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# Kapil Debnath

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## **Summary of Qualification**

Over 7 years of experience in silicon photonics, optoelectronics and semiconductor nano-fabrication.  
Core competencies:

- Optoelectronic and nano-photonics device design, simulation, fabrication and characterization.
- Process integration and development for die level micro/nano-fabrication.
- Project management skill by guiding several postgraduate and undergraduate students in various projects.
- Organizational, communication and planning skills for handling multifaceted and collaborative projects.

## **Research Interests**

- Silicon photonics
- Monolithic optoelectronic integration
- Photonic crystals
- Plasmonics
- Transparent metal oxides
- 2D materials
- Group IV light sources
- CMOS process technology

## **Educational Qualification**

- 2009-2013     **Doctor of Philosophy (PhD) in Physics**  
University of St Andrews, Scotland  
PhD Thesis Title: “*Photonic Crystal Cavity Based Architecture for Optical Interconnects*”
- 2007-2009     **Master of Technology (MTech) in Applied Optics**  
First class with CGPA 9.55 (10 point scale), Batch topper  
Indian Institute of Technology, Delhi, India  
Master Thesis Title: “*Fabrication of Photonic Crystals using Holographic Lithography*”
- 2000-2004     **Bachelor of Technology (BTech) in Electronics and Telecommunication Engineering**  
First class with 72.65%  
National Institute of Technology, Silchar, India

## **Employment History**

March2018-Present	<b>Assistant Professor</b> IIT Kharagpur, India
June2017-January2018	<b>Senior Research Fellow</b> University of Southampton, UK
February2015-May2017	<b>Postdoctoral Research Fellow</b> University of Southampton, UK
May2013-February2015	<b>Postdoctoral Research Fellow</b> University of St Andrews, UK
2006-2007	<b>Lecturer in Electronics and Communication Engineering Department</b> Sri Venkateshwara College of Engineering, Bangalore, India
2004-2005	<b>Officer Trainee</b> Bharat Petroleum Corporation Ltd., Ratnagiri LPG Import Terminal, India

## **Technical Skills**

### **Fabrication based**

Micro/nano-fabrication process at die and wafer-level.

Expertise involve:

- Photo-mask designing, GDS tape out and mask ordering procedure.
- Resist patterning with E-beam lithography and UV photo-lithography.
- Dry etching using RIE, ICP and CAIBE.
- Deposition using PECVD.
- Wet processes, such as sample cleaning, resist spinning and development, wet etching, lift off, spin on doping etc.
- Metal evaporation using thermal evaporator and electron beam evaporator.
- Metrological inspection with Optical microscope, SEM, AFM, Profilometer, Ellipsometer.

### **Characterization based**

- Experience in optical characterization of integrated photonic devices, such as waveguides, filters, photonic crystal structures etc.
- Experience in electro-optic characterization of silicon based modulators and photo-detectors using DC and high speed measurement setups.

### **Computer based**

- Programming in MATLAB for numerical simulations, data analysis and Mask designing.
- Finite Difference Time Domain (FDTD) method in RSoft and Lumerical for simulations of 2D/3D optical components.
- Analysis of Photonic Crystal structures using Plane Wave Expansion (PWE) method in MPB.

- Finite Element Method (FEM) modelling in COMSOL and Lumerical mainly for 2D/3D highly dispersive structures (e.g. metal).
- Basic knowledge of optical mode analysis using FIMMWAVE.

## **Research Experience**

### **Postdoctoral research**

1. Research funded by EPSRC through Doctoral prize (2013-2014).

Major achievements:

- Designed a patented novel silicon modulator structure based on a bulk silicon platform.

2. Research funded by a Proof of Concept project 'Frontier' from Scottish Enterprise (2013-2015).

Major achievements:

- Demonstrated electro-optic modulator using photonic crystal cavity operating in depletion mode.
- Demonstrated a patented design of an external cavity laser using photonic crystal cavity
- Developed a passive optical platform using inverted rib waveguide structure.

3. Research funded by EPSRC to develop energy efficient Si modulators (2015-2017).

Major activities:

- Design and development of a patented MZI Si optical modulator.
- Realization of passive optical components using anisotropic wet etching process
- Demonstrated Photonic crystal structures on a silicon rich nitride platform.
- Demonstrated fabrication of arbitrarily narrow dielectric slot waveguides in silicon.
- Day-to-day management of the research activities.

### **Doctoral research**

Research funded by UK Silicon Photonics consortium from EPSRC.

Major achievements

- Designed and developed a patented and efficient optical filter using vertically coupled photonic crystal cavity-waveguide system.
- Demonstrated silicon based electro-optic modulator with record low power consumption.
- Demonstrated silicon based wavelength selective photo-detector.
- Demonstrated multiplexing and demultiplexing architectures for dense WDM applications.

### **Masters research**

- Designed and demonstrated a holographic lithographic method using diffractive optical elements and recorded 2D and 3D periodic structures in silver halide emulsion and photorefractive material (LiNbO<sub>3</sub>).
- Simulation of photonic crystal structures and photonic crystal based optical components.

## **Teaching Experience**

### **Lecturer in Electronics and Communication Engineering Department**

Sri Venkateshwara College of Engineering, Bangalore, India

**Taught subjects:** Analog Electronic Circuits, Network Theory, Control System, Electromagnetic Field Theory, and Fiber Optics.

## **Lab Assistant**

University of St Andrews, UK

**Description:** Tasks included setting up basic experiments for undergraduate students, instructing experimental procedures and review their performance.

