Respected Sir/Madam,

I am Praloy Mondal, a Postdoctoral fellow in the Physics department of IIT Bombay, working under the supervision of Prof. S S Major. Recently I am working on ZnO-thin film/nanorod based Photodetectors on Si and GaN grown by reactive sputtering. I have also worked as Research Associate for 1.5 years in IISc Bangalore under the supervision of Professor Jaydeep Kr. Basu in the field of graphene and MoS_2. I have done my Ph.D. from Indian Association for the Cultivation of Science and registered under the University of Calcutta. My research area of thesis is to study the Nanocrystalline Silicon and Zinc Oxide Thin-Films: Synthesis, Characterization and Optimization for Applications In nc-Si Solar Cells fabricated by various deposition instruments such as **sputtering, both capacitively coupled and inductively coupled RF-PECVD and thermal CVD.**

Have the experience in the following:

- *Experience with a full new laboratory set up equipped with both capacitively coupled and inductively coupled plasma CVD for the synthesis of Si:H, SiN_x, SiC_x, SiO_x based nanostructures and thin films for applications to solar cells, Microwave CVD for deposition of various ZnO films., RF & DC Magnetron Sputtering unit for the deposition of various coating materials and transparent oxide materials and aluminum template unit.*

- *Experience in indigenous development of Metal Evaporation Unit, I-V measurement setup with low-temperature facilities, and aluminum template unit.*
- *Working with various deposition instruments such as sputtering, both capacitively coupled and inductively coupled RF-PECVD and thermal CVD.*

- *Experience in growth and characterization of silicon and ZnO-based thin films and nano-structure by capacitively coupled and inductively coupled PECVD.*
- *Experience in UV-VIS spectroscopy, photoluminescence spectroscopy, Fourier transformed infrared spectroscopy, X-ray photoemission spectroscopy, X-ray diffractometer, Transmission Electron Microscope (TEM), Scanning Electron Microscope (SEM), Atomic Force Microscopy (AFM).*
- *Photoconductivity and electrical transport property measurements of thin films and nanostructures at room and cryogenic temperature.*
- *Experience in operating micro-Raman spectroscopy and data analysis of silicon and ZnO-based nanostructures.*

· I am looking for a scientist position desperately. I am attaching the detailed CV. I would consider myself fortunate if there is an opportunity to work in this institute.

· Looking forward to hearing from you.

· Thanks, and best regards,
· Dr. Praloy Mondal

CURRICULUM VITAE

Dr.Praloy Mondal

Post-doctoral fellow

Department of Physics, IIT BOMBAY

Phone number: +919434945369, +919064975136.

Researcher ID: ORCID identifier is 0000-0003-3601-4722,

Personal Information:

Sex: Male

Citizenship: Indian

Home Address: West Bengal, India.

Educational Details:

- ***Post doctoral fellow (from 19.08.2019 to still now)***

  Physics Department, IIT Bombay
- ***Working on ZnO and Si based Photodetectors.***

- ***Research Associate (2017-07.05.2019)***

  Worked on Layered Graphene/MoS_2–Semiconducting Quantum Dot Devices

  Supervisor: Prof Jaydeep Kr basu

  Soft-Nano Materials Physics Group, Department of Physics, Indian Institute of Science

  Bangalore - 560 012. INDIA.

•Ph.D. Thesis title **Nanocrystalline Silicon And Zinc Oxide Thin-Films: Synthesis, Characterization And Optimization For Applications In nc-Si Solar Cells**

Starts from: 27.06.2011

Ph.D. Degree: degree obtained on 08. 05.2019

University: **University of Calcutta**

Principle Investigator: ***Prof. Debajyoti Das***

Energy Research Unit

Indian Association for the Cultivation of Science

Kolkata-700032, India

•Master of Science (Physics, Specialization in Quantum Electronics)

Year of Passing out: 2010.

University: Visva Bharati University, Birbhum, West Bengal, India.

Division: 1st class (71 %).

•Bachelor of Science (Physics Honours)

Year of Passing out: 2008.

University: Burdwan University, Burdwan, West Bengal, India.

Division: 1st class (69 %).

Language skills

English (Fluent)

Bengali (native, Fluent)

Hindi (good)

Academic achievements & Awards:

- ***Research Associate (2017- 07.05.2019)***
- ***Awarded Senior Research Fellowship by UGC (SRF) (2013-2017)***
- ***Awarded Junior Research Fellowship by Council of Scientific and Industrial Research (JRF-UGC) (2011-2013).***
- ***National Eligibility Test (UGC JRF) (2010)***
- ***Qualified Graduate Aptitude Test (GATE) Engineering (2011)***
- ***Qualified Joint Entrance Screening Test (2011)***

RESEARCH INTEREST:

FABRICATION AND CHARACTERIZATION OF *n*-GZO/*p*-Si HETEROJUNCTIONS:

Reactively co-sputtered GZO layers have been used to fabricate high quality n-GZO/p-Si heterojunction diodes displaying ideality factors in the range of (1-2). The GZO/Si heterojunctions formed with higher carrier concentrations > 10^{19} cm^{-3} and larger thickness (> 350 nm) of GZO layer display significant deviation from diode behavior, resulting in nearly non-rectifying contacts. The GZO layers deposited at lower thickness exhibit nearly complete *c*-axis orientation of crystallites, lower doping level of Ga and higher chemisorbed oxygen species, which contribute towards the significantly ideal heterojunction diode behavior, arising from the passivation of defects at junction interface and reduced recombination losses. The diode ideality factor values in the range of (1-2) for the n-GZO/p-Si heterojunction diodes fabricated with a low GZO layer thickness (< 300 nm) and higher O_2 percentages (> 5 %) lower substrate temperatures (~ 375 ^oC) as reported by the report, are highly promising for a wide range of possible device applications and integration with Si technology. The GZO columnar films/nanorod deposited by DC reactive sputtering grown over a wide range of substrate temperatures (200 - 700 ^oC) display a large variation of microstructure and morphology. However, in all these cases, the n-GZO/p-Si display close to ideal heterojunction characteristics offering themselves as promising building blocks for a wide range of electronic, optoelectronic and transparent electronic devices. The initial results of GZO/Si UV Photodetectors fabricated by reactive co-sputtering of GZO layer, displaying responsivity in the range of 0.25-0.40 A/W are highly promising.

