Atomic Force Microscopy for Defect Characterization and Strain Control of Two-Dimensional Materials

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Wednesday, April 22nd @ 2:00 pm in BRK 1001
Coffee and snacks served before seminar
also on [MS Teams]

Abstract: 2D materials are exciting materials for future technologies, both in traditional electronics and quantum applications. The properties of 2D materials depend strongly on defects and strain, which presents both a challenge and an opportunity. The challenge is that unwanted defects or random strain variations can degrade material performance. The opportunity is that controlled defects and strain can enable improved performance and new functionalities. In this talk, I will present atomic force microscopy (AFM)-based methods for atomic defect characterization and nanoscale strain control that enable investigations of defect-property and strain-property relationships. In the first part, I will describe our work on developing generalizable approaches for locating, quantifying, and differentiating defects in 2D materials with AFM. In particular, I will show that conductive AFM locates the same defects in transition metal dichalcogenides as scanning tunneling microscopy, providing an efficient method for accurate defect characterization. I will also demonstrate that lateral force microscopy (LFM), a purely mechanical technique, can locate certain types of defects in insulating materials, such as hexagonal boron nitride, and also in semiconducting materials on insulating substrates which is important for rapid growth characterization and characterization within device channels. In the second part of this talk, I will discuss our work on manipulating the strain distribution within 2D materials. Our approach is to use AFM to indent 2D materials which are placed on top of polymer films. We previously showed that this technique can introduce single photon emitters in monolayer WSe_2. The focus in this talk will be on understanding the limits of nanoindentation for introducing strain. Our work demonstrates a general technique for modifying the strain state of 2D materials, which will enable precise understanding of the impact of strain and strain gradients on 2D material behavior.

Bio: Matt received his B.S. (2010), M.S. (2012), and Ph.D. (2016) from the University of Illinois at Urbana-Champaign in the Department of Mechanical Science and Engineering. During graduate school, Matt was awarded the Department of Energy Graduate Research Fellowship. His graduate research focused on developing atomic force microscopy techniques for probing mechanical, thermal, and infrared properties at the nanometer-scale. He held a National Research Council Postdoctoral Fellow position at the U.S. Naval Research Laboratory (NRL) from 2016-2019 and was a staff scientist at NRL from 2019-2020. Since 2021, Matt has been an assistant professor in the Department of Aerospace and Mechanical Engineering at the University of Notre Dame. In 2024, he received an NSF CAREER award.

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