UNIVERSITY OF NOTRE DAME
NDnano
CENTER FOR NANO SCIENCE AND TECHNOLOGY

ND*nano* Undergraduate Research Fellowship (NURF)
2014 Project Summary

1. Student name: Robin M. Lawler

2. Faculty mentor name: Dr. Hsueh-Chia Chang (principal investigator), Dr. Zdenek Slouka (postdoctoral mentor)

3. Project title: Integrated Platform for Nucleic Acid Sensing

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

- EDC/NHS crosslinking chemistry to functionalize membrane with ssDNA probe
- Measurement of the sensing device's current/voltage profile
- Brightfield microscopy
- Experimental techniques for operating the integrated microfluidic device

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

This integrated pathogen-sensing platform offers a portable, affordable alternative to real-time PCR and DNA microarray which will revolutionize global diagnostics and environmental surveillance.

6. Begin two-paragraph project summary here (~ one type-written page) to describe problem and project goal and your activities / results:

Current methods of pathogen detection are cumbersome and costly. Real-time PCR units and DNA microarray equipment cost hundreds to thousands of dollars,[1,2] exhibit slow assay time,[3] and are difficult to transport. There is currently no realistic method for developing areas to monitor the spread of dengue, *E. coli,* and other prevalent diseases. Microfluidic biosensors are accurate and convenient diagnostic tools which will revolutionize healthcare through

their portability, quick assay time, and affordability. Our device weighs less than five grams, and its construction costs $2.00. It consists of three novel units: a pretreatment separator, a nucleic acid preconcentrator, and a sensor (Fig. 1). The separation technology uses an electric field to pass negatively-charged nucleic acids from lysed biological samples through agar gel. This process removes debris which may interfere with the assay. The preconcentration mechanism focuses the target around the detection region. The sensing mechanism involves single-stranded DNA (ssDNA) or microRNA hybridization to a functionalized membrane, thereby causing a measurable inversion of charge. Target ssDNA/RNA is detected within twenty minutes after loading into the sample reservoir.

My ND Nano project involved fabrication of sensors and testing of the integrated platform. To construct the sensors, immobilized membranes were functionalized with ssDNA/RNA probes for insertion into the chip. Meanwhile, the separation and preconcentration units were assayed using fluoresceinated nucleic acids. After inserting the sensor into the device, a baseline current/voltage (IV) curve was measured for reference (Fig. 2). A nontarget control was subsequently analyzed, resulting in a slight rightward shift of the curve due to nonspecific binding. A repeat of this experiment using the target ssDNA/RNA resulted in a more drastic rightward shift. Finally, a DNA/RNA-dehybridizing pH 13 wash resulted in a leftward shift, indicating the observed IV effects were indeed due to target detection.

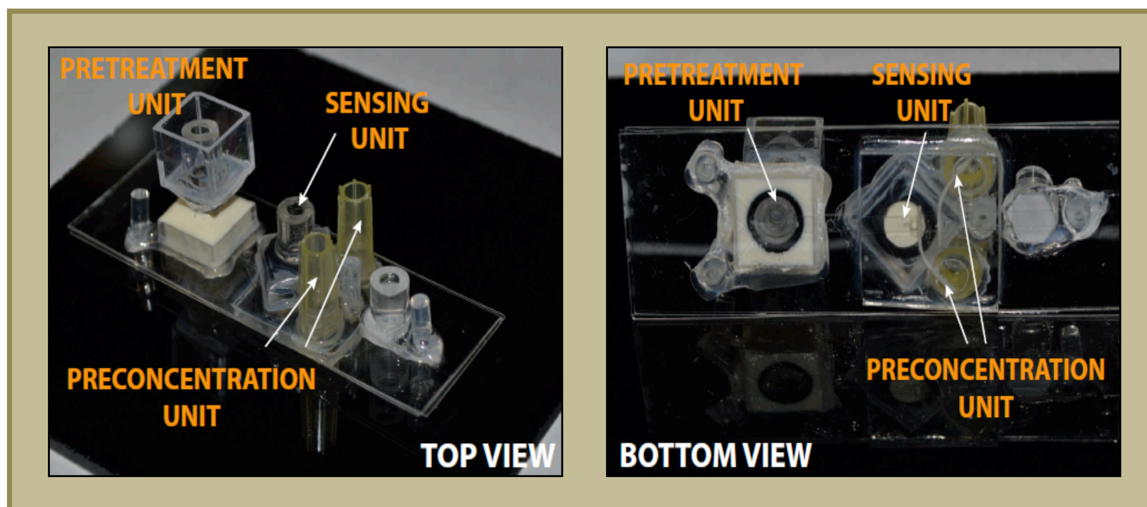

Figure 1: Integrated device.