- Recently I am working on ZnO and Si based Photodetectors.

- My research focuses on the development of Nanocrystalline Silicon and Zinc Oxide Thin-Films with its Synthesis, Characterization and Optimization for Applications in nc-Si Solar Cells.

- I have also worked on intrinsic ZnO thin films by playing on its inherent vacancies using RF magnetron sputtering, being the most commonly used technique due to its simplicity and possibility of obtaining good preferred orientation of the material with controlled morphology and defect profile at low growth temperature, with increased deposition rate and film uniformity.

- The development of transparent and conducting ZnO:Ga and ZnO:Ga:Cu thin films, using the RF magnetron sputtering, having preferred crystallographic orientation with organized structure at low growth temperature and low RF power.

- With an optimum incorporation of hydrogen at a low substrate temperature T_S= 100 °C corresponding in the RF magnetron sputtering plasma, ZnO:Ga:H film having enhanced crystallite size and improved crystallinity with preferred c-axis orientation attains a high electrical conductivity.

- The formation of the enhanced ultrananocrystalline component in the Si-network at elevated pressure, under the optimized parametric condition in 27.12 MHz H_2-diluted SiH_4 plasma by PECVD, promote nc-Si films of low microstructure factor at a low substrate temperature and an enhanced growth rate.

- I have also worked on Boron doped nanocrystalline silicon (nc-Si) films with high dark conductivity high crystalline volume fraction with large Si-ncs having preferred crystallographic orientation has been obtained under optimized parametric condition in 13.56 MHz H_2-diluted SiH_4 plasma by using B_2H_6 as dopant gas.
- Maximum solar cell efficiency (η) of 7.05 % with I_{sc} = 23.85 mA and V_{oc} = 0.510 Volt is obtained with absorber layer deposited at $D(H_2)$ = 97%.

- I have the interest to work on Silicon and Carbon nano-structured thin films at low temperature, for potential optoelectronic (e.g. photovoltaic, field emission, etc) and tribology (coatings) associated industrial applications.

Technical Skills

- ***Experience with full new laboratory set up equipped with both capacitively coupled and inductively coupled plasma CVD for synthesis of Si:H, SiN_x, SiC_x, SiO_x based nanostructures and thin films for applications to solar cells, Microwave CVD for deposition of various ZnO films., RF & DC Magnetron Sputtering unit for the deposition of various coating materials and transparent oxide materials and aluminum template unit.***
- ***Experience in indigenous development of Metal Evaporation Unit, I-V measurement setup with low temperature facilities and aluminum template unit.***
- ***Working with various deposition instruments such as sputtering, both capacitively coupled and inductively coupled RF-PECVD and thermal CVD.***
- ***Experience in growth and characterization of silicon and ZnO based thin films and nano-structure by capacitively coupled and inductively coupled PECVD.***
- ***Experience in UV-VIS spectroscopy, photoluminescence spectroscopy, Fourier transformed infrared spectroscopy, X-ray photoemission spectroscopy, X-ray diffractometer, Transmission Electron Microscope (TEM), Scanning Electron Microscope (SEM), Atomic Force Microscopy (AFM).***
- ***Photoconductivity and electrical transport property measurements of thin films and nanostructures at room and cryogenic temperature.***
- ***Experience in operating micro-Raman spectroscopy and data analysis of silicon and ZnO based nano-structures.***

Attended Symposium/Conference/Workshop:

1. *National Workshop on maintenance of electronics laboratory instruments, July 26-30, 2011, Jadavpur University, India.*
2. *57th DAE Solid State Physics Symposium, 3-7 December 2012, Bombay, Mumbai, India.*

3. *58^{th} DAE Solid State Physics Symposium, 17-21 December 2013, Patiala, Punjab, India.*
4. *59^{th} DAE Solid State Physics Symposium, December 16-20, 2014, VIT University, Vellore, Tamil Nadu, India.*
5. *60^{th} DAE Solid State Physics Symposium, 21–25 December 2015, Amity University, Uttar Pradesh, India.*
6. *National Seminar On Advanced Functional Materials, Technology & Its Social Implications (January 30-31, 2015) (NSAFMTSI-2014), Haldia Institute of Technology, Haldia, West Bengal, India.*

TEACHING DUTIES:

1. *Teaching Assistant in Optics & Solid State Physics Laboratories (Aug 2019 - March 2020).*

2. *Teaching Assistant for Applied Solid State Physics theory course (Aug 2020 - Dec 2020).*

3. *Teaching Assistant for the On-line Solid State Physics Laboratory Course, which was conducted in live-video mode (Jan 2021 – April 2021).*

4. *Teaching Assistant for the On-line Solid State Physics Laboratory Course, which was conducted in live-video mode (Aug 2021 – Dec 2021).*

5. *Teaching Assistant for the On-line Solid State Physics Laboratory Course, which was conducted in live-video mode (Jan 2022 – April 2022).*

Publications:

