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Resume of Prof. Samit Kumar Ray

1. Name : Samit Kumar Ray
2. Designation : Professor, Department of Physics, IIT Kharagpur
Director (On lien from IIT Kharagpur)
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3. Web address & citations: <http://scholar.google.co.in/citations?user=O4WvnJ4AAAAJ&hl=en>
4. Date of birth : May 10, 1961
5. Nationality : Indian
6. Educational background :
- Ph.D. : Microelectronics - 1991
Indian Institute of Technology, Kharagpur, India
Dissertation: Microwave Plasma Processing for Microelectronic Applications.
- M.Tech. : Materials Science (Semiconductor & Allied Materials) - 1984
Indian Institute of Technology, Kharagpur, India
- M.Sc. : Physics (Solid State Physics) - 1982
Indian Institute of Technology, Kharagpur, India

7. DETAILS OF EMPLOYMENT RECORDS :

- a) **Director, S. N. Bose National Centre for Basic Sciences**, Kolkata - October 2016 to till date (On lien from IIT Kharagpur)
- b) **Professor -- August 2004 to October 2016**, Dept. of Physics, IIT Kharagpur
Associate Professor -- May 1999 to August 2004, **Asst. Professor** -- Jan. 1995 to May 1999, **Lecturer** -- Dec. 1991 to Dec. 1, 1994,
Teaching in undergraduate (UG) and post-graduate (PG) physics and engineering programmes, supervising research projects in Ph.D., M.Tech. and M.Sc. levels; carrying out independent & sponsored research and industrial consultancy and other academic & administrative jobs in I.I.T.
- c) **Scientific officer** - Microelectronics Center, Dept. of Electronics & Electrical Communication Engineering and Materials Science Center, I.I.T. Kharagpur -- Sept., 1985 to December, 1991. Technology development and manpower training in microelectronics. Took a key role in the development of a modern microelectronics laboratory and establishment of a bipolar process vehicle for the fabrication of several integrated circuit chips. Developed a microwave plasma discharge system for the growth, deposition and etching of dielectric films for silicon based ICs. Actively involved in the growth of epitaxial thin films using Molecular Beam Epitaxy (MBE), Ion Beam, and rf Magnetron Sputtering and fabrication of their devices.
- d) **Scientist B, Solid State Physics Laboratory, Delhi** -- July, 1984 to Sept. 1985
R&D work for the development of charge coupled devices (CCDs) and their sub-systems. Involved in LPCVD polysilicon film deposition and ion implantation processes for the fabrication of CCDs.

8. Fellowship & Awards :

- a) MRSI-ICSC Superconductivity & Materials Science Annual Prize 2015
- b) Young Scientist Award : Indian National Science Academy - 1993
- c) Homi J. Bhabha Award : University Grants Commission –2001
- d) MRSI Medal Award – 2007
- e) Fellow : Indian National Academy of Engineering – 2008
- f) Fellow : West Bengal Academy of Science & Technology - 2011
- g) INSA – DFG Fellow – 2004
- h) DST BOYSCAST Fellow – 1995
- i) CDIL Award for Industry of IETE – 1997

9. Research Areas :

- Semiconductor and Oxide Nanostructures
- Nanoelectronic & Nano-photonic devices
- Flexible and Transparent Electronic & Sensing Devices
- Photovoltaic Materials and Devices
- Silicon Alloy Heterostructures
- Thin Film Technology
- Plasma and Ion Beam Processing of Materials

Some of the major research contributions are outlined below :

- **Semiconductor quantum structures : Growth & device physics**
Leading the semiconductor nanotechnology research activities at IIT Kharagpur with the first working MBE system in an educational institute in India for growing quantum structures. Demonstrated mid infrared Ge quantum dot photodetectors at room temperature using intersubband transitions in the valence band. A major breakthrough has been made by realizing the direct band gap light emission in compressively strained Ge films on relaxed SiGe substrate, which may lead to on-chip Si laser in near future. A significant improvement in the two dimensional ordering of the quantum dots and resultant PL emission intensity have been achieved by growing the quantum dots on FIB patterned substrates.
- **Ge nanocrystals embedded oxides for flash memory and light emitting devices**
The synthesis of Ge nanocrystals embedded in oxide matrices has been carried out to achieve nanometer sized structures without sophisticated nanolithography techniques. These Ge nanocrystals were shown to exhibit luminescence in the visible region due to the quantum confinement of carriers making silicon based semiconductors attractive as light emitters. On the other hand, luminescence at fiber optic communication wavelength has been achieved with rare earth (Er⁺) doped nanocrystals due to intra-4f transition from the first excited to the ground states ($4I_{13/2} \rightarrow 4I_{15/2}$), resulting in an enhanced energy transfer efficiency from nanocrystal excitons to the Er ions. Proposed a novel floating-gate flash memory device with high retention characteristics using quantum tunneling characteristics in Ge nanocrystals. The pioneering results have been used to contribute a Topical Review on “Nanocrystals for silicon-based light-emitting and memory devices” by Institute of Physics, UK for their journal *J. Phys. D: Appl. Physics* in 2013.
- **Photonic devices using 2-D / 3-D heterostructures**
Significant contribution on novel 2-D/3-D heterostructures using graphene, MoS₂ and WS₂ etc. for realizing large area photonic devices. The superior performance of the heterostructures in terms responsivity, tenability and plasmonic enhancement of the optical properties have been demonstrated. The research findings may pave the way for integration of 2D materials based photonic devices on Si CMOS platforms in near future.
- **Photovoltaic devices using semiconductor and hybrid nanostructures**
Studied the charge and energy transfer processes in semiconductor and quantum dot sensitized (Ge/Si QDs on TiO₂/ZnO nanowire or nanotube surface) and hybrid solar cells.

