

Debashree Banerjee, PhD

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EDUCATION

Examination	University	Institute	Year	CPI/Percentage
Ph.D.	IIT Bombay, India	IITB-Monash Research Academy	2015	8.95 (Course-work)
B.Tech(Post-graduation)	University of Calcutta, India	University of Calcutta	2008	81.1
B. Sc	University of Calcutta, India	Bethune College	2005	65
ISC	Council for ISC, New Delhi	Calcutta Girls' High School	2002	80.8
ICSE	Council for ISC, New Delhi	St. Agnes' Convent School	2000	91.3

PROFESSIONAL SKILLS

- My in-depth knowledge of the physics of semiconductors and nanoscale semiconductor devices along with the patience and ability to learn quickly and effectively in a new domain helped me fare well in a gamut of research activities; ranging from design and modelling to clean-room fabrication, material and device characterization and assembling complex laboratory equipment from scratch.
- Project planning and management capability in the current position as a researcher at Uppsala University is of utmost importance. This is a flagship project to harvest energy from waste heat and my role includes not only solving technical problems but also setting up collaborations and collating and interpreting data received from our collaborators.
- To communicate the importance and impact of our research activities to a wider audience I have presented the research data in conferences and seminars.
- The research skills and knowhow that I have developed are design and fabrication of nanoscale semiconductor devices, thermal characterization and analysis, optical characterization and analysis of the data for understanding the behavior of opto-electronic materials and devices, analysis of temperature dependent electrical transport and quantum effect experiments on spintronic and conventional devices as well as interpretation of the material characteristics from physical characterization and transient absorption spectroscopy measurements.

INDUSTRY EXPERIENCE

- Assistant Systems Engineer at Tata Consultancy Services Limited, Bangalore, August 2008- April 2010.
- Project at National Physical Laboratory, Electronics Material Division, New Delhi, Oct-Nov 2007; Advisor: Dr. S. N. Singh.

RESEARCH PROJECTS

Post-Ph.D: Phononic Thin-Film Silicon Thermoelectric Generators

From September 2015 I have worked on a project at Uppsala University where the primary aim is to control the thermoelectric properties of Si thin films through the use of phononic crystal structures: an artificial material created by introducing periodic holes in a continuous film. The material and the holes constitute two domains with different masses wherefrom matter waves (phonons) will reflect differently and give rise to interference patterns which in turn will modify the phonon transport properties.

I have designed a suspended test structure for measuring thermal properties of fragile thin films and commenced nano-fabrication. Additionally I handle the thermal characterization equipment, parts of which I am designing. Finally, thermoelectric generators will be fabricated using the optimized material. The initial phase of the project involved extensive planning, setting time-bound targets and participating in striking viable collaborations within and outside the university.

Ph.D: Design, Fabrication and Experimental Characterization of III-Nitride Semiconductor Based Light Sources

Period: July 2010 to December 2015, IIT Bombay and Monash University

- Theoretical modelling of laser dynamics in spin-polarized lasers and effects of geometrical design parameters on the performance of spin-polarized light-emitting diode (spin-LED).
 - ✓ *It was found that the spin-laser offers a higher frequency bandwidth during dynamical operation as compared to a conventional laser*
 - ✓ A smaller spin relaxation time is beneficial to a certain extent and increases the spin-laser bandwidth
 - ✓ *The effect of geometrical design on the spin-LED output circular polarization provides guidelines for better device design*
- We have developed a Gallium Nitride (GaN) based dilute magnetic semiconductor (DMS: a semiconductor that shows ferromagnetism due to introduction of a small amount of magnetic impurities) which is ferromagnetic at room temperature. This DMS has been used successfully for

injecting spins into the spin-LED for temperatures as high as 200 K.