1. *High performance GZO/p-Si heterojunction diodes fabricated by reactive co-sputtering of Zn and GaAs through the control of GZO layer thickness, Praloy Mondal, Shravan K. Appani, D. S. Sutar & S. S. Major, RSC Adv., 2021,11, 19779-1978. (IF: 3.36)*
2. *Enhancing Carrier Diffusion Length and Quantum Efficiency through Photoinduced Charge Transfer in Layered Graphene–Semiconducting Quantum Dot Devices, Riya Dutta, Avradip Pradhan, Praloy Mondal, Saloni Kakkar, T. Phanindra Sai, Arindam Ghosh and Jaydeep Kumar Basu, ACS Appl. Mater. Interfaces 2021, 13, 20, 24295–2430. (IF: 9.229)*
3. *Effect of oxygen partial pressure on the behavior of Ga-doped ZnO/p-Si heterojunction diodes fabricated by reactive sputtering, Praloy Mondal, Shravan K. Appani, D. S. Sutar & S. S. Major, Journal of Materials Science: Materials in Electronics volume 32, pages 4248–4257(2021). (IF: 2.478)*
4. *Electrical Tuning of Optical Properties of Quantum Dot–Graphene Hybrid Devices: Interplay of Charge and Energy Transfer, Riya Dutta, Saloni Kakkar, Praloy Mondal, Neha Chauhan, JK Basu, J. Phys. Chem. C 2021, 125, 15, 8314–8322 (2021). (IF: 4.126)*
5. *Effect of Oxygen vacancy induced defect on the optical emission and excitonic lifetime of intrinsic ZnO, P Mondal, Optical Materials 98, 109476 (2019). (IF: 3.08)*
6. *Oxygen vacancy induced anomalous Raman mode in intrinsic ZnO film, P Mondal, Vibrational Spectroscopy, 102939 (2019). (IF: 2.507)*
7. *Electrical Control of Defect Assisted Trapped Excitons and trions States in Monolayer MoS2, P HL, P Mondal, A Bid, J Basu, APS Meeting Abstracts.*
8. *Electrical and Chemical Tuning of Exciton Lifetime in Monolayer MoS2 for Field-Effect Transistors, P HL, P Mondal, A Bid, JK Basu ACS Applied Nano Materials 3 (1), 641-647 (2019). (IF: 5.097)*
9. *Development of optimum p–nc-Si window layers for nc-Si solar cells, P. Mondal and D. Das; Phys. Chem. Chem. Phys, 19 (32), 21357-21363, (2017). (IF: 3.676)*
10. *Effect of oxygen on the optical, electrical and structural properties of mixed-phase boron doped nanocrystalline silicon oxide thin films, D. Das and P. Mondal; Applied Surface Science, Volume 423, 30 November 2017, Pages 1161-1168. (IF: 6.707)*

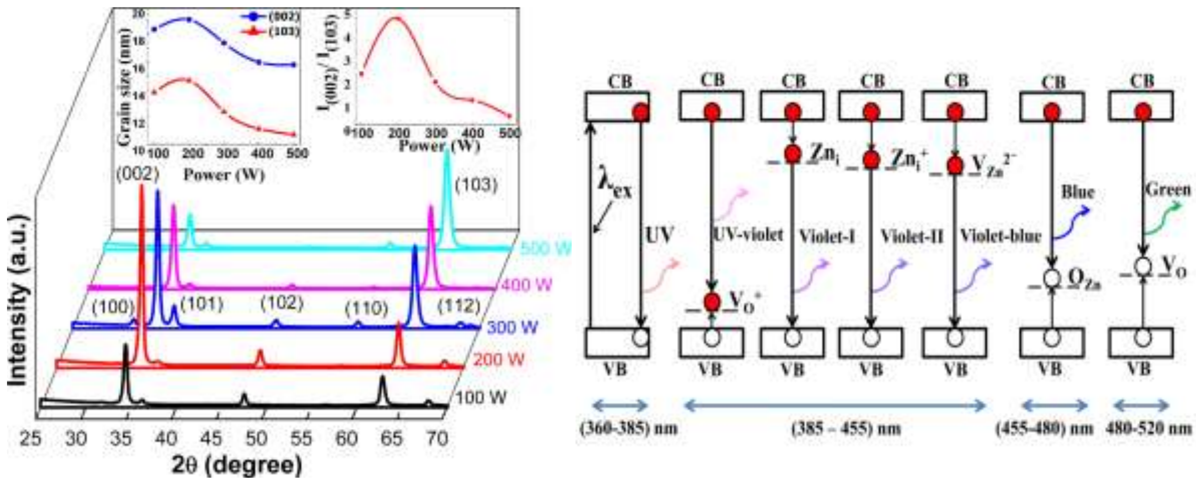
11. *Correlation between the physical parameters of the i–nc-Si absorber layer grown by 27.12 MHz plasma with the nc-Si solar cell parameters, D. Das and P. Mondal: Appl. Surf. Sci, Applied Surface Science, Volume 416, 15 September 2017, Pages 980-987 . (IF: 6.707)*
12. *The growth of ZnO:Ga:Cu as new TCO film of advanced electrical, optical and structural quality, D. Das and P. Mondal: Physica E: Low-dimensional Systems and Nanostructures, 91 (2017), 1–7. (IF: 3.382)*
13. *Further improvements in conducting and transparent properties of ZnO: Ga films with perpetual c-axis orientation: Materials optimization and application in silicon solar cells, P. Mondal and D. Das , Appl. Surf. Sci, 411 (2017), 315–320. (IF: 6.707)*
14. *Effect of hydrogen in controlling the structural orientation of ZnO:Ga:H as transparent conducting oxide films suitable for applications in stacked layer devices: P. Mondal and D. Das, Phys. Chem. Chem. Phys, 18 (2016), 20450–20458. (IF: 3.676)*
15. *Low temperature grown ZnO:Ga films with predominant c-axis orientation in wurtzite structure demonstrating high conductance, transmittance and photoluminescence: D. Das and P. Mondal; RSC Adv., 6 (2016) 6144–6153. (IF: 3.36)*
16. *Highly conducting and preferred <220> oriented boron doped nc–Si films for window layers in nc–Si solar cells: P. Mondal and D. Das; AIP Conf. Proc., 1731 (2016) 050037.*
17. *Preferential (220) Crystalline Growth in Nanocrystalline Silicon Films from 27.12 MHz SiH4 Plasma for Applications in Solar Cells: P. Mondal and D. Das; RSC Adv. 5 (2015) 54011–54018. (IF: 3.36)*
18. *Transparent C-axis Oriented Photoluminescent ZnO:Ga Films Grown by Low Temperature Magnetron Sputtering: P. Mondal and D. Das; AIP Conf. Proc. 1665 (2015) 080032-1–3.*
19. *Photoluminescence phenomena prevailing in C-axis oriented intrinsic ZnO thin films prepared by RF magnetron sputtering: D. Das and P. Mondal; RSC Adv. 4 (2014) 35735–35743. (IF: 3.36)*
20. *Conducting intrinsic nanocrystalline silicon films with high growth rate prepared at 27.12 MHz frequency: P. Mondal and D. Das; AIP Conf. Proc. 1591 (2014) 236–237.*
21. *Transparent and conducting intrinsic ZnO thin films prepared at high growth-rate with c-axis orientation and pyramidal surface texture: P. Mondal and D. Das; Appl. Surf. Sci. 286 (2013) 397–404. (IF: 6.707)*
22. *Preferred C-axis oriented photoluminescent ZnO thin films prepared by RF magnetron sputtering: P. Mondal and D. Das; AIP Conf. Proc. 1512 (2013) 644–645.*

