Barnali Ghosh (Saha)

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Guidance of Students/Post-Docs/Scientists

a) Ph.D. Students

1. Samik Roy Moulik; Synthesis and study of physical properties of binary oxide thin films and nanostructures and devices; Awarded
2. Chandan Samanta; Synthesis, Physical Properties And Application Of Metal Oxide Semiconductor Nanostructures And Thin Films; Thesis submitted
3. Avisek Maity; Synthesis, Characterization, Physical Property Studies & Applications of Perovskite Halide; Under progress
4. Purushottam Majhi; Structure And Physical Properties Of Strained Metal Oxide Films; Under progress; Prof. A.K.Raychaudhuri, CGCRI, Kolkata (Co-supervisor)
5. Snehamoyee Hazra; Investigation on Nanostructured Piezoelectric and Ferroelectric materials; Under progress
6. Sudipta Chatterjee; Investigation on transport and magneto-transport properties of transition metal based oxides and alloys; Under progress; Prof. Kalyan Mondal (Supervisor), Dr. Barnali Ghosh Saha (Co-supervisor)

b) Post-Docs

1. Arnab Ghosh; Synthesis of graphene and transition metal dichalcogenide based two dimensional nanostructures for applications in supercapacitor, gas sensor and piezoelectric nanogenerator devices

c) External Project Students / Summer Training

1. Saikat Mitra, SERB project student; Understanding of Growth of Vertically aligned Nanowires or nanotubes of binary oxides and Physics of isotopic fractionation of gases by them; S.N Bose National Centre For Basic Sciences
2. Ayan Ghosh, TRC project Asistant (shared); prototype development of gas sensor; S.N Bose National Centre For Basic Sciences
3. Sohel Siraj, TRC Project Student; Development of programming and packaging of prototypes; S.N Bose National Centre For Basic Sciences
4. Chandni Das, TRC Project Student (shared); Growth of Sensing material and their characterization; S.N Bose National Centre For Basic Sciences
5. Monalisa Yadav, M.Sc. Project Student; Studies of Oxygen Defficient Barium Titanate; IISER. Kolkata
6. Soumyaranjan Rath, M.Sc. Project; Growth, characterization and physical properties study on piezoelectric nanostructured material; Vellore Institute of Technology, Vellore

Teaching

1. Autumn semester; Integrated Ph.D programme, 3rd, Semester, Methods of Experimental Physics, PHY 391; Integrated PhD; 6 students
2. Spring semester; Project Research III (PHY 401); Integrated PhD; 2 students
3. Spring semester; Summer Project Research I (PHY 292) – 2nd Semester; Integrated PhD; 1 student

Publications

a) In journals

1. Chandan Samanta, Sekhar Bhattacharya, A. K. Raychaudhuri and **Barnali Ghosh**, *Broadband (Ultraviolet to Near-Infrared) Photodetector Fabricated in n-ZnO/p-Si Nanowires Core–Shell Arrays with Ligand-Free Plasmonic Au Nanoparticles*, The Journal of Physical Chemistry C, 124, 22235-22243, 2020

b) Conference proceedings / Reports / Monographs / Books

1. Snehamoyee Hazra, Subhamita Sengupta , Ankita Ghatak , Barnali Ghosh,and A.K.Raychaudhuri, "Effect of Electrode Material on the Voltage Generation of PZT Nanowire Based Nanogeneratori" AIP Proceedings, 2265,030668, 2020

Administrative duties

1. Purchase, up-gradation site preparation and installation of common facility equipments under TRC
2. Scientist - in charge of few Central equipment facilities
3. Maintenance as In-charge of common facility equipments under Technical Cell
4. Gardening and plumbing committee
5. Various thesis committee
6. Purchase committee,
7. Committees related to TRC
8. Various evaluation committees
9. Interview committee

