Indrasen Bhattacharya

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WORK EXPERIENCE

California Institute of Technology *2024 - current*
Postdoctoral Research Associate
Medical Engineering
Advisor: Prof. Lihong Wang
Caltech Optical Imaging Laboratory

KLA Corporation *2017 - 2023*
Computational Imaging Research Scientist
System Architecture and Technology group, Wafer Inspection Division
Contributions:

- Internal scientific consultant
- Critical analysis and evaluation of computational imaging pipeline for sensitivity roadmap of a nanoscale semiconductor defect inspection platform
- EM simulation and image system analysis for broadband inspection sensitivity analysis
- Ab-initio simulation based stack engineering for extreme-UV printcheck based reticle inspection
- Unsupervised deep learning for image anomaly detection
- System analysis and attribution of image noise contributions
- Intellectual property generation: two patent applications
- Multiple customer engagement and product feature contribution for mitigating process-related variation of defect inspection sensitivity across customer wafers

EDUCATION

University of California, Berkeley (MS+PhD) *Graduation: Dec 2017*
Applied Science and Technology (UC Berkeley's version of Applied Physics)
Qualifying exam committee: Prof. Connie Chang-Hasnain (research advisor), Prof. Ming Wu (chair), Prof. Eli Yablonovitch, Prof. Liwei Lin (external)
GPA: 3.846/4.000, Research in Computational Imaging and Nanophotonics, Coursework in Computational Optical Imaging, Advanced Photonics, Lightwave devices, Electromagnetism, Nanofabrication, Quantum Electronics, Thin film science and technology

Indian Institute of Technology, Bombay (B-Tech Honors) *Graduation: Aug 2012*
BTech (Bachelor in Technology) in the Electrical Engineering Department
Honors in Electrical Engineering and Minor in Computer Science
GPA: 9.86/10.00, Department Valedictorian and Institute Silver Medalist
Coursework in Signals and systems, Signal processing, Devices, Circuits, Microprocessors, Machine learning, Data structures, Quantum mechanics, Semiconductor Physics, Optics

Stanford Systems Engineering Professional Certificate *Spring 2021*
Coursework in Deep Learning (CS230), Convolutional Neural Networks (CS231N), Engineering Risk Management (MSE250A), Algorithms for Optimization (AA222), KLA Systems Engineering Course

TECHNICAL COMPETENCIES

Computational Imaging	Digital Filtering, Image Signal Processing, Lab Experience, Abbe Image Formation, Camera Calibration, Image alignment, Inverse Problems, Computed Tomography, OpenCV, Matlab, Python
Statistical Learning	Logistic regression, Outlier Detection, Random Forests, Convolutional Neural networks, Recurrent Models, LSTMs Python: tensorflow, keras, sci-kit learn, t-SNE and visualization
Electromagnetic Simulation	finite difference time domain (Lumerical, Meep), RCWA (Prolith), finite element (JCMwave)
Electro-optic Characterization	fluorescence microscopy, time resolved photoresponse, solar simulator, quantum efficiency, spectrophotometry
Nanofabrication	clean room procedures, photolithography, etching, deposition, electron beam lithography, electron microscopy

AWARDS AND SCHOLASTIC ACHIEVEMENTS

- US Permanent residence based on the Outstanding Researcher Category (EB1-B)
- Graduate research on tomographic 3D printing generated two patents and a publication in *Science* magazine with 900+ citations
- Gold medalist at the Indian National Physics Olympiad and selected to attend a training camp for the International Physics Olympiad
- Paper awards at International Nano-Optoelectronics Workshop (iNOW): second prize (Tokyo, Japan, *2015*) and third prize (Cargese, Corsica, France, *2013*)
- Extraordinary achievement in 3 courses at UC Berkeley: Computational Optical Imaging, Advanced Photonics, Optical Engineering
- 5-Year Berkeley Graduate Fellowship through the Anselmo J. Macchi fund for Graduate Students
- Department Valedictorian (Electrical Engineering) at the Indian Institute of Technology Bombay, awarded Institute Silver Medal for graduating class of 2012
- Rakesh Mathur excellence award, IIT alumni at Microsoft scholarship and Boeing scholarship for excellent academic standing at IIT Bombay
- Selected to attend a course on Semiconductor processes, devices and systems organized through the Indo-German winter academy (2010)
- Selected to attend, among 80 other undegraduates in Asia, a winter school on communications and theoretical computer science at the Chinese University of Hong Kong (2009)
- Work on 3D printing research was selected for Cyclotron road fellowship, with the primary recipient being a collaborator (declined)

