

DEPARTMENT OF PHYSICS & ASTRONOMY

Physics & Astronomy Colloquium

Dr. Ioannis Chatzakis

Texas Tech University

3:30 - 4:30 p.m. | Tuesday, April 22

Science Building 234

Carriers' Recombination and Enhanced Auger-Meitner processes in low-dimensional materials

Hexagonal boron nitride (hBN) is a wide, indirect bandgap semiconductor with significant potential for optoelectronic applications in the ultraviolet and mid-infrared spectral ranges. More importantly, it is a promising platform for single-photon emission (quantum light), making it a candidate for optical quantum qubits operating at room temperature. The performance of such optoelectronic devices is largely governed by the dynamics of photogenerated carriers. In this work, we investigate the dynamics of photoexcited free carriers in exfoliated, 10B-enriched (99%), hBN at room temperature using ultrafast spectroscopy. We identify three distinct recombination mechanisms: a slow, excitation-independent process attributed to Shockley–Read–Hall (SRH) recombination associated with lattice defects and impurities; a bimolecular recombination mechanism that dominates at moderate excitation densities; and Auger recombination, which becomes significant at higher excitation densities. Notably, the Auger recombination rate observed in hBN is considerably higher than in other nitride-based semiconductors. This elevated rate is sufficient to reduce the internal quantum efficiency of hBN-based devices under high charge carrier densities. The large Auger coefficient may be attributed to charge localization induced by defects and impurities, as well as strain-related built-in polarization fields. Finally, I will highlight how our work informs the development of next-generation electronic and photonic devices, paving the way for advancements in high-performance, energy-efficient technologies.

Refreshments at 3 p.m. | SC 103



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Bio: Dr. Ioannis Chatzakis earned his Ph.D. in Physics from Kansas State University in Dec. 2009. After completing his coursework, he moved to Columbia University to work on the optical and electronic properties of carbonic materials under the supervision of Prof. Tony F. Heinz. He also holds an M.Sc. degree in Physical Chemistry (Applied Molecular Spectroscopy), and a B.Sc. degree in Electrical Engineering. Before joining TTU, he was an American Society for Engineering Education (ASEE) research fellow residing at the U.S. Naval Research Laboratory (NRL) in Washington, DC. Prior to the NRL appointment, he trained as a postdoctoral researcher at Iowa State University/Ames Laboratory, Stanford University, and the University of Southern California (USC). His research focuses on the nonequilibrium phenomena in quantum materials investigated by ultrafast spectroscopy. Dr. Chatzakis was recently awarded a DoD HBCU/MI grant and one of the two 2024 Global Faculty Exchange Research Seed Grants. He is a member of the American Physical Society, Materials Research Society, and Optical Society of America, and he serves the community as a referee in several scientific journals.

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