Institut national de la recherche scientifique

Dr. Bhagwat Singh **Chouhan**
Specialist in Photonics and Terahertz Metamaterials
Mob No. +919589830710
Email. bhagwatsingh1111@gmail.com
LinkedIn: click here, Google Scholar: click here

COMPETENCES OVERVIEW

Research Focus: Nonlinear optics and photonics with a current focus on designing and fabricating active and passive broadband terahertz metamaterials to address the terahertz gap for 6G communication and advanced sensing applications. Research involves engineering complex responses through planar and multilayer configurations, including filters, toroidal structures, and systems demonstrating electromagnetically induced transparency (EIT) and bound states in the continuum (BIC).

Research Experience: 5 years of theoretical and experimental research experience in terahertz metamaterials, gained at the Indian Institute of Technology, Guwahati. This includes the design, fabrication, and characterization of novel devices, with extensive hands-on experience in cleanroom techniques such as electron beam lithography (EBL), photolithography, and thin-film deposition. Experience extends to building a Terahertz Time-Domain Spectroscopy (THz-TDS) setup from scratch for experimental validation. This work is demonstrated in 9 peer-reviewed publications, 5 conference contributions, and 1 filed patent.

Education: PhD in Physics from the Indian Institute of Technology, Guwahati; Master of Science (M.Sc.) from the Indian Institute of Technology, Guwahati; Bachelor of Science (B.Sc.) from the Regional Institute of Education, Bhopal.

Teaching: Basic experience in university-level instruction earned as a Teaching Assistant for postgraduate physics laboratory courses at IIT Guwahati. Advanced experience in supervision acquired from mentoring undergraduate, research intern, graduate, and postgraduate students in terahertz and metamaterials research.

Leadership: Advanced skills in team leading and management, actively practiced through elected leadership roles as Vice President (2022-2024) and Secretary (2020-2022) of the IEEE Photonics Society Student Chapter at IIT Guwahati.

Project Acquisition: Active contribution to the formation of a number of national research proposals. This includes developing proposals for metamaterial-based terahertz modulators for 6G communication systems submitted to the India Semiconductor and Packaging Ecosystem Conference (ISPEC-2024) and for investigating THz plasmon dynamics using FEL techniques submitted to the Inter-University Accelerator Centre (IUAC).

PROFESSIONAL EXPERIENCE

Doctoral Researcher (2020-2025), INDIAN INSTITUTE OF TECHNOLOGY, Guwahati, (IN)

Main investigator of projects related to broadband terahertz metamaterials. Responsible for the terahertz time-domain spectroscopy development and fabrication laboratories in the

group. Initiator of and active contributor to multiple research collaborations.

Research focus: Here, I started my career in academia as a doctoral student and researcher and extensively studied active and passive terahertz metamaterials as a novel platform to address the terahertz gap for next-generation applications. My work has focused on engineering broadband and tunable responses by developing both planar and multilayer device configurations. In particular, my research enabled the use of integrated phase-transition materials, such as VO_2 and perovskites, as a functional testbed for achieving dynamic control of terahertz waves, and for exploring novel physical phenomena like phonon-polariton-induced Rabi splitting.

Methods: Design, fabrication, and characterization of terahertz planar and multi-stacked hybrid metamaterials. Numerical and theoretical studies based on commercial solvers (CST Microwave Studio, COMSOL Multiphysics). Extensive hands-on cleanroom fabrication experience (incl. EBL, photolithography, and thin-film deposition). Terahertz-wave manipulation and characterization using a self-developed Terahertz Time-Domain Spectroscopy (THz-TDS) setup. Application of machine learning algorithms for metamaterial optimization.

Dissemination: Based on my theoretical and experimental findings as well as a powerful network of collaborators, I was able to publish a series of articles in top-tier peer-reviewed journals (incl. a Nature Scientific Report, and multiple in the Journal of Lightwave Technology). For a fast dissemination of my results, and to widen my own professional network, I presented my work at multiple peer-reviewed international conferences, where I earned essential recognition through several awards (e.g., Best Poster Awards at WRAP-2022 and FTTA-2021). I further gained know-how in technology transfer due to a patent application for a tunable modulator technology I developed.

Scientific commitment: During my work, I also gained my first experience as a team leader by mentoring undergraduate, graduate, and post-graduate students on projects based on my original research ideas. Finally, I am proud that I could contribute to the academic community at my institute through elected leadership roles in the IEEE Photonics Society Student Chapter (as Vice President and Secretary), which fostered a vibrant environment for young researchers.

