prepared by hydrothermal method. In the alkaline electrolyte, the NiS/NiO nanocomposite has shown excellent catalytic HER properties at the low onset potential and small Tafel slope of 72 mVdec-1. A current density of 10 mA/cm2 is achived by the sample 4 at the cost of 429 mV vs RHE. The sample 4 carries more active sites and surface area that allow it to act as excellent HER catalyst. Based on this study, we conclude that increasing the nickel content into composite material that facilitates the HER process. Additionally, a long term HER stability of 10 hours and good durability is also demonstrated by the sample 4. Moreover, EIS study showed the small charge transfer resistance and large capacitance double layer value for the sample 4 which strengthened the claims made on the polarization curves for HER. Our findings reveal that the optimization of nickel content in the catalyst leads to the excellent HER activity and stability which further provides an alternative HER catalyst for the design of practical water splitting devices and other related energy storage devices.

Improvement of Internal Quantum Efficiency by using bandgap engineered green light-emitting diodes.

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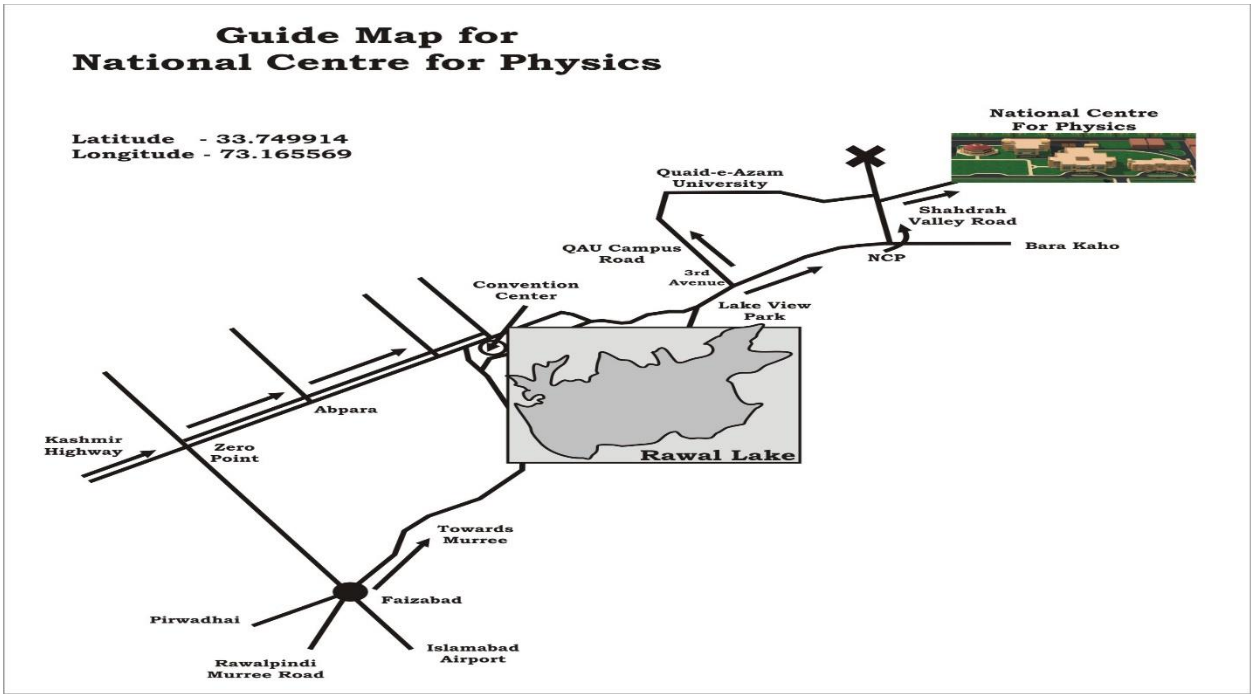
In order to enhance the internal quantum efficiency of green light emitting diodes we have presented W-shaped quantum well. The numerical results of our proposed structure suggests that optoelectronic properties i.e. internal quantum efficiency, light output power, and radiative recombination rate are enhanced significantly. The enhancement is related with significant improvement of hole confinement because of localization of indium in the active region.

In-Situ Synthesis of Polyaniline/FNCO Composite for electrode material of Supercapacitor with improved cyclic stability

Muhammad Usman

In this work, polyaniline/FNCO nanocomposites have been prepared by in-situ addition 10 weight % FNCO as fillers in the polyaniline matrix. The nanocomposites were then characterized via scanning electron microscopy (SEM), X-ray diffraction (XRD), thermogravimetric analysis (TGA), UV-Vis spectrophotometry in order to observe the morphology, phase, thermal stability samples, respectively. SEM results showed that FNCO wires were fairly dispersed in the polyaniline matrix while XRD results showed a broad peak for nanocomposites due to semi crystalline nature of polymers. The electrochemical properties of the samples were then analyzed via cyclic voltammetry (CV), galvanostatic charge-discharge cycles (CED) and Electrochemical Impedance Spectroscopy (EIS). Polyaniline/ 10 wt.% FNCO nanocomposites showed the highest capacitance of 1171 Fg^{-1} at 1 Ag, this composite shows the lowest charge transfer resistance (R_{ct}).

Directions



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