

Charge-transfer plasmonics and nanophotonics in graphene heterostructures

Zhe Fei, Iowa State University

Session: 9:05 am – 9:45 am

Abstract

Charge transfer in graphene heterostructures provides a powerful means to control the electronic properties and nanoscale optical responses across the interface. In this talk, I will discuss our recent studies of charge-transfer plasmonics and nanophotonics in several graphene heterostructures. I will first present near-field studies of Gd-intercalated graphene, where interlayer separation and charge transfer induced by intercalation produce nanoscale conductive domains with enhanced infrared responses. In oxide/graphene heterostructures, interfacial charge transfer strongly modifies the carrier density of graphene and enables pronounced tuning of graphene plasmons, including their wavelength, damping, and gate response. Finally, I will discuss PTCDA/graphene heterostructures, in which electrostatic gating of graphene leads to strong modifications in molecular vibrational excitations, pointing to an important role of dynamic charge transfer and electron–vibron coupling.

Short Bio

Zhe Fei is currently an Associate Professor in the Department of Physics and Astronomy at Iowa State University. He received his Ph.D. in Physics (2014) at the University of California, San Diego. Before joining ISU in 2015, he served as an Assistant Scientist at the Center for Nanoscale Materials, Argonne National Laboratory. His research is focused on exploring the nano-optical physics and properties of low-dimensional materials with near-field optical imaging and spectroscopy techniques.

Measuring thermal transport and nanoscale temperature distribution with s-SNOM

Jingang Li, Purdue University

Session: 9:45 am – 10:25 am

Abstract

This talk introduces two SNOM-based techniques for nanoscale thermal characterization. First, spatially separated pump-probe nanoscopy combines femtosecond temporal resolution with nanoscale probing to directly visualize energy transport beyond the optical diffraction limit. Measurements on metallic structures reveal distinct hot-electron and thermal diffusion regimes, as well as geometry-dependent heat-transport pathways. Second, noncontact near-field optical thermometry uses periodic Joule heating and thermal-optical signal amplification to map temperature oscillations in operating devices with high spatial and temporal resolution. Applications include imaging current crowding, heat diffusion, and reversible phase transitions. Together, these techniques provide complementary capabilities for using SNOM to resolve energy transport and temperature distributions in nanoscale materials and devices.

Bio

Jingang Li joined Purdue University as an assistant professor in School of Mechanical Engineering and School of Materials Engineering in Fall 2025. Prior to this, he completed postdoctoral training with Prof. Costas P. Grigoropoulos's in the Department of Mechanical Engineering at University of California, Berkeley. He received Ph.D. from the Department of Mechanical Engineering with Prof. Yuebing Zheng at The University of Texas at Austin and his B.Sc. in applied physics from University of Science and Technology of China. His research aims to understand fundamental opto-thermal processes and light-matter interactions and to develop novel laser processing and diagnostic technologies for nanotechnology, energy, electronics, and health.

Polarization-Resolved Photovoltage Measurements in Cryogenic s-SNOM

Bogdan Borodin, University of Notre Dame

Session: 10:40 am – 11:20 am

Abstract

Quantum geometry governs nonlinear responses in quantum materials, yet experimentally accessing its local manifestations remains challenging. Here, we introduce a cryogenic, polarization-sensitive local terahertz photocurrent microscopy technique that combines terahertz excitation with scanning-probe detection to enable real-space characterization of quantum materials with deep sub-diffractive spatial resolution. Local control of the excitation polarization allows us to resolve the spatial dependence of photocurrent and distinguish intrinsic response from parasitic contributions near contacts and other inhomogeneous regions.

We demonstrate the technique on dual-gated AB bilayer graphene, where inversion symmetry breaking and the electronic band structure can be controlled electrostatically. Spatially and polarization-resolved measurements reveal a strong enhancement of the bulk photovoltaic effect and optical conductivity as the tunable bandgap approaches the terahertz photon energy. We further resolve a local shift-vector texture with C2 symmetry whose carrier-density dependence reflects fine details of the band structure, including trigonal warping.

These results establish cryogenic terahertz photocurrent microscopy as a versatile multimodal approach for nanoscale characterization of nonlinear responses and local quantum-geometric properties in quantum materials.

Bio

Dr. Bogdan Borodin is a postdoctoral researcher in the Department of Physics at the University of Notre Dame. His research focuses on nanoscale characterization of quantum materials, with an emphasis on two-dimensional materials, graphene, and phonon-polariton systems. He develops and applies scanning-probe-based optical and photocurrent techniques, including cryogenic terahertz nanoscopy, to investigate local electronic, optical, and quantum-geometric properties of quantum materials. His work combines nanoscale imaging with polarization- and gate-dependent measurements to uncover spatially resolved responses that are inaccessible to conventional far-field techniques.

neaSCOPE for Nanoscale Optical Material Characterization with 10nm Spatial Resolution Technology and Applications

Tobias Gokus, attocube

Session: 11:20 am – 12:00 pm

Abstract

Every scientific question has its own merits and demands specific instrumentation to search for answers. Nanoscale infrared is a novel versatile optical microscopy technology which allows to probe material properties such as chemical composition, molecular orientation, stress & strain fields, and free-carrier concentration with 10 nm spatial resolution.

In our presentation, we will introduce the basic working principle of near-field optical microscopy modalities available for the neaSCOPE microscope system and will highlight the broad spectrum of applications for studying the nanoscale optical, electronic and structural properties of various material classes such as polymers, minerals, 2D and layered materials, semiconductors, photonic as well as novel photovoltaic and battery materials.

Bio

Dr. Tobias Gokus finished his Diploma at University Siegen and Tuebingen working on single molecule/particle optical microscopy and spectroscopy of individual carbon nanotubes. For his PhD he joined the group of Prof. Achim Hartschuh at LMU, Munich for developing dedicated confocal and near-field optical microscopes optimized for studying the luminescence properties of low dimensional carbon materials. Captivated by the possibility to introduce the huge application potential of infrared near-field microscopy to a broader scientific community Tobias joined the nanoscale analytics department (ALX) of attocube systems AG as application engineer. In his current position he is exploring together with researchers in academia and industry new applications of near-field microscopy for their research.