Research Project Student (2015-2017), INDIAN INSTITUTE OF TECHNOLOGY, Guwahati (IN)

Project Title: Electro-Optical Properties of Photochromatic Bio-Nano Hybrid Complex

Research focus: My first steps toward a professional research career took place during my master's studies, where I worked on a fruitful research project investigating the electro-optical properties of novel bio-nano hybrid materials. This work explored the effects of optical doping and analyzed charge transport dynamics in thin films, which inspired me to further investigate light-matter interactions in advanced materials during my PhD studies.

Methods: Thin film fabrication of graphene, bacteriorhodopsin, and hybrid films on various substrates using drop-casting and vacuum filtration techniques. Characterization of material properties and charge transport dynamics through I-V measurements using a Keithley Source Meter. Studied optical doping effects and electric hysteresis under light exposure.

EDUCATION

Ph.D. in Physics (2020-2025), Indian Institute of Technology, Guwahati, India
Thesis: *Engineering Broadband Response in Active and Passive Terahertz Metamaterials Using Planar and Multilayer Configurations*

M.Sc. in Physics, Indian Institute of Technology, Guwahati, India, 2017
Thesis: *Electro-Optical Properties of Photochromatic Bio-Nano Hybrid Complexes*

B.Sc. in Physics, Regional Institute of Education, Bhopal, India, 2015

Year	Degree	Institute / Board	CGPA
July 2020 to Jun 2025	PhD	Indian Institute of Technology, Guwahati	9.77 (Coursework)
May-2017	M.Sc.	Indian Institute of Technology, Guwahati	7.06
May 2015	B.Sc.	Regional Institute of Education, Bhopal	7.37

PUBLICATIONS

Journal Publications

1. **Bhagwat Singh Chouhan**, Bhumidhar Barman, Lavi Kumar Vaswani, Anuraj Panwar, and Gagan Kumar, "Broadening of Resonance with the Bending of Strongly Coupled Strip Resonators in a Planar Terahertz Metamaterial," *Journal of Lightwave Technology (JLT)*, Vol. 42, pp. 3283, 2024.Link
2. **Bhagwat Singh Chouhan**, Nityananda Acharyya, Anuraj Panwar, Dibakar Roy Chowdhury, and Gagan Kumar, "Multi-stacked polarization-insensitive broadband terahertz metamaterial," *Journal of Applied Physics (JAP)*, Vol. 135, pp. 173103, 2024.Link
3. **Bhagwat Singh Chouhan**, Ali Nawaz, Asit Das, Rohith K M, Amir Ahmad, and Gagan Kumar, "Machine learning-driven ultra-broadband terahertz multilayer metamaterial," *Journal of Lightwave Technology (JLT)*, Recently published, DOI: 10.1109/JLT.2024.3509492.Link
4. Angana Bhattacharya, **Bhagwat Singh Chouhan**, Kajal Sharma, Sami M. Halawani, Amir Ahmad, and Gagan Kumar, "Terahertz binary computing in a coupled toroidal metasurface," *Scientific Reports (Nature Publication)*, Vol. 14, pp. 8721, 2024.Link
5. Lavi Kumar Vaswani, **Bhagwat Singh Chouhan**, Angana Bhattacharya, Anuraj Panwar, and Gagan Kumar, "Single and Dual-band Electromagnetically Induced Transparency in a Strongly Near Field Coupled Planar Toroidal Terahertz Metamaterial," *Optics & Laser Technology (OLT)*, Vol. 176, pp. 111006, 2024.Link
6. Lavi Kumar Vaswani, **Bhagwat Singh Chouhan**, Anuraj Panwar, and Gagan Kumar, "Electromagnetically induced transparency in a strongly coupled orthogonal polarization-insensitive planar terahertz metamaterial," *Journal of Physics D: Applied Physics (JAPD)*, Vol. 57, pp. 075103, 2024.Link
7. Angana Bhattacharya, **Bhagwat Singh Chouhan**, Rajan Singh, Bhairov K Bhowmik, and Gagan Kumar, "Polarization-independent lattice-coupled terahertz toroidal excitation," *Journal of Physics D: Applied Physics (JAPD)*, Vol. 56, pp. 415101, 2023.Link
8. KM Dhriti, Ashish Kumar Chowdhary, **Bhagwat Singh Chouhan**, Debabrata Sikdar, and Gagan Kumar, "Tunable Terahertz Absorption Modulation in Graphene Nanoribbon-Assisted Dielectric Metamaterial," *Journal of Physics D: Applied Physics (JAPD)*, Vol. 55, pp. 285101, 2022.Link
9. **Bhagwat Singh Chouhan,** Sirsendu Ghosal, Rohith K M, Soumyadeep Ray, P. K. Giri, Amir Ahmad, and Gagan Kumar, "Ultra-Broadband Actively Tunable Terahertz Modulator Based on Multi-Stacked Metamaterial," *Scientific Reports*. Link
10. **Bhagwat Singh Chouhan,** Sirsendu Ghosal, Rohith K M, Soumyadeep Ray, P. K. Giri, Amir Ahmad, and Gagan Kumar, "Ultra-Broadband Actively Tunable Terahertz Modulator Based on Multi-Stacked Metamaterial," *Optics and Laser Technology*, **under review**.
11. Lavi Kumar Vaswani, Rohith K M, **Bhagwat Singh Chouhan,** Sirsendu Ghosal, Anuraj Panwar, P. K. Giri, and Gagan Kumar, "Dynamic Control of Electromagnetically Induced Transparency Using Thermal Effects via Flexible Terahertz Metasurface," *IEEE Journal of Selected Topics in Quantum Electronics*, **under review**.
12. Amit Haldar, Kshitij V Goyal, Ruturaj Puranik, Vivek Dwij, Kanha Ram Khator, Subhashis Ghosh, **Bhagwat Singh Chouhan,** Gagan Kumar, Satyaprasad P. Senanayak, Shriganesh Prabhu, and Shovon Pal, "Phonon-Polaritons Mediated Dual Electromagnetically Induced Transparency in a THz Metamaterial," *ACS Photonics*, **under review**.

