Lab information and available research projects

PI: Prof. Gagan Kumar
Name of the lab: Terahertz Optics and Meta-Photonics Laboratory
Website: https://iitg.ac.in/gk/

Research description

My research interests in recent years have focused on investigating plasmonic and metamaterials for application in terahertz photonics. Our research activities encompass theory, experiment, and modelling, aiming to develop new devices, including modulators, filters, and sensors with enhanced speed and sensitivity.

Our lab, the "Terahertz Optics and Meta-Photonics Lab," was established in 2013 and is equipped with the necessary tools and instruments for conducting terahertz research. We utilize advanced 3D electromagnetic simulation software such as CST Microwave Studio and COMSOL for designing plasmonic and metamaterial structures. These devices are fabricated in the clean room facility at IIT Guwahati, while characterization is performed using a terahertz time-domain spectrometer available in our lab.

Currently, we are collaborating with several institutions in India and abroad to further our research efforts and explore new frontiers in terahertz photonics and metamaterials. For details, please visit our research group website: https://iitg.ac.in/gk/

Available Research Projects

- **Terahertz Topological photonics waveguides for 6G and beyond:** The advent of 6G technology is poised to revolutionize telecommunications, necessitating innovative approaches to handle the expected exponential increase in data rates, connectivity, and network capacity. One of the emerging technologies in this domain is terahertz (THz) topological photonics waveguides. This project will focus on the design of terahertz (THz) topological photonics waveguides using COMSOL Multiphysics and CST Microwave Studio software, understanding the underlying physics. It will be followed by the fabrication of the optimized design and characterization at terahertz frequencies.
- **Design and development of meta-devices for terahertz photonics:** Meta-devices, or devices based on metamaterials, are at the forefront of advancing terahertz (THz) photonics, promising to unlock the potential of THz frequencies (0.1 to 10 THz) for a wide array of applications. These artificially structured materials exhibit unique electromagnetic properties not found in natural materials. The project will focus on the design of optimized metamaterials leading to polarization conversion, broadband modulators, slow light systems, etc., through commercial simulation software, followed by experimental characterization.
- **AI-assisted plasmonic and meta-devices:** The integration of artificial intelligence (AI) with meta-devices is revolutionizing the design and functionality of these advanced materials. Meta-devices, constructed from metamaterials, exhibit unique

electromagnetic properties that can be precisely tailored for specific applications. AI technologies enhance the design, optimization, and real-time adaptation of these devices, leading to unprecedented capabilities in various fields. The project will include the development of algorithms for optimized meta-devices, followed by experimental characterization.

- **Dynamically tunable terahertz metasurfaces using phase transition materials:** Dynamically tunable terahertz (THz) metasurfaces are cutting-edge devices that leverage the unique properties of phase transition materials (PTMs) to achieve real-time control over THz waves. The focus will be on investigating 2D materials with phase transition possibilities, followed by the integration of these materials with the metasurfaces. Subsequently, we will explore the dynamically tunable resonance behavior at terahertz frequencies.