Research Summary

Intrinsic ZnO film

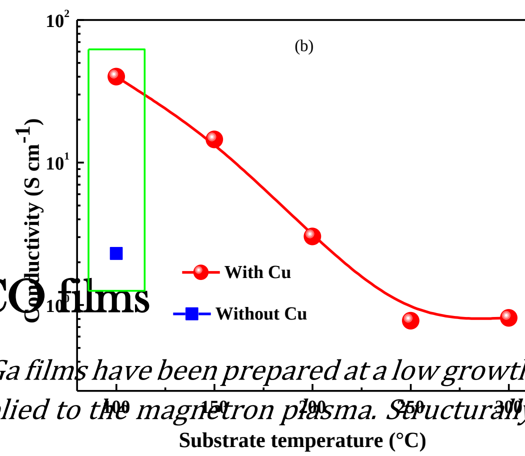
The present chapter deals with the studies of ZnO thin films by playing on its intrinsic vacancies using RF magnetron sputtering, being the most commonly used technique due to its simplicity and possibility of obtaining good preferred orientation of the material with controlled morphology and defect profile at low growth temperature, with increased deposition rate and film uniformity. The growth of ZnO thin films has been optimized by adjusting the intrinsic ion vacancies, by controlling the RF power applied to the plasma in magnetron sputtering. Preferred c-axis oriented intrinsic ZnO films with largest grain size and a hexagonal wurtzite structure, exhibiting high room temperature conductivity ~ 1.37 S/cm, high transparency ~80–90% within 450–800 nm and ~90–96% within 800–1900 nm, low reflectance (<5% in the visible range) was obtained at a very high deposition rate ~214 nm/min, at 300 ^{O}C, by maintaining higher concentration of Zn interstitials or singly ionized oxygen vacancy, corresponding to an optimized RF power of 200 W. At higher applied powers, disorder-activated Raman scattering introduces well resolved B_1^{high} mode and gradually growing second order Raman peaks, ($E_2^{high} – E_2^{low}$) and ($B_1^{high} – B_1^{low}$) caused by the breakdown of translational symmetry of the lattice by defects or impurities, leading to deviation from preferred c-axis orientation with $I_{002}/I_{103} < 1$. Out diffusion of oxygen from the network

creates increasing oxygen vacancy states (V_O, V_O^+) and in addition, various other defects e.g., Zn interstitial (Zn_i, Zn_i^+), doubly ionized Zn vacancy (V_{Zn}^{2-}) and oxygen antisite (O_{Zn}) as the dynamic acceptor defects acting as the origins of different visible photoluminescence components classified in the UV-violet, violet, violet-blue, blue and green
regions.



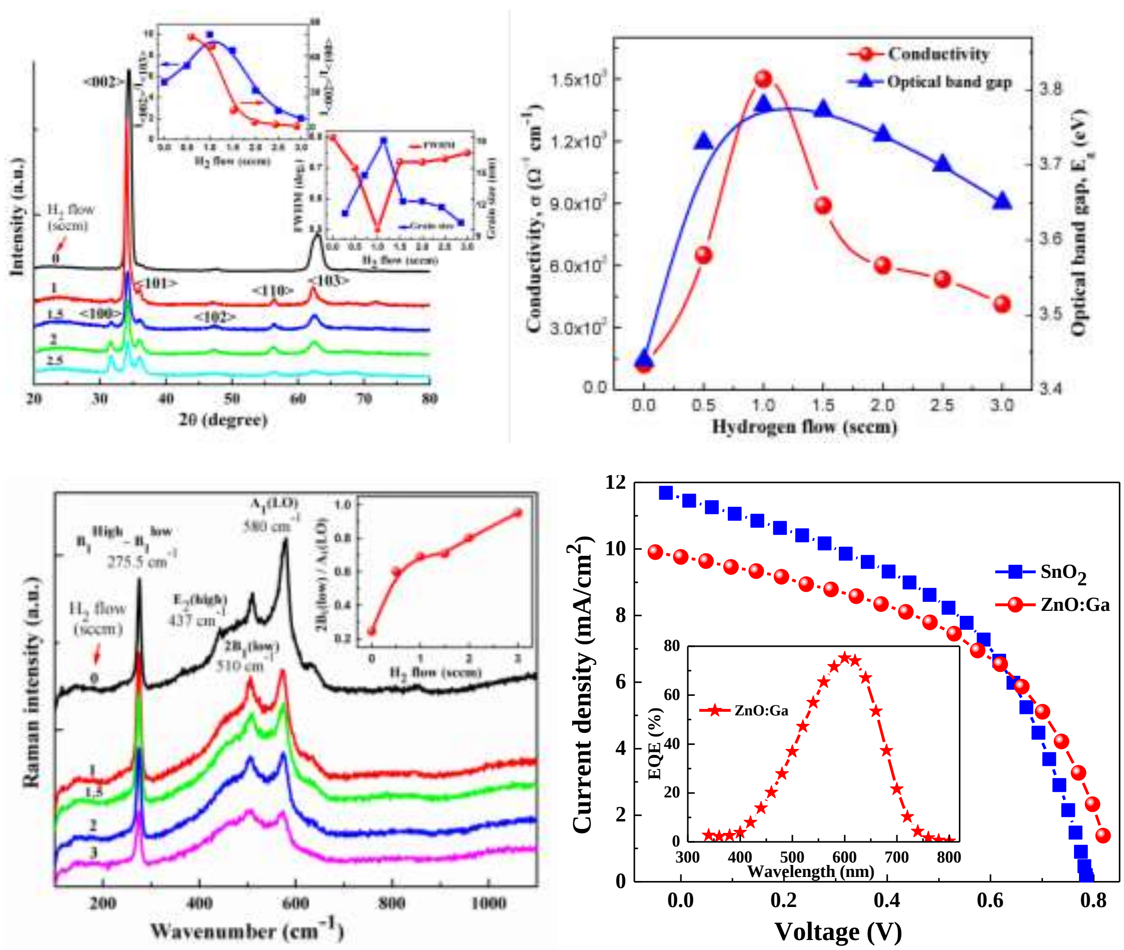
Low temperature grown ZnO:Ga and ZnO:Ga:Cu films