Patents Taken and Process Developed with Details

1. Indian Patent has been granted (Grant no: 351816 , Dated 20/11/2020) Patent title: A method to grow single crystalline sharp nano needles of piezoelectric materials. The patent provides the growth of chemically synthesized ferroelectric PZT nanowire with single crystalline pencil tip by hydrothermal method. The full mechanical contact between single crystalline pencil tip PZT and electrode will enhance the performance of the device. The growth of pencil tip PZT nanowires on any flexible substrate has been achieved. The measurement of dielectric properties of single crystalline pencil tip PZT nanowires on flexible substrates shows the value of dielectric permittivity is very high which makes the nanowires promising candidate for flexible device storage applications; 351816; Granted
2. A technique to regenerate ferroelectric phase by surface and subsurface engineering of BaTio3 thin films , Barium Titanate thin film on metallic substrate comprising regenerated surface and/or subsurface modified Barium Titanate thin film on highly oriented single crystalline substrate is provided including transformed non-ferroelectric phase of said film surface and/or subsurface to ferroelectric phase. A process is also provided whereby said regeneration of ferroelectric phase in Barium Titanate (BaTiO3) thin films grown on any highly oriented single crystalline substrate by surface and subsurface engineering is made possible using a hybrid technique coupling Inductive Coupled Plasma Reactive Ion Etching (ICPRIE) along with post annealing at high temperature with excess of BaCO3." FER report submitted. on September 2020"; 201731036353 A; Applied
3. "Flexible thin film transistor using eletrcic double layer as gate dielectric and a method of fabrication Thereof. The present invention discloses a flexible thin film transistor using a polymer electrolyte based gate dielectric that forms an electric double layer at the gate region), configured to operate in small threshold gate voltage and having high channel ON/OFF current ratio and sharp switching. The present flexible thin film transistor comprises a flexible substrate, a semiconductor channel disposed over said flexible substrate; and a polymer electrolyte based operating gate dielectric disposed over said semiconductor channel facilitating transistor operation. The polymer electrolyte based operating gate dielectric(G) form electric double layers which act as a nano-gap capacitor having capacitance fixed by atomic

distance of constituent elements of the double layer facilitating transistor operation at small threshold gate voltage." FER report submitted. on January2021"; 201731015268; Applied

4. A Gas-sensing system for selective detection of (Nitric Oxide) NO gas and a method for fabricating the same, The present invention relates to nitric oxide (NO) gas sensing. More specifically, the present invention is directed to develop a room-temperature operable, hand-held nanostructure based nitric oxide (NO) gas sensing system and a method for fabricating the same. The NO gas sensing system of the present invention is particularly adapted to exhibit long-lasting reusability, stability and perform the NO gas detection at room temperature and even in an open environment. "FER report submitted. on March 2021"; 201731038036; Applied

Membership of Learned Societies

1. Life member Indian Physics Association
2. Life member Indian Association for the Cultivation of Science
3. American Physical Society
4. American Chemical Society

Extramural Projects (DST, CSIR, DAE, UNDP, etc.)

1. Understanding of Growth of Vertically aligned Nanowires or nanotubes of binary oxides and Physics of isotopic fractionation of gases by them; SERB- DST; 06/07/2021- 05/07/2022; PI
2. An investigation on certain emerging aspects of Metal- Insulator Transition in thin oxide films; SERB- DST; 24/3/2017- 23/07/2021; Co-PI
3. Technical Research Centre, Centre project, One of the activity leader among others; DST; 01/01/2016 to 30/ 06/2021; PI

Scientific collaborations with other national / international institutions (based on joint publications)

1. CGCRI Kolkata; Sl. No. 1; National

Outreach program organized / participated

1. International Science Festival (IISF) – 2020, organized by the Ministry of Science & Technology, Ministry of Earth Sciences and Ministry of Health & Family Welfare in association with Vijnana Bharati (VIBHA) during 22-25 December 2020 at New Delhi in Virtual Mode.

Areas of Research

Study of Photoresponse and gas sensing property in binary oxide hetero junction systems. Growth and physical property study of perovskite lead halide Synchrotron X-ray and Neutron diffraction study in complex oxides. Paper electronic based device for gas sensing activity of perovskite halides Study on paper electronic based Photo detector of perovskite halides Growth of binary and complex oxide nanowires and thin films by using different techniques like; wet chemistry and pulsed laser deposition methods and atomic layer deposition. Fabrication of single nanowire device of complex oxide systems by using different lithographic techniques and transport measurement on single nanowire. cross-sectional TEM study in binary and complex oxide nanowires, nanocrystals and thin films Growth of high performance thin film transistors (TFT) and physical property study

Broadband (Ultraviolet to Near-Infrared) Photodetector Fabricated in n-ZnO/p-Si Nanowires Core–Shell Arrays with Ligand-Free Plasmonic Au Nanoparticles

We show a high-response optical detector based on n-ZnO/p-Si nanowires (NWs) core – shell arrays decorated with plasmonic Au nanoparticles(NPs) that works in the broad frequency range from UV (300 nm) to NIR (1100 nm) and consumes low power (few W). The optical detector combines the visible and NIR detectability of Si NWs with the UV detectivity of ZnO through the core – shell structure and broadband detectivity in the visible range has been achieved by decorating core – shell arrays with ligand-free Au NPs synthesized by using pulsed laser ablation in liquid. The photodetector uses n-ZnO as the active photoconductive channel that is sensitive in the UV region. However, using photogating as well as favorable band alignments, the carriers generated at longer wavelengths in visible and NIR in Au

NPs and Si NWs arrays were introduced into the conduction band of ZnO, leading to its broadband performance. We observed significant enhancement of responsivity R not only in the visible range but also in the UV and NIR region with a high detectivity of 1011 cm Hz1/2 W – 1. The responsivity of the detector is 1 A/W from 700 nm to a longer wavelength (at a bias of 1 V) and, in the visible region, the responsivity of the photodetector with Au NPs is > 0.5 A/W and increases to > 1 A/W in the UV region.