PATENTS

- US11639031B2 (active): Maxim Shusteff, James Oakdale, Robert Matthew Panas, Christopher M. Spadaccini, Hayden K. Taylor, Brett Kelly, Indrasen Bhattacharya, Hossein Heidari,"Photocurable Resins for Volumetric Additive Manufacturing", granted: 2023-05-02, UC Berkeley and Livermore National Lab
- US10647061B2 (active): Brett Kelly, Robert Panas, Maxim Shusteff, Christopher Spadaccini, Hayden Taylor, Indrasen Bhattachaya, "System and method for computed axial lithography (CAL) for 3D additive manufacturing", granted: 2020-05-12, UC Berkeley and Livermore National Lab
- P6314US (application): Abdurrahman Sezginer, Patrick McBride, Indrasen Bhattacharya, Robert M. Danen, "Shot noise reduction using frame averaging", KLA Corporation
- P6154US1 (application): Kuljit S. Virk, Minchuan Zhou, Indrasen Bhattacharya, Abdurrahman Sezginer, "Multi-mode Optical Inspection", KLA Corporation

EXEMPLARY RESEARCH PROJECTS

KLA Tencor: Vacuum-UV Spectrophotometry Setup summer, 2016
mentors/collaborator: Dr. Anatoly Shchemelinin, Dr. Elena Starodub, Dr. Matthew Derstine

- I built a spatially and spectrally resolved spectrophotometry setup to measure absorption in optical components for beta versions of a high throughput wafer inspection tool.
- The multi-instrument setup was automated using LabVIEW.
- **Key contribution**: measurement of optical components in deeper ultraviolet operating windows

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UC Berkeley: Tomographic single shot 3D printing Prof. H. Taylor
Can tomographic reconstruction algorithms inspire novel 3D printing modalities? *2016-2018*

- Non-linear thresholding provided by resin development process can lead to exact tomographic reconstruction for some test geometries with computationally optimized projections
- **Key Contributions**: Optimization and image computation algorithm, hardware proof-of-principle, physical modeling of printing, python and Matlab based projection computation repository
- Github repository of computational implementation: `https://github.com/indrasen1/tomo3D_repo`
- Resulting publications and conference presentations:

Bhattacharya, I.*, Toombs, J.*, (co-first author) and Taylor, H. High fidelity volumetric additive manufacturing. *Additive Manufacturing*, **47**, 102299, 2021

Kelly, B.*, **Bhattacharya, I.***, Heidari, H.*, (co-first author), Shusteff, M., Spadaccini, C. M. and Taylor, H Volumetric additive manufacturing via tomographic reconstruction. *Science*, **363**, 6431, 2019.

(invited talk) **Bhattacharya, I.**, Kelly, B., Shusteff, M., Spadaccini, C. and Taylor, H. *Computed axial lithography: volumetric 3D printing of arbitrary geometries*, SPIE Defence and Commercial Sensing, Orlando, 2018.

MIT: Dynamics of Terahertz Quantum Cascade Lasers summer, 2011
mentors/collaborators: Dr. Ivan Chan, Prof. Qing Hu

- **Key contribution**: understanding lasing temperature dependence using a more accurate simulation model accounting for the stimulated emission scattering channel in a self-consistent manner
- Publications:

Bhattacharya, I., Chan, C. W. I. and Hu, Q. Effects of stimulated emission on transport in terahertz quantum cascade lasers based on diagonal designs. *Appl. Phys. Lett.* **100**, 011108 (2012).

UC Berkeley: Monolithic infrared quantum well nanolasers Prof. C. Chang-Hasnain
How do we build a nanoscale laser to couple directly into silicon waveguides? *2012-2017*

- Context: Integrating optically active materials and devices on a silicon substrate is a long
- Result: Efficient electroluminescence at 1.45 μm and electrically injected gain has been achieved for nanopillar-quantum well devices grown in deterministic locations directly on silicon.
- **Key Contributions**: device fabrication and characterization, optical excitation experiments, FDTD simulations, short-loop material characterization using photoluminescence spectroscopy
- Publications:

Lu, F.*, **Bhattacharya, I.*** (co-first author), Sun, H., Tran, T-T.D., Ng, K.W., Malheiros-Silveira, G. N. and Chang-Hasnain, C. Nanopillar quantum-well lasers grown on silicon with silicon-transparent wavelengths. *Optica*, **4**, 7, 717-723, 2017.

