NDnano
Center for Nano Science and Technology

# NDnano Summer Undergraduate Research 2019 Project Summary

**1. Student name & home university:** Grant Barthelmes, University of Notre Dame

**2. ND faculty name & department:** Gregory Snider, Electrical Engineering

**3. Summer project title:** Synthesis and measurement of charge switching in mixed valence molecules

**4. Briefly describe new skills you acquired during your summer research:**

- I learned how to read and write in C code. Although my experience is limited
- I learned how to use 3D design software such as Solidworks
- I learned how to use multiple IC fabrication machines inside the clean room
- I learned how to use solder paste, stencils, and an oven to make a circuit board
- I learned how to interface with a Phidget Microcontroller

**5. Briefly share a practical application/end use of your research:**

My research was mainly focused on automating the testing systems that our group uses to test the devices which we research. My largest contribution was a stepper motor setup and control system that allows the settings of cryogenic cooling chamber we use to cool our devices to be accessed and modified from anywhere. This allows the cool down and warm up procedures to occur much more quickly. I also conducted multiple tests in the clean room that will be used to modify our fabrication process of devices with tunnel junctions.

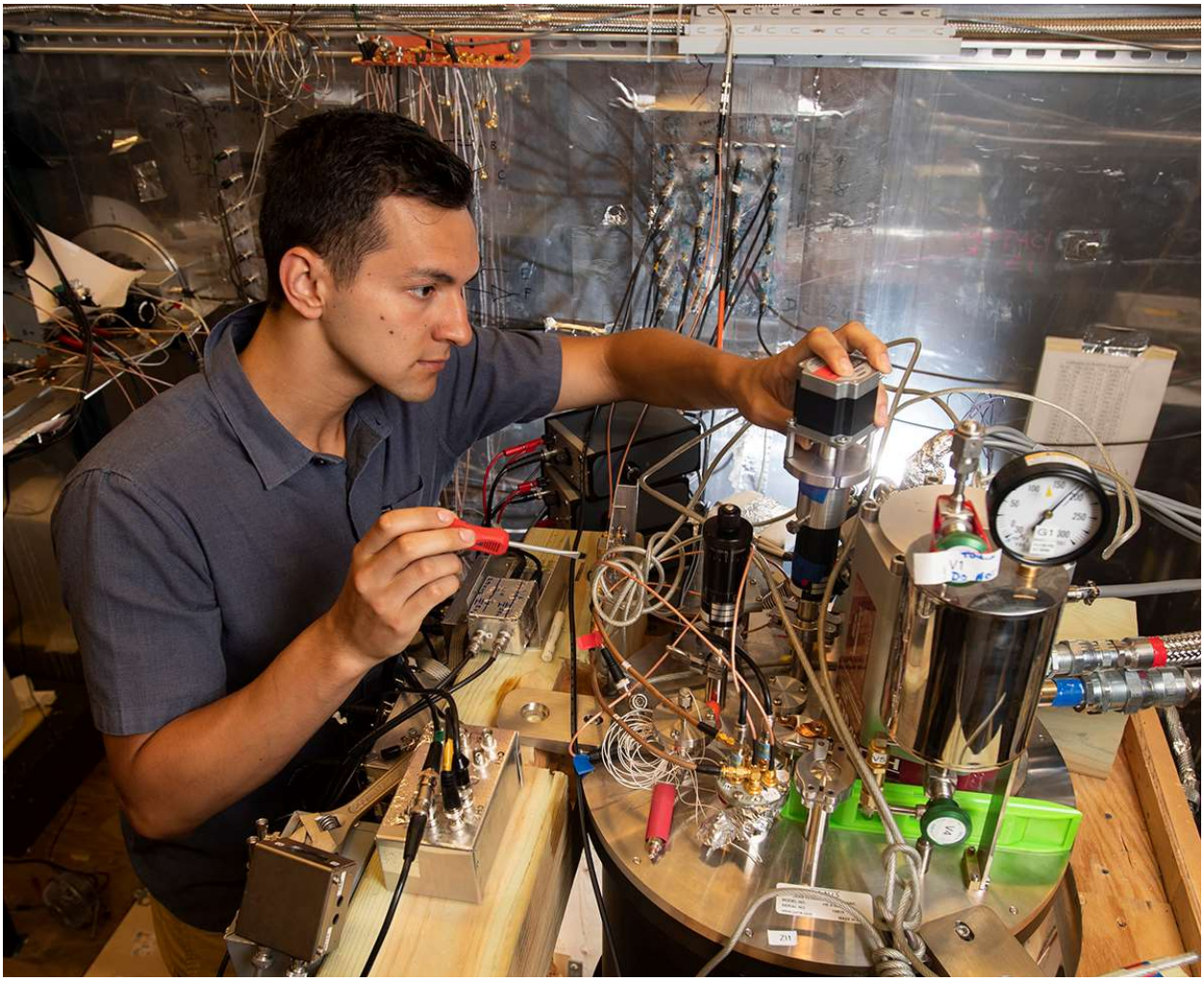
**6. 50- to 75-word abstract of your project:**