In this study we demonstrate the development of transparent and conducting ZnO:Ga and ZnO:Ga:Cu thin films, using the RF magnetron sputtering, having preferred crystallographic orientation with controlled morphology and defect profile at low growth temperature and low RF power. The Ga doped ZnO films grown at a low substrate temperature (~50 °C) and a low RF power ~50 W in RF magnetron sputtering possess a predominant c-axis orientation in wurtzite structure with $I_{<002>}/I_{<101>}$ ~ 40 in the XRD pattern; which has been further supported by the most prominent presence of the allowed Raman active A1 (LO) mode. Incorporation of Ga and Cu ions into the ZnO matrix promotes the violation of the local translational symmetry as suggested by the relaxation of the Raman selection rules in the network, evident by the presence of strong (B_1^{high} – B_1^{low}) modes which are usually Raman inactive. The consequences of Cu doping has been compared with identically prepared ZnO and ZnO:Ga films.



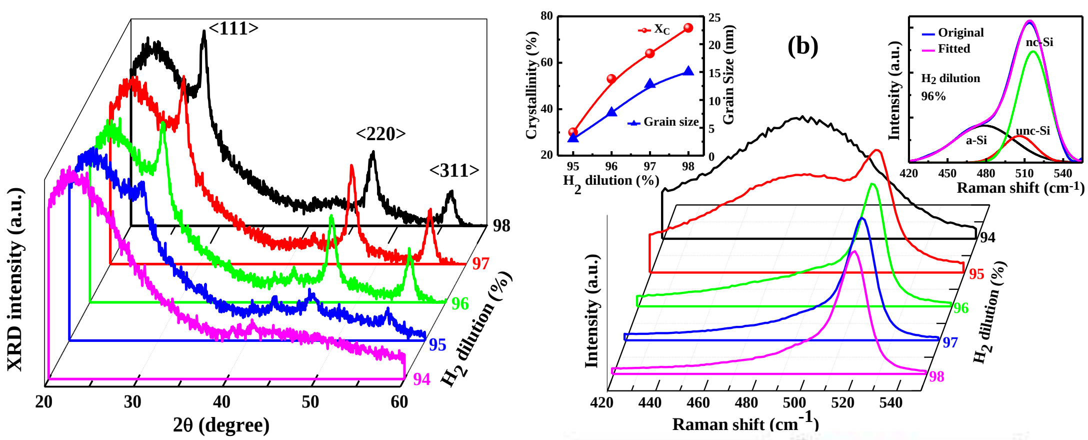
ZnO:Ga:H as TCO films

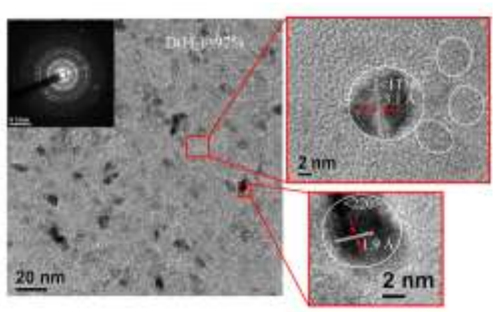
Technologically appropriate device friendly ZnO:Ga films have been prepared at a low growth temperature (100 °C) by changing the RF power (P) applied to the magnetron plasma. Structurally *preferred c-axis orientation of the ZnO:Ga network has been attained with $I_{<002>}/I_{<103>} > 5$. The c-axis oriented grains of wurtzite ZnO:Ga grows geometrically and settles in tangentially, providing favorable conduction path for stacked layer devices. The optimized ZnO:Ga thin film prepared at RF power of 200 W has <002> oriented grains of average size ~10 nm and exhibits a very high conductivity ~200 S cm^{-1} and elevated transmission (~93% at 500 nm) in the visible range. Hydrogenation of the ZnO:Ga network has been chosen as one promising avenue to further upgrade the optoelectronic as well as the structural properties of the films. With an optimum incorporation of hydrogen at a low substrate temperature, T_S =100 °C, in the RF magnetron sputtering plasma, ZnO:Ga:H film having large crystallite size (~17 nm) and improved crystallinity along the optimally preferred c-axis orientation with respect to both <100> ($I_{<002>}/I_{<100>}$ ~74) and <103> ($I_{<002>}/I_{<103>}$ ~10) directions attains a high electrical conductivity (σ ~1.5 x 10^3) and ~90% of visible range optical transmission that yields an wide optical band gap of ~3.78 eV.*