One dimensional Si nanostructures have been demonstrated to exhibit superior antireflection characteristics, which have been used as templates for the fabrication of the nanowire heterojunctions. The photodiode characteristics of the n-Si-p-CuS heterojunction showed significant improvement in responsivity and EQE due to enhanced light absorption and efficient photo-carrier extraction in the nanocone radial heterojunction. Hybrid photovoltaic devices have been fabricated with CdS modified and unmodified ZnO nanorods blended separately with regioregular poly(3-hexylthiophene) (P3HT) polymer as the active layer. The surface modification of ZnO nanorods with CdS lead to an increase in the open circuit voltage and short circuit current, with enhanced efficiency by 300% over the unmodified ZnO:P3HT device, because of the cascaded band structure favouring charge transfer to the external circuit.

- **Hybrid electronic, photonic and sensing devices**

Demonstrated a novel graphene oxide (GO) based p-n heterojunction on n-Si. The fabricated vertical GO/n-Si heterojunction diode shows a very low leakage current density and excellent rectification characteristics up to 1 MHz. GO based heterojunction diodes could be used for UV and broadband photodetectors, compatible with silicon device technology. Transparent and flexible resistive memory devices with a very high ON/OFF ratio have been demonstrated incorporating gold nanoparticles into the Bombyx mori silk protein fibroin biopolymers. The novel electronic memory effect is based on filamentary switching, which led to the occurrence of bistable states with an ON-OFF ratio larger than six orders of magnitude. The proposed hybrid bio-inorganic devices show promise for use in future flexible and transparent nanoelectronic systems. Chemically derived graphene-based gas sensors on ceramic substrates have been developed for low power, sensitive and highly selective chemical sensors.

- **Semiconductor based Terahertz sources & detectors**

In international collaboration with US and Russian scientists, demonstrated impurity and modulation doped SiGe quantum wells for Terahertz sources and detectors attractive for biomedical imaging, THz communication, and remote detection of explosives and biological warfares. A coauthor of an US patent on THz devices and reported the THz absorption in doped Si & SiGe layers for the first time (cf. Physics & Technology News, May 2004).

10. Research Citations

- Rare-Earth oxides for silicon-germanium quantum dot memories highlighted in Naotechweb.org in Nov. 21, 2013. <http://nanotechweb.org/cws/article/lab/55431>
- The Topical Review paper "Nanocrystals for silicon based light-emitting and memory devices" *J. Phys. D: Appl. Physics*, 46, 153001 (2013) has been selected by the Editors as the "**Highlights of 2013**" collection
- Free carrier absorption of THz waves : Phys Org.com – Internet based latest **Physics & Technology News**, May 2004
- The work on THz Devices – **Business Week, USA**, APRIL 28, 2003, The News Journal, May 10, 2003
- The work on SiGeC MOSFET at Austin has been **cited** in **News and analysis** section of **Scientific American**, January 1998
- The work on Vertical SiGe MOSFET has been **cited** in **Research Review** of the journal Compound Semiconductors

11. International Visiting Professor / Researcher Assignments

- Tokyo Institute of Technology, Japan** ; Visiting professor, May – July, 2007 – Silicon nanoelectronic devices