- ✓ We could prepare the DMS with above 300 K Curie temperatures by the cost-effective method of thermal drive-in and activation.
 - ✓ First demonstration of edge-emitting spin-LED in the InGaN-system using Cr-doped GaN as the spin injector.
 - ✓ *Established the potential of the Cr-doped GaN DMS, prepared in the manner mentioned above, as a viable technology option for room temperature spintronic devices.*
- Demonstrated superluminescent behavior in a lateral InGaN-based nanowire LED.
 - ✓ Benefits associated with the method of preparing the wires are many. The manifestation of these benefits is seen in the performance enhancement of the LED device.
 - ✓ *Presented a novel method of obtaining highly controllable narrow quantum wires in the III-Nitride material system, which is otherwise extremely challenging to grow in a bottom-up approach.*
 - Additionally, design, fabrication and characterization of a nanowire laser have been completed. Onset of lasing at low threshold current densities at room temperature.
 - ✓ Ultra-low threshold current density of the laser for room temperature operation.
 - ✓ *We could use an LED heterostructure to fashion a lateral nanowire laser, thus decoupling the challenging laser heterostructure manufacturing method from aspects of creation of the optical gain cavity. This translates to simplifying the growth and fabrication processes.*

B. Tech.: Studies on the Properties of LHM Structures for Microwave and Millimeter-wave Applications
Period: From August 2007 to May 2008, Institute of Radiophysics and Electronics, University of Calcutta

In the project we obtained an understanding of the left handed material properties theoretically and investigated the effect of the geometry of the split ring resonators and cut lines on the resonant frequency. Different structures and substrates were studied for the purpose.

PATENTS, AWARDS AND SCHOLARSHIPS

1. Patent Number: **202/MUM/2015** (filed), Title: *Light emitting diode made of Indium-Gallium Nitride based lateral nanowires and method of manufacture.*
2. Scholarship obtained under the IITB-Monash Research Academy during the PhD tenure (2010-2014).
3. IETE-S K Mitra Memorial Award (2010) for the best research oriented paper (Journal #12) in September 2010 by The Institution of Electronics and Telecommunication Engineers.
4. Ranked 3rd in B. Tech in RadioPhysics and Electronics (2008).

PUBLICATIONS

1. P. Chaturvedi, S. Chouksey, **D. Banerjee**, S. Ganguly and D. Saha, “Carrier and photon dynamics in a topological insulator Bi₂Te₃/GaN type II staggered heterostructure”, Applied Physics Letters, vol. 107, 192105, 2015.
2. **D. Banerjee**, K. Takhar, S. Sankaranarayanan, P. Upadhyay, R. Ruia, S. Chouksey, D. Khachariya, S. Ganguly and D. Saha, “Electrically injected ultra-low threshold room temperature InGaN/GaN-based lateral triangular nanowire laser”, Applied Physics Letters, vol.107, 101108, 2015.
3. P. Upadhyay, M. Meer, K. Takhar, D. Khachariya, Akhil Kumar S, **D. Banerjee**, S. Ganguly, A. Laha and D. Saha, “Improved Ohmic contact to GaN and AlGaIn/GaN two-dimensional electron gas using trap assisted tunneling by B implantation”, Physica Status Solidi B, vol. 252, No. 5, 989, 2015.
4. **D. Banerjee**, M. B. Nadar, P. Upadhyay, R. Ruia, D. Khachariya, N. Pande, K. Thakar, S. Ganguly and D. Saha, “High exciton binding energy in GaN based superluminescent light emitting diode on naturally survived sub - 10 nm lateral nanowires”, <http://arxiv.org/abs/1503.02279>; Patent No.: 202/MUM/2015.
5. R. Adari, **D. Banerjee**, S. Ganguly and D. Saha, “Fermi level depinning at metal/GaN interface by an insulating barrier”, Thin Solid Films, vol. 550, 564, 2014.
6. R. Adari, **D. Banerjee**, S. Ganguly and D. Saha, “Memory Elements Using Multiterminal Magnetoresistive Devices”, Applied Physics Express, vol. 6, 043002, 2013.
7. **D. Banerjee**, R. Adari, S. Sankaranarayan, A. Kumar, S. Ganguly, R. W. Aldhaheri, M. A. Hussain, A. S. Balamesh and D. Saha, “Electrical Spin Injection using GaCrN in a GaN based Spin Light Emitting Diode”, Applied Physics Letters, vol. 103, 242408, 2013.
8. P. Suggisetti, **D. Banerjee**, R. Adari, N. Pande, T. Patil, S. Ganguly and D. Saha, “Room Temperature Ferromagnetism in Thermally Diffused Cr in GaN”, AIP Advances, vol. 3, 032143, 2013.