## **Research Fund Raising**

**Title of the research proposal:** Transistor Compatible Optical Interconnects

**Sponsoring Organization:** Engineering and Physical Sciences Research Council (EPSRC)

**Period of Funding:** June 2013 to May 2014 (One Year)

**Amount of Grant:** £38,000

## **Achievements and Additional Information**

- 2012 One of the finalists in the “UK ICT Pioneers” competition held by EPSRC in London, UK.
- 2012 Winner of the prize for best student poster presentation during the “Group Four Photonics” conference in San Diego, USA.
- 2011 2<sup>nd</sup> Prize for 2<sup>nd</sup> year School of Physics and Astronomy PhD student talk.
- 2007 Graduate Aptitude Test in Engineering (GATE) jointly organized by IISc and IITs. All India rank 397 with 600 GATE score. (Among top 1%).

## **References**

### **Prof. Thomas F. Krauss**

*(PhD Supervisor)*

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## Journal Publications

1. K. Debnath, L. O'Faolain, F. Y. Gardes, A. G. Steffan, G. T. Reed, and T. F. Krauss, "Cascaded modulator architecture for WDM applications," *Optics Express* 20, 27420-27428 (2012).
2. K. Debnath, K. Welna, M. Ferrera, K. Deasy, D. G. Lidzey, and Liam O'Faolain, "Highly efficient optical filter based on vertically coupled photonic crystal cavity and bus waveguide," *Optics Letters* 38, 154-156 (2013).
3. K. Debnath, F. Y. Gardes, A. P. Knights, G. T. Reed, T. F. Krauss, and L. O'Faolain, "Dielectric waveguide vertically coupled to all-silicon photodiodes operating at telecommunication wavelengths," *Applied Physics Letters* 102, 171106 (2013).
4. A. Debnath, K. Debnath, and L. O'Faolain, "Extraction of group index of lossy photonic crystal waveguides," *Optics Letters* 40, 193-196 (2015).
5. K. Debnath, R. Moore, A. Liles, and L. O'Faolain, "Toolkit for photonic integrated circuits based on inverted rib waveguides," *IEEE Journal of Lightwave Technology* 33, 4145-4150 (2015).
6. K. Welna, K. Debnath, T. F. Krauss, and L. O'Faolain, "High Q photonic crystal cavities realised using deep ultraviolet lithography," *Electronics Letters* 51, 1277-1279 (2015).
7. A. Liles, K. Debnath, L. O'Faolain, "Lithographic wavelength control of an external cavity laser with a silicon photonic crystal cavity-based resonant reflector," *Optics Letters* 41, 894-897 (2016).
8. K. Debnath, P. Damas, L. O'Faolain, "Electro-optic modulation in bulk silicon using surface plasmon resonance," *Photonics and Nanostructures-Fundamentals and Applications* 18, 31-35 (2016).
9. K. Debnath, H. Arimoto, M. K. Husain, A. Prasmusinto, A. Al-Attili, R. Petra, H. M. H. Chong, G. T. Reed, and Shinichi Saito, "Low-loss silicon waveguides and grating couplers fabricated using anisotropic wet etching technique," *Frontiers in Materials* 3, 10 (2016).
10. K. Debnath, A. Z. Khokhar, S. A. Boden, H. Arimoto, S. Z. Oo, H. M. H. Chong, G. T. Reed, and S. Saito, "Low-loss slot waveguides with silicon (111) surfaces realized using anisotropic wet etching," *Frontiers in Materials* 3, 51 (2016).
11. K. Debnath, T. Dominguez Bucio, A. Z. Al-Attili, A. Z. Khokhar, S. Saito, F. Y. Gardes, "Photonic crystal waveguides on silicon rich nitride platform," *Optics Express* 25, 3214-3221 (2017).
12. Prasmusinto, M. Sotto, A. Z. Al-Attili, K. Debnath, and S. Saito, "Theoretical Designs for Novel Photonic Crystal Nanocavities with Si (111) Interfaces," *Photonics and Nanostructures-Fundamentals and Applications* 26, 1-7 (2017).
13. K. Debnath, A. Z. Khokhar, G. T. Reed, and S. Saito, "Fabrication of Arbitrarily Narrow Vertical Dielectric Slots in Silicon Waveguides" *IEEE Photonics Technology Letters* 29, 1269-1272 (2017).
14. K. Debnath, M. Clementi, T. Dominguez Bucio, M. Galli, A. Z. Khokhar, S. Saito, F. Y. Gardes, "Ultra-high Q silicon rich nitride photonic crystal cavities," *Optics Express* 25, 27334-27340 (2017).
15. K. Debnath, M. Clementi, T. Dominguez Bucio, M. Galli, A. Z. Khokhar, S. Saito, F. Y. Gardes, "Ultra-high Q silicon rich nitride photonic crystal cavities," *Optics Express* 25, 27334-27340 (2017).

16. K. Debnath, D. J. Thomson, W. Zhang, A. Z. Khokhar, C. Littlejohns, J. Byers, L. Mastronardi, M. K. Husain, K. Ibukuro, F. Y. Gardes, G. T. Reed, "All-silicon carrier accumulation modulator based on a lateral metal-oxide-semiconductor capacitor," *Photonics Research* 6, 373-379 (2018).

### **Patents**

1. Granted: The University of St Andrews, T. F. Krauss, W. Whelan-Curtin, K. Debnath, K. Welna, "Wave vector matched resonator and bus waveguide system," US 9322999.
2. Published: The University of St Andrews, W. Whelan-Curtin, K. Debnath, "Optical Modulator with Plasmon Based Coupling," Application No. US14908228.
3. Published: The University of St Andrews, K. Debnath, W. Whelan-Curtin, "External cavity laser comprising a photonic crystal resonator," Application No. PCT/GB2015/052686.
4. Published: The University of Southampton, K. Debnath, S. Saito, G. T. Reed, "Dielectric slot in optical waveguide for electro-optic modulator and method of fabrication," Application No. 1613791.1.