One paper has been published in *The Journal of Physical Chemistry C* 2020 *124* (40), 22235-22243

Universal sensing of ammonia gas by family of lead halide perovskites based on paper sensors: Experiment and molecular dynamics

We show that, high sensitivity and high selectivity room temperature ammonia (NH_3) gas sensors with both visual and electrical response can be made from family of lead halide perovskites with different cations and anions. These sensors, based on papers, act as general platforms for new generation of solid state gas sensors for sensitive detection of NH_3 gas by simple color change (~10 ppm sensitivity) as well as electrical resistance change with sub ppm sensitivity limited by electrical noise only. The sensors with materials like $CH_3NH_3PbI_3$ (MAPI), $CH_3NH_3PbBr_3$ (MAPB) and $CH(NH_2)2PbI_3$ (FAPI), are grown on paper from solution. MAPB changes color from orange to white and FAPI and MAPI from black to yellow under NH_3 gas exposure respectively. For electrical sensor operation, a fixed concentration (20 ppm) of NH_3 gas, the sensitivity of MAPI is highest at 96 % followed by MAPB at 82 % and FAPI at 65 %. The sensors with electrical read out could trace NH_3 gas well below ppm level with only few nanowatt of power consumption. Based on experiments, a sensing mechanism has been proposed. The proposed mechanism mainly consists of decomposition of the perovskite halides to lead (Pb) halide by preferential adsorption of NH_3 gas molecules. The proposed mechanism has also been substantiated by molecular dynamics simulations. These sensors fabricated by simple solution process on paper substrates and operable at ambient temperature, are compatible with very low power (~ nW) paper electronics.

Proof of concept established, the "Indian patent has been granted (Grant no: : 317234, dated 31/07/2019)".

One paper published in Materials Research Bulletin 136 (2021) 111142.

Plan of Future Work Including Project

A) Technology development related work (under TRC project): 1) Development of Hazards Gas Detection Sensor based devices and prototypes : (see details given in serial no 13) 2) Development of nano-generator using piezoelectric nanostructures: a) Piezo-electric nanowires for energy harvesting and sensitive motion. Work is being done on self powered nano systems combine the nano generator with functional nanodevices in order to harvest mechanical energy from the environment into electricity to power nano devices. (An Indian Patent has been granted (Grant no: 351816 , Dated 20/11/2020) Patent title: A method to grow single crystalline sharp nano needles of piezoelectric materials B) Basic research: i) Study on Paper electronics based broad band photo detector using perovskite halides ii) Synthesis & optical properties, crystallographic structure microstructural study on Perovskite halide systems iii) Growth and Physical property study on piezoeletcroc nanostrcutures iv) Physical Property study on Single nanowire based devices v) Growth to Physical Properties on thin film transistors (TFT) vi)vi) Study of interface physics of complex and binary Oxide thin films and multilayers 1).Work under Project SERB ref no: EMR-2016/002855 dated 20/3/2017 Synchrotron and Neutron Diffraction study on perovskite oxides 2) Work under project SERB ref no: EMR/2017/001990 dated July 2018 Understanding of Growth of Vertically aligned Nanowires or nanotubes of binary oxides and Physics of isotopic fractionation of gases by them: one paper has been published: J. Phys. Chem. C 2019, 123, 2573 – 2578. Further work is under study.

Any other Relevant Information including social impact of research

1. Main area of work: i) Environment related issue: Making of sensor for Hazardas gas detection ii) Health Care Sector: Technology development for making device for detection of disease 1. Fabrication of Piezo electric nano generator :