Deshpande, S.*, **Bhattacharya, I.*** (co-first author), Malheiros-Silveira, G. N., Ng, K.W., Schuster, F., Mantei, W., Cook, K. and Chang-Hasnain, C. Ultra-compact position-controlled InP nanopillar LEDs on silicon with bright electroluminescence at telecommunication wavelengths. *ACS Photonics*, **4**, 3, 695-702, 2017.

Stanford: Semantic Segmentation of Aortic Dissection Prof. L. Hahn
Do recurrent deep learning models help with a 3D segmentation problem? *2018*

- Context: Radiologists painstakingly segment 500-1000 z-slices of CT scans for every study on each patient with the aortic dissection pathology
- Result: Modeling Z-dependencies using an Encoder-Decoder U-Net like architecture with recurrent blocks (conv-LSTM) in Decoder led to improvements in segmentation accuracy
- **Key Contributions**: convolutional-LSTM network for 3D segmentation task, metrics for evaluation, data augmentation and preparation, GPU based training with tensorflow

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A full list of resulting publications and conference abstracts is maintained at goo.gl/Fw3AYz

REPRESENTATIVE PUBLICATIONS AND TALKS

1. Kelly, B. E.*, **Bhattacharya, I.***, Heidari, H.*, Shusteff, M., Spadaccini, C. M. and Taylor, H. K. Volumetric additive manufacturing via tomographic reconstruction. *Science* **363**, 6431, 1075-1079, (2019). (* indicates equal contribution)

2. Lu, F., **Bhattacharya, I.***, Sun, H., Tran T-T.D., Ng. K. W., Malheiros-Silveria G. N., and Chang-Hasnain, C. Nanopillar quantum well lasers directly grown on silicon and emitting at silicon-transparent wavelengths. *Optica* **4**, 7, 717-723, (2017). (* indicates equal contribution)

3. **Bhattacharya, I.***, Toombs, J., Taylor, H. K. High fidelity volumetric additive manufacturing. *Additive Manufacturing* **47**, 102299, (2021). (* indicates equal contribution)

4. Deshpande, S.*, **Bhattacharya, I.***, Malheiros-Silveira, G. N., Ng, K. W., Schuster, F., Mantei, W., Cook, K. and Chang-Hasnain, C. Ultra-compact position-controlled InP nanopillar LEDs on silicon with bright electroluminescence at telecommunication wavelengths. *ACS Photonics* **4**, 3, 695-702, (2017). (* indicates equal contribution)

5. **Bhattacharya, I.**, Chan, C. W. I., and Hu, Q. Effects of stimulated emission on transport in terahertz quantum cascade lasers based on diagonal designs. *Applied Physics Letters* **100**, 1, (2012).

6. Malheiros-Silveira, G. N., **Bhattacharya, I.**, Deshpande, S., Skuridina, D., Lu, F. and Chang-Hasnain, C. Room-temperature Fabry-Perot resonances in suspended InGaAs/InP quantum-well nanopillars on a silicon substrate. *Optics Express* **6**, 1, 271-277, (2017).

7. Ko, W. S.*, **Bhattacharya, I.***, Tran, T-T.D., Ng, K.W., Gerke, S. and Chang-Hasnain, C. Ultrahigh responsivity-bandwidth product in a compact InP nanopillar phototransistor directly grown on silicon. *Nature Scientific Reports* **6**, 33368, (2016). (* indicates equal contribution)

8. Ko, W. S.*, Tran, T-T. D.*, **Bhattacharya, I.**, Ng, K. W., Sun, H. and Chang-Hasnain, C. Illumination angle insensitive single indium phosphide tapered nanopillar solar cell. *Nano Letters* **15**, 4961-4967 (2015). (* indicates equal contribution)

9. Kamath, A., Patil, T., Adari, R., **Bhattacharya, I.**, Ganguly, S., Aldhaheri, R. W., Hussain, M. A. and Saha, D. Double-channel AlGaN/GaN high electron mobility transistor with back barriers. *IEEE Electron Device Letters* **33**, 12, 1690-1692 (2012).