- b) **National Taiwan University** : Visiting Professor, June – July, 2005 - Teaching a course on Nanoelectronic Devices
- c) **Max-Planck Institute for Solid State Research, Stuttgart, Germany** : May 15 to July 15, 2004 – DFG Fellow, Research in self-assembled SiGe nanostructures
- d) **University of Delaware, Newark, USA** : January 2002 to June 2003 – Visiting Scientist : Research in SiGe based quantum cascade THz devices
- e) **University of Delaware, Newark, USA** : May to July, 2001 - Visiting Scientist : Research in MBE growth for THz lasers
- f) **University of Texas at Austin, USA** : May to July, 1998 – Visiting Fellow for research in novel heterostructure SiGe devices.
- g) **University of Texas at Austin, USA** : February to December, 1996 – DST BOYSCAST fellow for research on advanced silicon heterostructure MOSFETs
- h) **Queen's University of Belfast, U.K.** : June to December, 1995 – Academic visitor for research on European Commission project on silicon heterostructure devices

12. Editorial board members :

- Editorial Board Member – Nanotechnology, IOP, UK
- Associate Editor : Scientific Reports (A Nature Publishing Group Journal)
- Associate Editor : Frontiers in Materials : Optics and Photonics - Switzerland
- Editorial Board Member : Journal of Nano Energy and Power Research - USA
- Editorial Board Member : Nanotrends - India

13. Administrative & other positions held :

a) **Dean, Postgraduate Studies and Research, IIT Kharagpur, Oct. 2015 to Oct. 2016**

b) **Head, School of Nano-Science & Technology, IIT Kharagpur, March 2014 to Oct. 2016**

Founder Head of the newly established School of Nanoscience and Technology with 35 associated faculty members of IIT Kharagpur. Led the school in planning and development of the infrastructure, building and laboratory facilities in the proposed Diamond Jubilee Complex. Initiated the Ph.D. program of the school with effect from the autumn semester 2014. The recruitment of the faculty members and curriculum development for the post-graduate level courses have been initiated. A laboratory was set up with two capital equipments e.g, Electron Beam Lithography and Spark Plasma Sintering systems.

c) **Head, Department of Physics, IIT Kharagpur, March 2011 to Feb. 2014**

Involved in the faculty recruitment, curriculum revisions and setting up centralized research laboratories in the department through external and internal funding. Eight new faculty members were recruited during the tenure. The concept papers for several new academic programs like 4-yr B.Tech. in Engineering Physics and B.S. in Physics have been initiated. Three new centralized research labs. like FIST lab., Ultrafast Science lab. and advanced Condensed Matter Physics Lab. have been established in the department with a funding of about Rs.10.00 crores. Some of the sophisticated experimental facilities include X-ray Photoelectron Spectroscopy System, Femto-second Laser & Spectroscopy system, Laser deposition, PPMS and Photolithography systems. Organized six International and National Conferences/Workshop in the department during the tenure including the India-Singapore Joint Physics Symposium, February 2013 and International Conference on Theoretical and Applied Physics, Dec. 2013.

d) **Member, Research Council – Central Glass & Ceramic Research Institute, Kolkata since 2010**

Acting as an external member of the Research Council of Central Glass & Ceramic Research Institute (CGCRI) Kolkata to review the progress of major projects and to advise on the recruitment, scientific planning and development of the laboratory.

e) **PAC member, DST on Condensed Matter Physics & Materials Science since 2011**

Acting as a Program Advisory Committee (PAC) member of the Department of Science and Technology, Govt. of India in the area of Condensed Matter Physics & Materials Science since 2011. Involved in the evaluation and monitoring of DST funded research projects to various institutes and identifying the thrust areas for DST projects.

- f) **PRSG member, Deity Centers of Excellence in Nanoelectronics since 2013**
Working as a PRSG member to monitor and review the progress of two Deity funded major projects on “Centres of Excellence in Nanoelectronics – Phase II at IIT, Bombay and IISc Bangalore
- g) **Chairman, Physical Sciences, Advanced Technology Development Center, IIT Kharagpur since 2010**
Acting as the Chairman to lead the academic activities and development of the Physical Sciences division of the multidisciplinary Advanced Technology Research Center at IIT Kharagpur for the last four years
- h) **Coordinator**, SRIC Research Council on Physical & Earth Sciences, IIT Kharagpur

14. TEACHING EXPERIENCE : (at IIT Kharagpur)

- a) Graduate Courses : Science & Technology of Nanomaterials (Newly developed course), Physics of Semiconductor Devices, Thin Film Technology, Amorphous Materials & their applications
- b) Undergraduate Courses : Physics-I and Physics – II, (for UG Students of Electrical Sciences, Metallurgy Engineering and Mathematics). Linear electronic devices and circuits, Digital and Integrated Electronics, Applied Electronics
- c) Research Guidance at doctoral level : Nineteen – Completed, Eleven – Under Guidance
- d) Guidance at Master' s level : Thirty – Completed, Three – Under Guidance