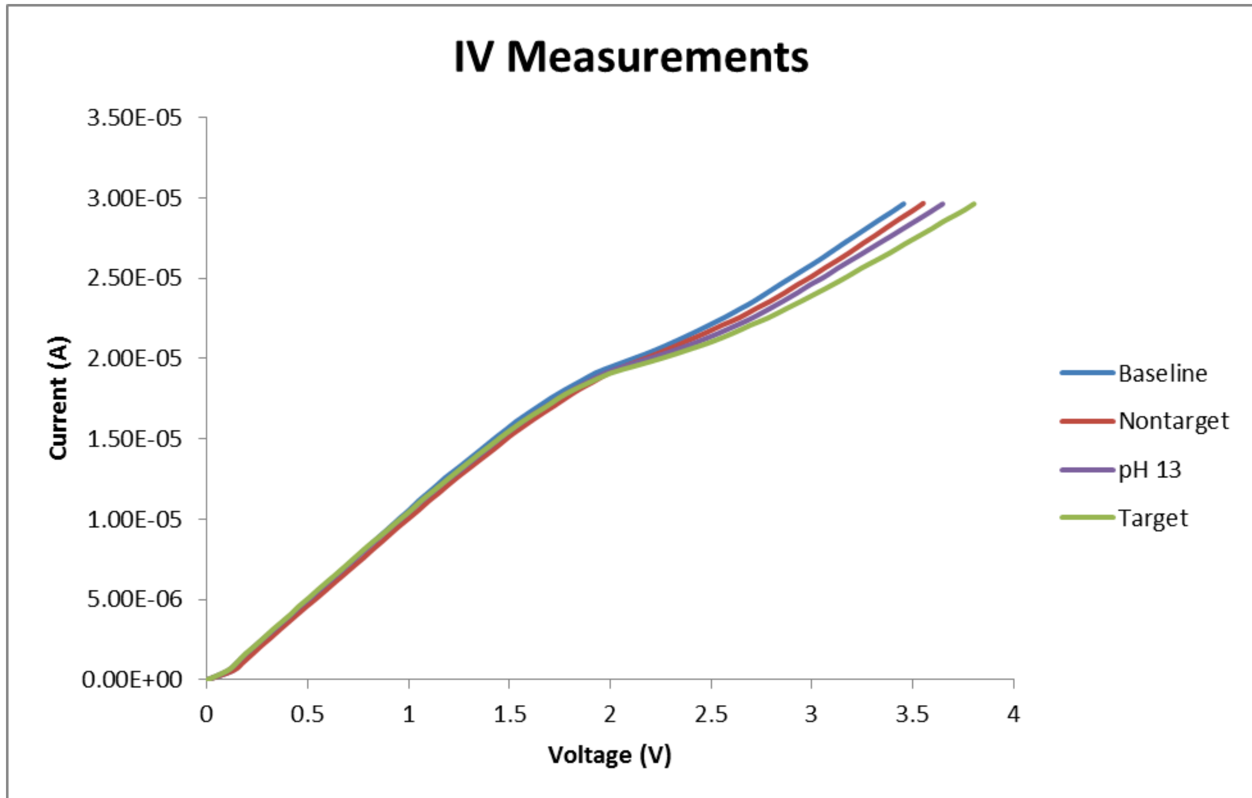

Figure 2: IV curves for baseline, nontarget assay, target assay, and pH 13 wash after target assay.

Sources:

1. "Printed Oligonucleotide DNA Analysis." Duke University DNA Microarray Center. 2004. Duke University Center for Applied Genomics and Technology. 30 Nov. 2013. <http://mgm.duke.edu/genome/dna_micro/core/spotted.htm>

2. Chang, Dr. Hsueh-Chia. E-mail interview. 24 Nov. 2013.

3. Senapati S, Basuray S, Slouka Z, Cheng L J, Chang H C. 2011. A Nanomembrane-Based Nucleic Acid Sensing Platform for Portable Diagnostics. Top Curr Chem. 304:153-169.