Quantum Devices Based on Atomically Thin Materials (E, Churchill)

Quantum devices have properties that are enabled or enhanced by quantum effects, either by material design, nanostructuring, or both. In the Churchill Lab, we combine physics, materials science, and electrical engineering to fabricate and measure nanoscale electronic and optoelectronic quantum devices. Materials with layered structures can be peeled apart so that 2D crystals with thicknesses of one or a few atoms can be isolated and studied. We use techniques that take advantage of the weak out-of-plane bonds in these materials to pick up and stack them in different combinations, each of which can have different physical properties.

This area of research is particularly well-suited to undergraduate involvement, and there are already several undergraduates working on various projects in the lab. During the summer, an REU student will learn how to peel apart layered materials, identify atomically thin flakes on a substrate, pick-up and stack them together with 3D-printed stamps, design electronic devices based on the stacks, and measure the properties of the fabricated devices. In particular, we are currently interested in stacks of hexagonal boron nitride, black phosphorus, and tungsten diselenide placed over pre-patterned metal electrodes that control the behavior of electrons inside the atomically thin materials. The overall goal of this work is to use electrical and optical measurements to understand the properties of electrons in these materials, which may enable the creation of devices that function in new ways or that consume very little power.