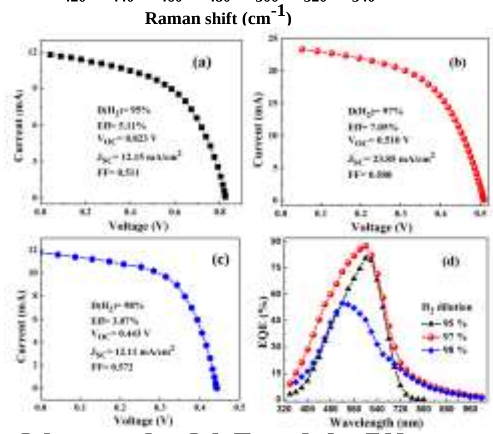


nc-silicon films from 27.12 MHz Frequency Source

Growth of highly conducting nc-Si thin films of optimum crystalline volume fraction, involving dominant <220> crystallographic preferred orientation with simultaneous low fraction of microstructures at a low substrate temperature and high deposition rate, is a challenging task for its promising utilization in nc-Si solar cells. Using an excitation frequency (27.12 MHz), higher than the conventional frequency of 13.56 MHz, and its stimulus impact in terms of larger ion flux densities with the reduced peak ion-energy in the plasma and its associated ability to efficiently generate atomic hydrogen, nanocrystalline silicon (nc-Si) films are produced which at elevated pressure possess, in general, enhanced growth rate, lesser hydrogen content, lower microstructure factor, preferred <220> crystallographic orientation, possessing significant fraction of ultra-nanocrystalline component in the Si-network, along with a higher intensity of monohydride bonding by bond-centered Si–H–Si mode in platelet-like configuration. Single junction nc-Si solar cells in p-i-n configuration have been prepared with i–nc-Si absorber layer and optimized. The preferred <220> alignment of crystallites, its contribution to the low recombination losses for conduction of charge carriers along the vertical direction, its spectroscopic correlation with the dominant growth of silicon ultra-nanocrystallites (unc-Si) and corresponding longer wavelength absorption, especially in the neighborhood of i/n–interface region recognize scientific and technological key issues that pave the ground for imminent advancement of multi-junction silicon solar cells. Single junction nc-Si *p-i-n* solar cells have been prepared with i–nc-Si absorber layer and optimized. The physical parameters of the absorber layer have been systematically correlated to variations of the solar cell parameters.



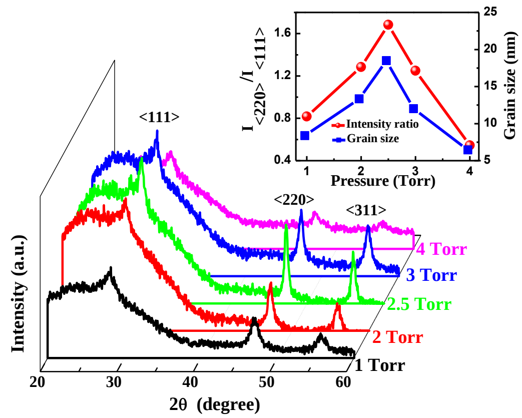


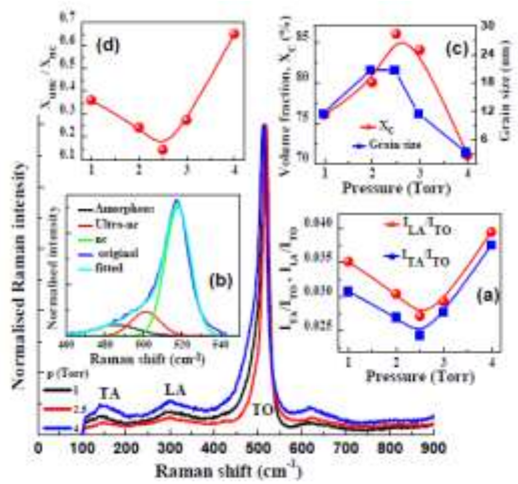


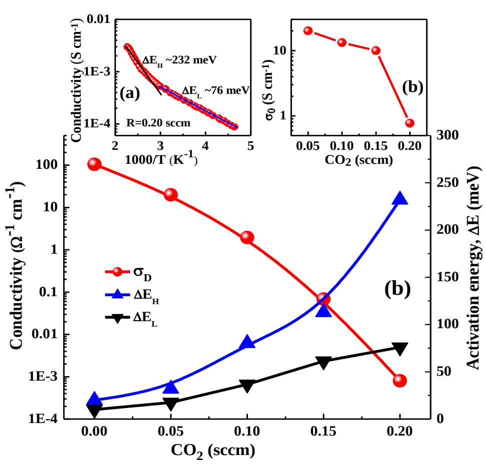
Boron doped nc-Si and SiO_x:H films

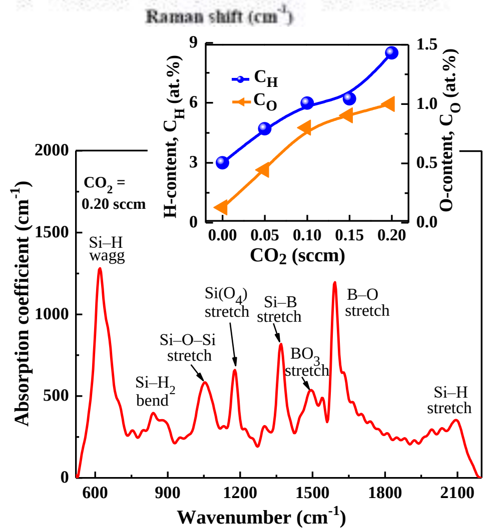
The p-type nc-Si films (p–nc-Si) have been optimized at low growth temperature (~180 ºC) and low power (~30 W) parametric condition in 13.56 MHz RF-PECVD. At elevated gas pressure (p), the growth rate enhances, however, the optical band gap reduces. At optimum p=

2.5 Torr, the p–nc-Si window-layer possessing high crystallinity, large grain size, high electrical conductivity, wide optical band gap and a preferred <220> crystallographic orientation of the nanocrystallites is obtained. Single p–i–n junction nc-Si solar cells in superstrate configuration have been realized with reasonably acceptable conversion efficiency, η ~7.05%. The preferred <220> oriented ($I_{<220>}/I_{<111>}$ ~1.68) highly crystalline (X_C ~86%) p–nc-Si window-layer minimizes the lattice mismatch at the p/i–junction, facilitates the growth of proper crystallinity in i–nc-Si absorber layer from its incubation stage during its sequential growth over the window layer and ensures low recombination losses for conduction of charge carriers along the vertical direction at the p/i–interface. Further improvement in cell efficiency sensitively depends on proper optimization and future upgradation of the i–nc-Si absorber layer, and the single junction nc-Si cell could play a significant role as an integral part of the premium all-Si tandem structure solar cells.









