NDnano Undergraduate Research Fellowship (NURF)
2013 Project Summary

1) Student name: **Truong Pham**
2) Faculty mentor name: **Dr. Hsueh-Chia Chang**
3) Project title: **Photoactive Material for Biological Sensing**

4) Briefly describe any new skills you acquired during your summer research:
- Operate e-beam metal evaporator
- Use scanning electron microscope to characterize nanostructure
- Fabricate PDMS channel
- Use different electrochemical tests such as cyclic voltammetry and chronoamperometry to study properties of a semiconductor electrode

5) Please briefly share a practical application/end use of your research:
- Biosensing based on DNA's absorption of UV photons
- Potential biosensing based on DNA and other biomolecules' adsorption on the surface of titania

Project summary:

The development of inexpensive, sensitive and specific methods of detecting DNA in biological samples has always been an active research area in biomedical engineering. DNA, especially single-stranded DNA (ssDNA), absorbs light strongly in the UV region due to the nitrogenous bases present on this molecule. When two complementary ssDNA molecules hybridize, however, these bases are buried inside the newly-formed double-stranded molecule, and, as a result, decreases UV light absorption activity of the complex. This property has been widely employed in biology labs to study the dynamics of DNA denaturation (or hybridization). The goal for this summer research project is to use titania - a photoconductive oxide that also absorbs UV light - to develop a DNA sensing platform.

Poly-crystalline titania was deposited on and FTO electrode. A 3-electrode system, which consists of a working electrode (titania), counter electrode (Pt) and reference electrode (Ag-AgCl), was used to study the photochemistry of titania under 254-nm UV illumination (see this experiment configuration in figure 1). Electrochemical measurements were carried out by a Gamry potentiostat. In the first stage of this project, the UV-absorption effect of DNA on the system was studied. A hypothesis was made: because ssDNA molecules absorbs UV light, if they were placed in the solution between titania and the light source, they would absorb UV photons, thus decreasing the photocurrent in titania (figure 2). The experimental results supported this hypothesis: as the concentration of DNA increased, the photocurrent decreased (figure 3). The lowest concentration of DNA that caused a significant decrease in photocurrent was 1 uM. It was expected that the sensitivity would go up if the illumination area were made smaller.

In the second part of this research, the effect of DNA adsorption on the surface of titania was studied, for it can potentially affect the sensing mechanism. DNA was incubated in a PDMS resevoir placed above titania overnight. The electrochemical current was found to increase as a result. Chronoamperometry test result also seemed to support this behavior. Nevetherless, more tests need to be done to make sure this increase in current is solely due to DNA, since the presence of ions generated from previous trials can also increase the overall current. Long, careful washing of the reservoir is the key to experimental reliability.

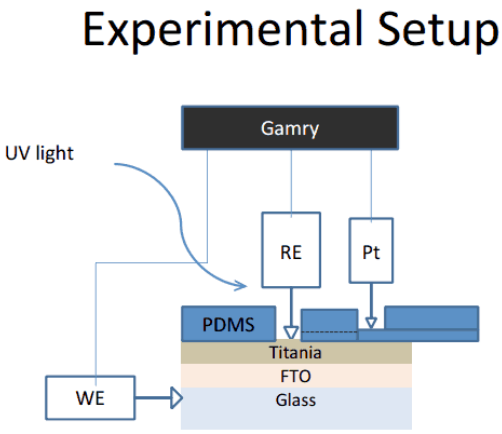

Figure 1: The 3-electrode system

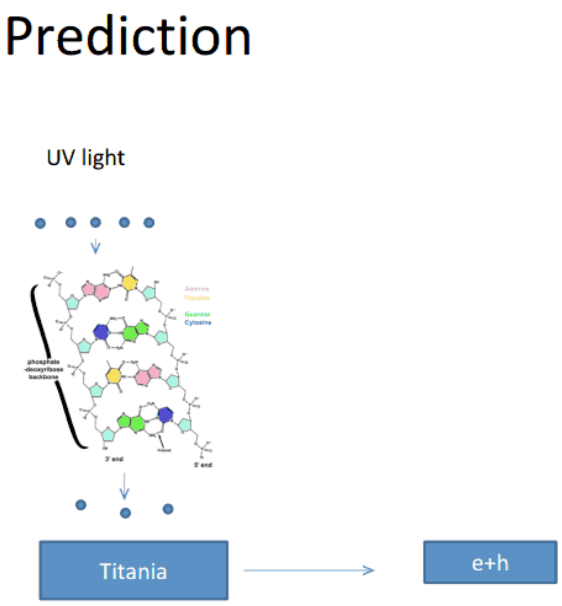

Figure 2: UV-absorption effect of ssDNA

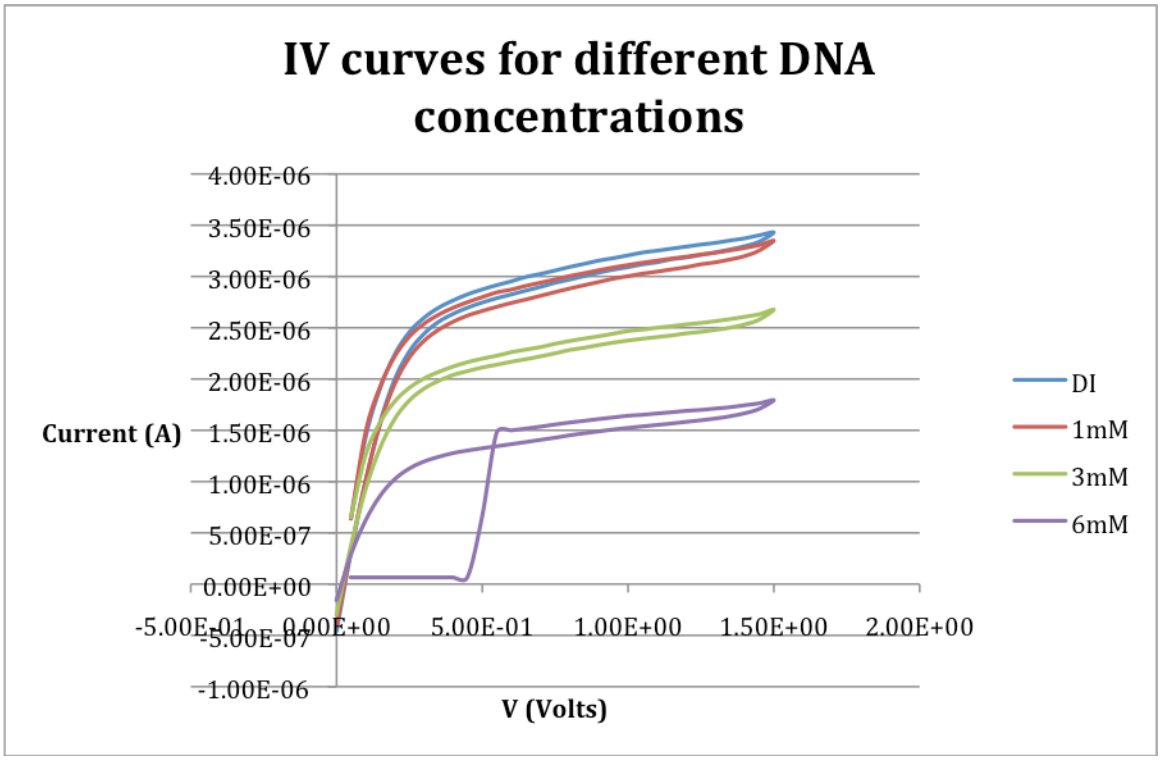

Figure 3: Photocurrent decreases with concentration of DNA