15. Organizational Experience :

- a) Chair, International Conference on Fiber Optics & Photonics (PHOTONICS-2014) held at IIT Kharagpur during Dec. 13-16, 2014
- b) Co-Chair, Symposium – B: “Earth Abundant Materials for Solar Energy Harvesting” in ICMAT – 2015 to be held in Singapore during June 28 – July 3, 2015
- c) Chair, India-Singapore Joint Physics Symposium, February 2013, IIT Kharagpur
- d) Chair, International Conference on Theoretical and Applied Physics, Dec. 2013, IIT Kharagpur
- e) Convener, DAE-BRNS Symposium on “Pulsed Laser Deposition”, Nov. 2013
- f) Secretary, International Conference on MEMS and Semiconductor Nanotechnology, Dec. 20 –22, 2005, IIT Kharagpur
- g) Organizing Secretary, International Conference on Fiber Optics & Photonics (PHOTONICS-2000) Dec. 18 – 20, Hotel Taj Bengal, Calcutta
- h) Secretary, Local Organizing Committee, National Laser Symposium –2003 held at IIT Kharagpur, Dec. 22-24, 2003

16. Sponsored Research Projects as a Principal Investigator in last 5 years

- a) DST - Copper Zinc Tin Sulfo-selenide [Cu₂ZnSn(SSe)₄] Based Radial Heterojunction Solar Cells for Integration into Flexible and c-Si Substrates : 70.6 lakhs (2016 – 2018)

- b) DST : FIST PROJECT - TO STRENGTHEN THE POST-GRADUATE TEACHING AND RESEARCH FACILITIES IN THE DEPARTMENT, (2011-2015), 365.0 lakhs
- c) CSIR : Graphene based hybrid solar cells (GBH) (2013 – 2016). 20.92 lakhs
- d) DST – India Trento Program for Advanced Research : Green photonics using semiconductor nanostructures, 2013 – 2016, Rs. 32.45 lakhs
- e) DST - Russian Foundation of Basic Research : Semiconductor Superlattices for Terahertz Emission at Room Temperature, 2013 – 2015, Rs. 17.40 lakhs
- f) IIT Kharagpur – Challenge Grant : Studies on ultrafast processes in electronics, spintronics, magnonics and photonics, 2014 – 2017, Rs. 250.00 lakhs
- g) DST : MBE growth of strained Si/Ge layers and self-assembled Ge islands for heterostructure MOSFETs and flash memory devices : RS. 161.66 lakhs (2009-2012)
- h) DST : Si/Ge Nanostructure sensitized & hybrid Solar cells- 2011- 2014, 47.5 lakhs
- i) DRDO : Development and characterization of nanostructured thin films for SiGe quantum well infrared photodetector (QWIP) and ferroelectric based gas/chemical sensor: Rs. 201.80 lakhs, (2007 - 2012)
- j) DST-India-Trento Programme for Advanced Research : Fabrication and characterization of Novel Photonic Crystal Structures and Si/Ge Quantum Dots for Photonic Applications : Rs. 28.14 lakhs (2008 -2011)
- k) DST-Russian Foundation of basic Research : Terahertz emission of Si/SiGe structures doped with shallow acceptors, 9.63 lakhs (2008 – 2010)
- l) MHRD : Development of Terahertz sensors for biomedical imaging and remote detection of chemical / biological warfare agents, Rs. 10.00 lakhs (2005 – 2008)
- m) DST (Nanomission) : Synthesis and characterization of nanostructured materials for functional and structural applications”, 279.51 lakhs (2006 – 2009)
- n) DIT : Development of Quantum-well Infrared Photodetectors in wavelength range 8-14 μm using Si/SiGe Nanotechnology, 93.00 lakhs, 2006 – 2009
- o) DRDO : “Growth and nucleation of multilayer thin films for device applications” Rs. 321.00 lakhs (2002 – 2007)
- p) Fabrication of group-IV semiconductor (Si&Ge) nanowires for flash memory and nanoelctronic devices: India-Taiwan Programme in Science & Technology (2009 – 2012)

17. Members of professional bodies : IEEE, USA; MRS, USA; MRSI, India; Semiconductor Society of India; Plasma Society of India

18. Patents: US Patent No. : US 7,386, 016 B2 dated 10th June, 2008 - “Terahertz frequency radiation sources and detectors based on group-IV materials and method of manufacture” by J. Kolodzey, **S. K. Ray**, T. N. Adam, P. Lv, R.T. Troeger, M.S.Kagan, I N. Yassievich, M. A. Odonoblyudov

19. Publications : Please see Annexure – I for details

Book / Book Chapters : 11, Journals : 302, International / National Conferences : 298

Total citations : 4600, h-index : 33 (Google scholar)