Electrical and Chemical tunable exciton lifetme in monolayer MoS_2

Unique optical properties of monolayer MoS2 such as strong binding energy of excitons and trions at room temperature make it a suitable material to study the dynamics of these quasi particles. In *spite of many studies of basic consequence and device applications involving MoS2 the fine tuning of exciton dynamics is more challenging in these 2D materials. Theoretical calculation shows that the lifetime of excitons increases with increasing the doping at all temperatures. We report a transition between quasiparticle states using Time Resolved Photoluminescence (TRPL) and Photoluminescence (PL) spectroscopy by tuning the carrier density of MoS2 monolayer in FET configuration. The chemical doping along with FET facilitates us to tune the carrier density up to ∼ 75% . We are able to make the fine tuning of exciton environment through the doping. Our results show a decrease in exciton lifetime with increasing the doping, which is in contradiction with the theory. To our best knowledge this is the first study where the local exciton properties have been controlled via both chemical and electrostatic doping at room temperature. These fine tuning of excitons in monolayer MoS2 can provide a platform for probing the excitonic physics and photonic applications.*

Ga doped ZnO/p-Si hetero-junction photodectors by RF/DC sputtering

One dimensional Ga-doped ZnO columnar films/nanorods (GZO) were fabricated using a simple reactive magnetron co-sputtering with 2 % GaAs area coverage of the erosion track of Zn target, at 20 % O_2 in Ar-O_2 atmosphere. Cross-sectional scanning electron microscopy of GZO films and nanorods fabricated under various deposition conditions have shown that substrate temperature perilously controls their growth morphology, ultimately resulting in the development of vertically c-axis oriented, highly aligned and separated ZnO nanorods at substrate temperatures of 700 °C. Effect of the substrate temperature on the performance of GZO nanorod/*p*-Si heterojunction diodes has been investigated in detail by I-V characteristics as well as by capacitance-voltage technique. X ray diffraction and X ray photoelectron spectroscopy show that the *c*-axis orientation of crystallites, Ga/Zn ratio and the presence of oxygen related defect species depend substantially on substrate temperature of GZO layers. The heterojunction diodes fabricated with mixed structure of GZO columnar films and nanorods display better rectifying behavior. The diode fabricated GZO layers grown at 475 °C display nearly ideal rectification with diode ideality factors in the range of 2.5, together with, turn-on voltage ~ 0.4 V, reverse saturation current ~10^{-5} A, barrier height ~0.3 eV, built in voltage~0.3 V and series resistance ~ 20 kΩ. The improved diode performance is primarily attributed to the compact structure at of nanorods with small Ga/Zn ratio (~ 0.004). This is due to diffusion and substantially non-substitutional incorporation of Ga in thin GZO layers. These factors lead to the self-adjustment of doping concentration in thin GZO layers, which, together with better crystallite orientation along c-axis and larger presence of chemisorbed oxygen/hydroxyl species, lead to the formation of diodes with nearly ideal characteristics, not reported earlier for GZO/*p*-Si heterojunction system. Interestingly, the isolated GZO nanorod/*p*-Si diode fabricated at high growth temperature (~700 °C) also display great rectifying behavior, which are promising building blocks for heterojunction optoelectronic devices.

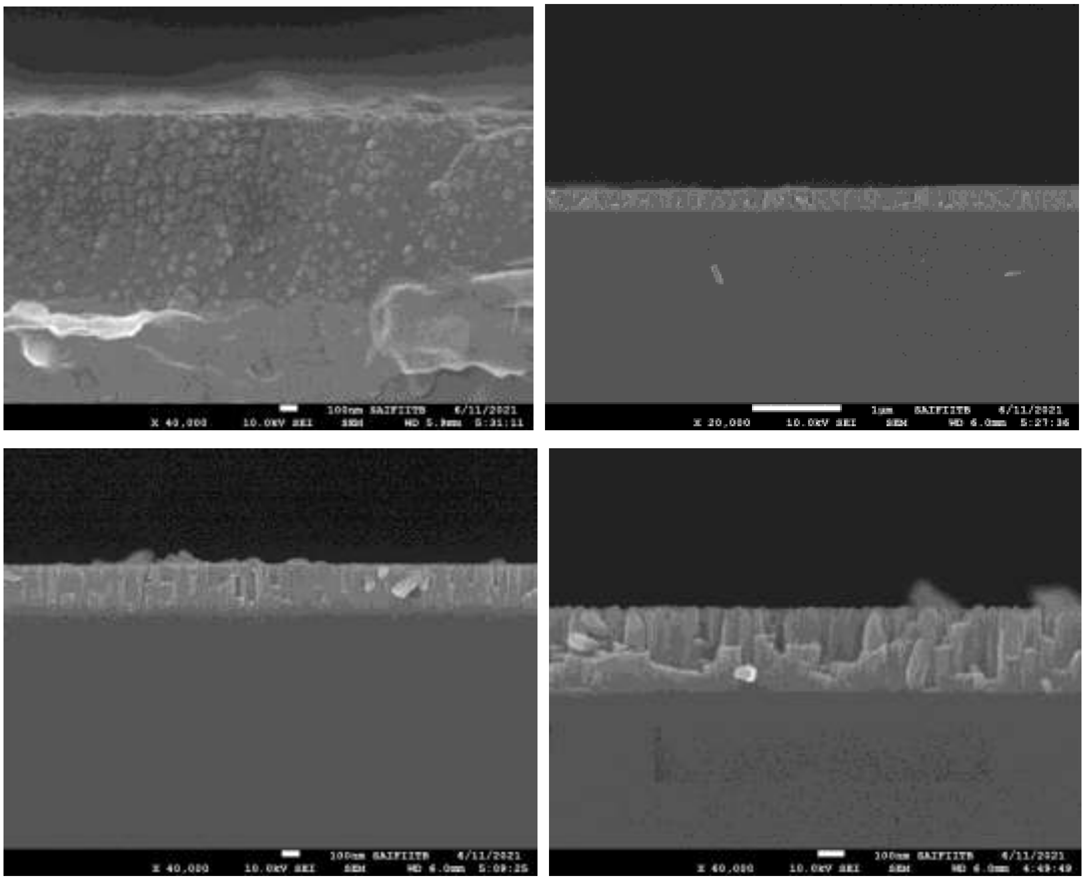


Fig.14 Cross-sectional FESEM images of ZnO columnar films/ nanorods grown at different substrate temperatures; (a) 200 °C, (b) 475 °C, (c) 570 °C and (d) 680 °C.