9. **D. Banerjee**, R. Adari, T. Pramanik, S. Ganguly and D. Saha, "Effect of Device Geometry on Output Circular Polarization in a Spin-LED", IEEE Transactions on Magnetics, vol. 48, No. 11, 2012.
10. **D. Banerjee**, R. Adari, T. Patil, M. Murthy, P. Suggisetti, S. Ganguly, and D. Saha, "Modulation bandwidth of a spin laser", Journal of Applied Physics, vol. 109, 07C317, 2011.
11. **D. Banerjee**, T. Roy and S. Kar, "A Computer-Aided Analytical Study on Characteristics of LHM Structures at Microwave Frequencies", IETE Journal of Research, vol. 55, No. 3, 112, May-June 2009.
12. T. Roy, **D. Banerjee** and S. Kar, "Studies on Multiple Inclusion Magnetic Structures Useful for Millimeter-wave Left Handed Materials", IETE Journal of Research, vol. 55, No. 2, 83, March-April 2009.

CONFERENCES

- "InGaN/GaN lateral nanowire laser for low threshold current", **D. Banerjee**, K. Takhar, S. Sankaranarayanan, S. Ganguly and D. Saha, Oral presentation in the *18th International Workshop on Physics of Semiconductor Devices 2015 (IWPSD 2015)*, at Indian Institute of Science, Bangalore, India.
- "GaN based nanowire LEDs and lasers", **invited talk** at the Low Dimensional Systems topical meeting under the *Current Trends in Condensed Matter Physics* conference held in the National Institute of Science Education and Research (NISER), Bhubaneswar, India, 2015.
- "Nanowire formation on InGaN-based quantum well LED heterostructure by wet chemical etching", **D. Banerjee**, P. Upadhyay, M. B. Nadar, S. Ganguly and D. Saha, *International Workshop on Nitride Semiconductors 2014*, Wroclaw Poland.
- "Effect of Device Geometry on Output Circular Polarization in a Spin-LED", **D. Banerjee**, S. Ganguly and D. Saha, *IEEE International Magnetics Conference 2012*, Vancouver, Canada, May 2012.
- "Effect of Drift on Spin Polarization in a Spin-LED", **D. Banerjee**, T. Pramanik, R. Adari, T. Patil, P. Suggisetti, S. Ganguly, and D. Saha, *56th Conference of Magnetism and Magnetic Materials*, Scottsdale, Arizona, USA, November 2011.
- "Modulation bandwidth of a spin laser", **D. Banerjee**, R. Adari, T. Patil, M. Murthy, P. Suggisetti, S. Ganguly, and D. Saha, *55th Conference of Magnetism and Magnetic Materials*, Atlanta, USA, November 2010.
- "Room-temperature Ferromagnetism in Homogeneous Cr-doped GaN", P. Suggisetti, T. Patil, R. Adari, **D. Banerjee**, T. Pramanik, D. Saha and S. Ganguly, *56th Conference of Magnetism and Magnetic Materials*, Scottsdale, Arizona, USA, November 2011.

- “Temperature Dependent Characteristics of Fe/n-GaN Schottky Diodes”, R. Adari, B. Sarkar, T. Patil, **D. Banerjee**, P. Suggisetti, S. Ganguly and D. Saha, *SSDM 2011*, Nagoya, Japan, September 2011.

TECHNICAL SKILLS

- **Clean-room Fabrication:**

Various tools for the patterning of semiconductor surfaces, metal deposition systems, rapid thermal processing, Reactive Ion Etchers and packaging tools like dicer and wire bonder; Ellipsometer and reflective interferometers for thin film characterization, growth tools like atomic layer deposition system and LPCVD.

- **Characterization Tools:**

Raman spectroscopy for temperature measurement, Deep Level Transient Spectroscopy for defect analysis in materials; assembling and operating the Magneto-Optic Kerr Effect spectroscopy, Hall and magneto-resistance measurement setups; Photoluminescence spectroscopy, optical measurements like L-I and spectral response, low temperature electrical measurements, transient absorption spectroscopy, cryogenic probe station for electrical measurements.

- **Software:**

GPIB automation through MATLAB interfacing, Lumerical MODE, APSYS, MATLAB, COMSOL, NGSPICE, Sentaurus process and device simulation software, JAVA (Sun Certified Java Programmer)