Piezo-electric nanowires for energy harvesting and sensitive motion, Power generation from waste energy: for (a) battery application, (b) self- powered sensor for pulse rate monitoring. Indian Patent has been filed. b) Indian Patent Grant no: 351816, Dated 20/11/2020) Prototype: Packaging of the device (SMART SHOE) has been done. 2. A) Development of ultra-sensitive sensor for hazards gas detection: Ammonia gas sensor : a)"Visual color change based ammonia gas sensor (<10ppm)for stand - alone use for hazards. "Prototype is ready for use which can sense ammonia<10ppm level by visual effect (just by colour change)" patent granted (Grant no: : 317234, dated 31/07/2019 : publication: Scientific reports(2018) 8:16851) (11 citation) b)" High sensitivity NH3 gas (~10 ppb) solid state sensor with electrical readout" High sensitive sensor can be used as markers for renal disease and chronic kidney diseases (CKD). Even during dialysis of a patient exhaled NH3 can used to check the efficacy of the dialysis. Prototype under process, (Indian patent no: 201831001993, FER submitted) publication: Scientific Reports (2019) 9:7777 (42 citation) 3 .Development of Nitric oxide (NO) gas sensor: solid state sensor, detecting NO gas (sensitivity: 500ppm). Exhaled NO can be used as the markers for Asthma and Chronic obstructive pulmonary disease (COPD). Prototype under process.

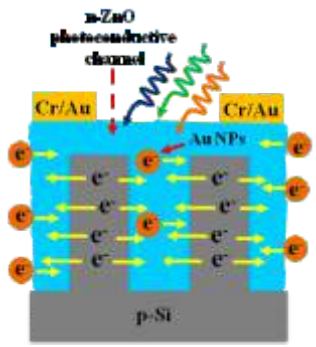

Fig 1(a) photogated device where the nZnO channel receives carriers from the core of Si NWs as well as Au NPs when they are illuminated

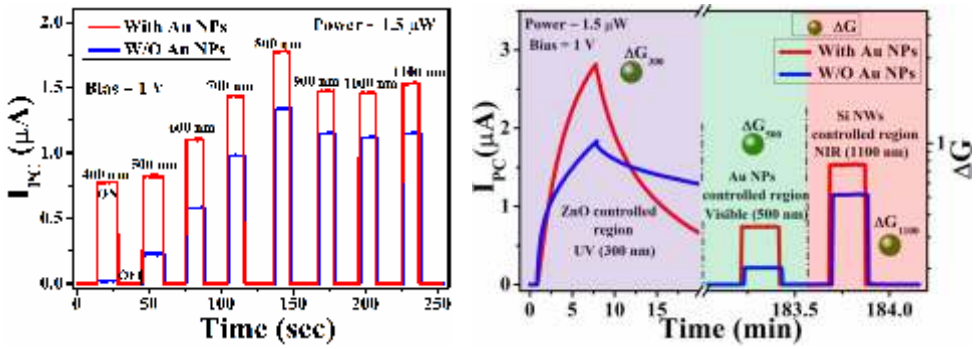

Fig 1(b) Photocurrent (IPC) under different illuminations of light of wavelength ranging from 400 to 1100 nm at a fixed power of 1.5 ᴍW. The illumination was turned ON and OFF. (c) Plot of IPC at different wavelengths for the n-ZnO/p-Si core – shell array with and without Au NPs

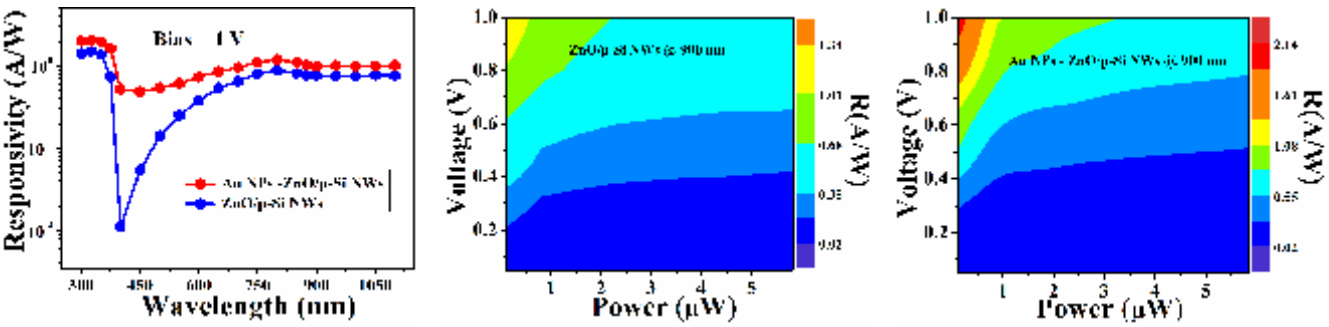

Fig 2 (a) Spectral responsivity (R) of ZnO/p-Si NW core – shell arrays with and without Au NPs under different wavelengths. Contour plot of responsivity R as a function of bias V and illumination power P of **(b)** n-ZnO/p-Si NWs and **(c)** Au NP-decorated n-ZnO/p-Si NW core – shell arrays.