Conference proceedings:

1. **Bhagwat Singh Chouhan**, KM Dhriti, Ashish Kumar Chowdhary, Debabrata Sikdar, and Gagan Kumar, "Modulating broadband terahertz in a graphene-assisted dielectric Metamaterial," Workshop on Recent Advances in Photonics **(WRAP)-2022**, DOI: 10.1109/WRAP54064.2022.9758283.
2. **Bhagwat Singh Chouhan**, KM Dhriti Maurya, Bhairov Kumar Bhowmik, Angana Bhattacharya, and Gagan Kumar, "Graphene-Dielectric based Tunable Terahertz Polarization Insensitive Modulator," IEEE Photonics Conference **(IPC)-2022**, DOI: 10.1109/IPC53466.2022.9975603.
3. **Bhagwat Singh Chouhan**, Partha Pratim Barman, Bhumidhar Barman, and Gagan Kumar, "Polarization-Insensitive Ultra-Broadband Terahertz Metamaterials for 6G Applications," 14th International Conference on Metamaterials, Photonic Crystals and Plasmonics **(META-2024),** ISSN: 2429-1390.
4. Angana Bhattacharya, Haina Bhawnani, **Bhagwat Singh Chouhan**, Anuraj Panwar, and Gagan Kumar, "Electromagnetically Induced Transparency in Broadside Coupled Toroidal Metasurfaces," IEEE Workshop on Recent Advances in Photonics **(WRAP-2024)**, DOI: 10.1109/WRAP59682.2023.10712997.
5. **Bhagwat Singh Chouhan** and Gagan Kumar, "Metamaterial-Based Terahertz Broadband Active Modulator

Using VO_2-Resonators for 6G Communication Systems," RIC Conclave-2024, ***Springer Nature***, accepted, DOI: yet to be generated.

PATENT INFORMATION

- **Title:** **An ultra-broadband actively tunable terahertz modulator based on multi-stacked metamaterial and a method of preparation.**
- **Application No.:** 202431065
- **Status:** Early publication completed, currently under early examination stage.

AWARDS AND FELLOSHIPS

1. **Best Poster Award**: International Conference on "Frontiers in Terahertz Technology and Applications **(FTTA-2021)**, 2021
2. **Best Poster Award**: IEEE Workshop on Recent Advances in Photonics **(WRAP-2022**), 2022
3. **First Prize:** INUP-**HACKATHONS 5G & 6G** Technology Hackathon 2023.
4. **Qualified: GATE, JEST** and **NET** (National-level examinations).
5. Received a **prestigious travel grant from CSIR-HRDG** for the international conference.
6. Received a **prestigious travel grant from ANRF** for the international conference.
7. Received a **prestigious travel grant from ICTP** for attending the international conference.

