ND*nano* Undergraduate Research Fellowship (NURF)
2013 Project Summary

1) Student name: John O'Brien
2) Faculty mentor name: Dr. Gregory Snider
3) Project title: Ultra-low energy computation

4) Briefly describe any new skills you acquired during your summer research:

I have learned much more this summer than I would ever be able to write down in this report. My skill set as an electrical engineer has multiplied simply by the fact that I was able to work next to experienced and driven professors and graduate students. Specifically, I have gained many skills in the design, fabrication, and usage of printed circuit boards and integrated circuits. I have also been given my first opportunity to work in and experience a clean room environment.

5) Please briefly share a practical application/end use of your research:

The research that I participated in this summer is aimed at lowering the energy used to do a computation. The research focuses on a method of reversible computing that would lead to less heat dissipation in a device and therefore a reduction in the amount of energy used. If successful, the research would revolutionize the field of electronics as much less energy would be required to perform the same task.

Project summary:

My summer project surrounded an experimental set up that will be used to test a reversible computing circuit. The circuit, shown in Figure 1, uses a shift register along with transmission gates to do computations and then recycle the energy used by essentially moving the electrical charge back to the source. From Figure 1, one can see that the circuit consists of three inverters and five transmission gates. This circuit is carefully fabricated in a clean room environment through a series of general integrated circuit fabrication steps.

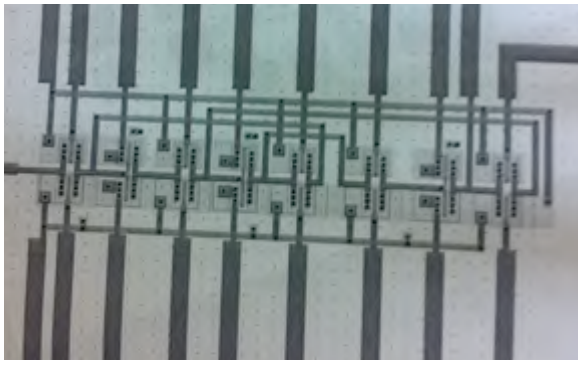

Figure 1. Reversible Computing Circuit

Once the circuit is printed onto a silicon wafer, we can apply signals to the pads that are shown in Figure 2. By doing this, we can control which gates are functioning and when they are

functioning. Much of the work of the experiment came from perfecting the signals that would be applied to these pads.

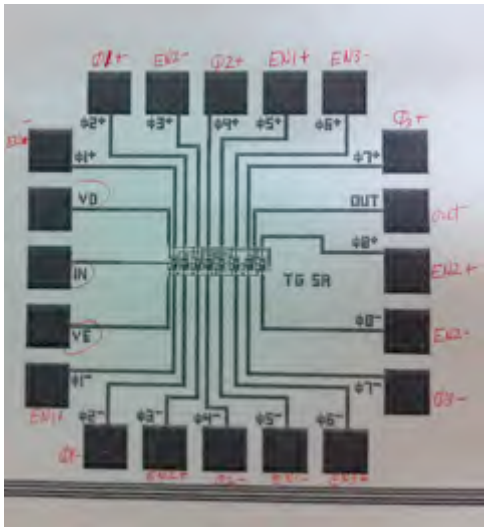

Figure 2. Application of Experimental Signals

The first step in the hardware part of the experimental set up was to manufacture a couple of kludge boxes. The first box that I created is shown in Figure 3. This box functions as a differential amplifier. Through the making of this box I gained valuable experience with transformers, voltage regulators, and PCBs.

Figure 3. Differential Amplifier Box

Besides the differential amplifier, I also designed a power supply circuit and an inverting circuit that uses NOR gates. Together, these boxes, along with seven function generators, a probing station, and a breakout box for the probing station, will be used to apply the correct signals to the reversible computing circuit and test the theories that the team has proposed. A picture of the complete experimental set up is shown in Figure 4.

Figure 4. Complete Experiment Set Up

Publications (papers/posters/presentations):