Nebraska Center for Materials and Nanoscience

2019 Fall Seminar Series

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Mid-IR to Thz Polaritons: Realizing Novel Materials for Nanophotonics

The field of nanophotonics is based on the ability to confine light to sub-diffractional dimensions. Up until recently, research in this field has been primarily focused on the use of plasmonic metals. However, the high optical losses inherent in such metal-based materials has led to an ever-expanding effort to identify, low-loss alternative materials capable of supporting sub-diffractional confinement. Beyond this, the limited availability of high efficiency optical sources, refractive and compact optics in the mid-infrared to THz spectral regions make nanophotonic advancements imperative. One highly promising alternative is to implement polar dielectric crystals, whereby sub-diffraction confinement of light can be achieved through the stimulation of surface phonon polaritons within an all-dielectric, and thus low loss material system. Due to the wide array of high quality crystalline species and varied crystal structures, a wealth of unanticipated optical properties have recently been reported. This talk will discuss recent advancements from our group including the realization of localized phonon polariton modes, the observation and exploitation of the natural hyperbolic response of hexagonal boron nitride as well as the implementation of hybridization of polaritonic modes and manipulation of the phonon dispersion and density of states as a means to design infrared nanophotonic materials. Beyond this, methods to improve the material lifetime, realize active modulation, control polariton propagation with nanoscale precision and to provide additional functionality hybridization of optical modes will be discussed.

Dr. Joshua Caldwell was awarded his bachelors of Chemistry from Virginia Tech in 2000 before heading to the University of Florida where he received his PhD in Physical Chemistry in 2004 under the direction of Prof. C. Russell Bowers. There he used magnetic resonance methods to investigate electron-nuclear spin coupling within low-dimensional quantum wells and heterostructures. He accepted a postdoctoral fellowship at the Naval Research Laboratory, using optical spectroscopy as a means of understanding defects within wide-band gap semiconductors. He was transitioned to permanent staff in 2007, where he began work in the field of nanophotonics, investigating coupling phenomena within plasmonic materials. More recently, Dr. Caldwell merged his prior work in wide band gap semiconductor materials with his efforts in nanophotonics, leading to his efforts to use undoped, polar dielectric crystals for low-loss, sub-diffraction optics. Dr. Caldwell was awarded a sabbatical at the University of Manchester with Prof. Kostya Novoselov in 2013-2014, investigating the use of van der Waals crystals such as hexagonal boron nitride for mid-IR to THz nanophotonics. He accepted a tenured Associate Professorship at Vanderbilt University within the Mechanical Engineering in June, 2017. He has published over 120 papers, >3900 citations and 9 patents.

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206 Scott Engineering Center
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