As the longevity of Moore's law is in question and limits on heat dissipation force design compromises, new options for computing must be explored. One promising model is molecular based computing, in which one of the first steps is to measure the movement of a single localized electron within a molecule. To do this, a highly sensitive electrometer, such as a modified single electron transistor, must be designed and tested. To facilitate the development of these electrometers, testing and fabrication systems must be optimized. First, testing time is cut down by converting a manual controlled thermal switch into a computer controlled system through the use of a stepper motor, sensors, microcontroller, and writing a program to interface with this system. Secondly, fabrication time is lessened by developing precise lithography, development, and wet etch steps used to make consistent undercuts needed in the Dolan Bridge Process used to make these electrometers.

**One-page project summary that describes problem, project goal and your activities / results:**

This summer, through the help of the Woodward's, my faculty mentors, and graduate student mentors, I have received a great undergraduate research experience I could not have gotten otherwise. Our project worked to measure the movement of an electron across a mixed-valence molecules for the purpose of one day creating molecular based computers. The most difficult problems countered in this project centered on testing, fabrication, and design. I was tasked to automate parts of our testing process in order to cut down testing time and to refine parts of our fabrication procedure in order to produce more consistent devices. First of all, to test these highly sensitive devices, a cryogenic chamber must be cooled down to 0.3 Kelvin and then heated back up afterwards. To do this the chamber uses multiple thermal switches which must be adjusted manually. My job was to automate this procedure so it could be done remotely and thus much more quickly. I used a stepper motor, network of sensors, and a microcontroller to successfully design a system in which the user can interface with a program to control the thermal switches. Additionally, I designed a mount for the stepper motor and sensors using computer aided design software. We then 3D printed this design and attached it to the thermal switch regulator it controls. Concurrently in the clean room, I ran tests to refine our procedure to create the delicate tunnel junctions that our electrometers need to work. This included testing the amount our wet etching agent needed to be diluted to slow down the etch rate and varying variables in the lithographic process of a specific photoresists in order to create a contrast curve for it. By the end of my research fellowship, I successfully accomplished all of these tasks, only lacking in that while an etch rate vs dilution curve was created for our etching agent, I was not able to run my final undercut test for varying dilutions due to unforeseen problems in setting up the experiment.

All in all, I am very grateful for my research fellowship this summer since this experience has allowed me to be exposed to many different kinds of amazing technologies and the research environment in general. This has helped me begin the process of narrowing down my career aspirations and finding what I am truly interested in. Also I have had the chance to get to know some amazing mentors including the Woodwards themselves and my faculty advisors, Gregory Snider and Alexei Orlov.



Working hard on the cryogenic cooler in the shield room of our lab