Representative conference talks *updated October 2021*

1. *(contributed)* Heidari, H., Kelly, B., **Bhattacharya, I.**, and Taylor, H. *Support-free direct 3D-printing of millifluidic and microfluidic chips with tunable stiffness through computed axial lithography*, SPIE BiOS, 2019.

2. *(contributed)* Deshpande, S., **Bhattacharya, I.**, Malheiros-Silveira, G. N., Mantei, W., Cook, K. and Chang-Hasnain, C. *Bright LEDs using position-controlled MOCVD growth of InP nanopillar array on a silicon substrate*, Compound Semiconductor Week (including IPRM), Toyama, 2016.

3. *(invited talk)* Deshpande, S., **Bhattacharya, I.** and Chang-Hasnain, C. *InGaAs/InP quantum-well-on-nanopillar LED on a silicon substrate using position controlled MOCVD*, SPIE-Photonics West, OPTO, paper 10114-6, San Francisco, 2017.

4. *(contributed)* **Bhattacharya, I.**, Lu, F., Malheiros-Silveira, G.N., Deshpande, S., Ng, K. W. and Chang-Hasnain, C. *Room-temperature InGaAs/InP quantum-well-in-nanopillar laser directly grown on silicon*, presented at CLEO, paper SF2L.5, San Jose, 2016.

5. *(contributed)* **Bhattacharya, I.**, Lu, F., Malheiros-Silveira, G.N., Deshpande, S., Ng, K. W. and Chang-Hasnain, C. *Room-temperature InGaAs/InP quantum-well-in-nanopillar laser directly grown on silicon*, presented at CLEO, paper SF2L.5, San Jose, 2016.

6. *(invited talk)* **Bhattacharya, I.** and Chang-Hasnain, C. *InP-based nanopillars on silicon for nanophotonics applications*, presented at MRS Fall 2015, Symposium P: Synthesis and Applications of Nanowires and Hybrid 1D-0D/2D/3D Semiconductor Nanostructures, Boston, 2015.

7. *(contributed)* **Bhattacharya, I.**, Ko, W. S., Lu, F., Gerke, S. and Chang-Hasnain, C. *III-V nanopillar phototransistor directly grown on silicon*, presented at CLEO, paper SW4N.2, San Jose, 2015.

Felicitated poster presentations *updated October 2019*

1. *(second prize)* Bhattacharya, I., Ko, W.S., Tran, T-T. D., Ng, K. W., Sun, H. and Chang-Hasnain, C. *Illumination angle insensitive indium phosphide nanopillar solar cell grown on a silicon substrate*, presented at the International Nano-optoelectronics Workshop (iNOW), Tokyo, 2015.

2. *(third prize)* Bhattacharya, I., Tran, T-T. D., Sun, H., Ng, K. W., Lu, F., Yablonovitch, E. and Chang-Hasnain, C. *Variability study of InP micropillars grown on a silicon substrate towards ensemble solar cell devices*, presented at the International Nano-optoelectronics Workshop (iNOW), Cargese, France, 2013.

VOLUNTEER ACTIVITIES

- Contributed to control system modeling for a small cubesat through the attitude determination and control subsystem on the IIT Bombay student-run microsatellite project (Pratham)
- Project management experience with Department of Energy Sunshot program, National Science Foundation Energy Efficient Electronics Science program, Semiconductor Research Corporation
- Teaching experience in nanoscale fabrication (1 semester), ordinary differential equations (half semester) and complex analysis (half semester)
- Design editor for graduate student-run science magazine *Berkeley Science Review*: researched and designed visualizations and art for full length articles as well as 'labscopes' and 'briefs'
- Volunteer for Science is Elementary, program for bringing science education to primary and kindergarten
- Mentored 2 high school students, one undergraduate summer intern and 2 visiting masters students
- Collaborated with an instructor at the Los Angeles Trade Technical college to design a course on circuits for the California community college system (through NSF E3S).

- Revived activities of Berkeley's student-run optical society chapter 'Photobears', serving as President and Treasurer on consecutive years
- Volunteered in farming villages in the Konkan district through the National Service Scheme chapter of IIT Bombay and demonstrated smoke-less cooking utensils: recognized for active participation