ATTENDED EVENTS DURING 2020-2025

Conferences

1. 16th International Conference on Fiber Optics and Photonics **(Photonics-2024).**
2. 7th Annual Conference on Quantum Condensed Matter **(QMAT-2024).**
3. Research and Industrial Conclave Integration **(RIC- 2024), IIT Guwahati.**
4. 14th International Conference on Metamaterials, Photonic Crystals and Plasmonics **(META-2024).**
5. India Semiconductor and Packaging Ecosystem Conference **(ISPEC-2024).**
6. International Conference on Advanced Nanomaterials & Nanotechnology **(ICANN-2023).**
7. The Indo-French Conference on Photonics and Metamaterials **(IFCFPM-2023)**
8. Research and Industrial Conclave Integration **(RIC-2022),** IIT Guwahati
9. IEEE Photonics Conference **(IPC-2022)**
10. International Conference on "Frontiers in Terahertz Technology and Applications "**(FTTA-2021).**
11. IEEE Silicon Photonics, London, England **(IEEE-Si-photonics-2025)**

Workshops

12. Workshop on Advancements and Applications of Analytical Instruments **(AAAI-2024).**
13. IEEE WRAP 2022: IEEE Workshop on Recent Advances in Photonics **(WRAP-2022)**
14. The Indian Nanoelectronics Users Program **(INUP-2022)**, IIT Guwahati

Schools

15. IEEE Sensors Winter School 2023
16. ICTP Winter College on Optics: Terahertz Optics and Photonics **(ICTP-2023)**.

Symposiums

17. Frontiers in Optics & Terahertz Photonics **(FiOTP-2024).**
18. Frontiers in Optics & Terahertz Photonics **(FiOTP-2023).**
19. Frontier in Metasurfaces & Terahertz Photonics **(FiMTP-2025).**

User Meetings

20. **INUP Users' Meet**, IIT Bombay – August 10, 2024

PROSESSIONAL MEMBERSHIPS

- **IEEE Photonics Society:** Student member (2020-2025)
- **Vice President**, IEEE Photonics Society Student Chapter, IIT Guwahati (2022-2024)
- **Secretary, IEEE** Photonics Society Student Chapter, IIT Guwahati (2020-2022)
- **Optica (formerly OSA):** Student member (2023- Present)

TEACHING & MENTORING EXPERIENCE

- **Teaching Assistant**, IIT Guwahati, [2022]
  - Assisted in postgraduate physics laboratory courses.
- **Mentored undergraduate, research interns, graduate students and post-graduates** in terahertz and metamaterials research.

TPROJECT PROPOSAL WRTITING EXPERIEINCE

As part of my research, I have worked on project proposals in terahertz metamaterials, Plasmonics, and machine-learning-assisted photonic devices. These proposals focus on next-generation communication systems, ultrafast switching, and tunable terahertz devices, combining theoretical modelling and experimental techniques. Below are some key proposals I have contributed to:

1. **Title: Metamaterial-based Terahertz broadband active modulator using VO2 material for the 6C communication systems**.
   - **Objective:** Develop cutting-edge phase change materials to enhance the performance and efficiency of 6G communication systems, focusing on improved data storage, faster information processing, and superior signal transmission capabilities at terahertz (THz) frequencies.
   - This proposal was written under the supervision and guidance of my supervisor, Prof. Gagan Kumar, and submitted to the "India Semiconductor and Packaging Ecosystem Conference (ISPEC-2024).
2. **Title**: **Investigating THz Plasmon Dynamics in Metasurfaces using FEL Techniques.**
   - **Objective:** To explore THz-induced plasmon dynamics in metasurfaces using Free Electron Laser (FEL) techniques, focusing on the Inverse Faraday Effect (IFT) for applications in polarization control and all-optical switching.
   - This proposal was prepared with inputs from my lab mate, Mr. Rohit K.M., under the supervision and direction of my supervisor, and submitted to the Inter-University Accelerator Centre (IUAC) Delhi, 2024.
3. **Title: Building and Investigating machine-assisted metamaterials for the terahertz photonics applications.**
   - **Objective:** Design and fabricate machine-learning-assisted metamaterials for various terahertz applications, including toroidal metamaterials, high-Q resonance structures, and EIT- and BIC-induced metamaterials, which can be utilized in terahertz photonic devices.
   - This proposal was jointly developed with Prof. Amir Ahmad under the supervision and guidance of my supervisor and Prof. Amir Ahmad, with my contributions focused on structural design and optimization.

Thank you for your time.