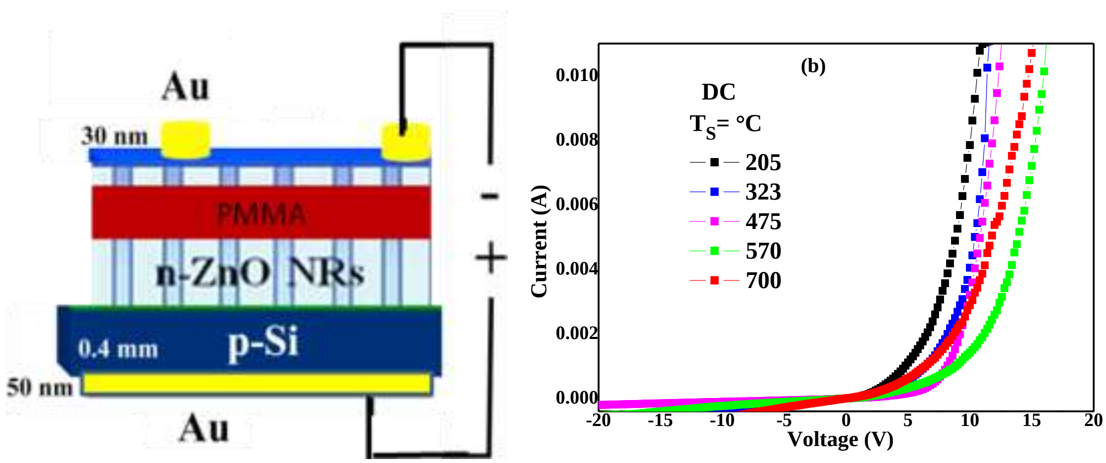
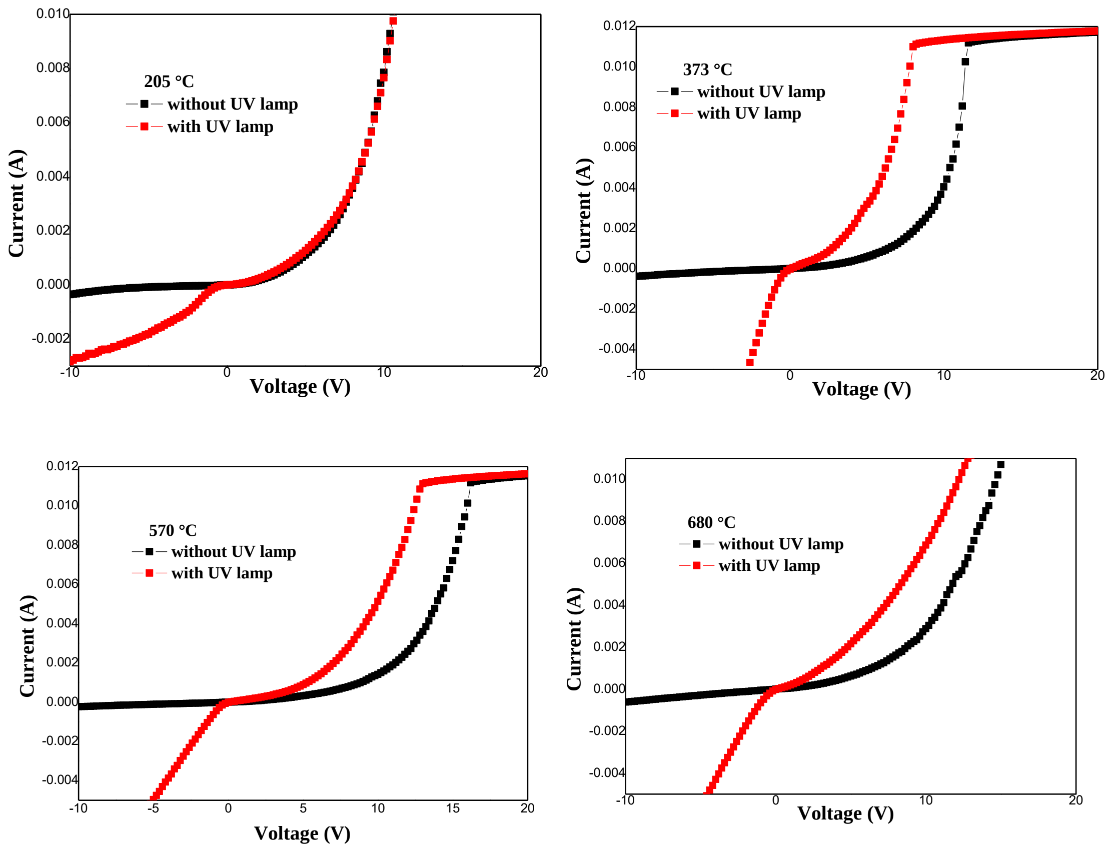


Fig.15 (a) The schematic structure of *n*-GZO/*p*-Si hetero-junction diode, (b) the I-V characteristics of the junctions fabricated with GZO films deposited at different T_S (as indicated) in sputtering atmosphere.



205 °C
without UV lamp
with UV lamp
Current (A)
Voltage (V)
373 °C
without UV lamp
with UV lamp
Current (A)
Voltage (V)
570 °C
without UV lamp
with UV lamp
Current (A)
Voltage (V)
680 °C
without UV lamp
with UV lamp
Current (A)
Voltage (V)