

## **NDnano Undergraduate Research Fellowship (NURF) 2013 Project Summary**

- 1) Student name: *Jack Weisenberger*
- 2) Faculty mentor name: *Prof. Grace Xing, Prof. Vladimir Protasenko*
- 3) Project title: *Plasmons in Semiconductors and what they can do for us*
  
- 4) Briefly describe any new skills you acquired during your summer research: *I became very familiar in operating Raman spectroscopy measurements and atomic force microscopy scans (AFM). I learned how to operate lasers through different lenses at the same time and enhanced my software skills necessary for carrying out and manipulating the data to produce the clearest results.*
  
- 5) Please briefly share a practical application/end use of your research: *We have various applications for the experiments we ran. By developing our method for tip-enhanced Raman scattering (TERS), we were able to provide a procedure for future TERS experiments and a template to compare future results. Also, examining characteristics of pressure strained MoS<sub>2</sub> monolayer flakes gives us new insight as to how this material can be used in future electronic devices. More knowledge of these materials electronic properties gives better perspective on how to create the most efficient semiconductor devices.*

*Our goal this summer is to examine various characteristics of 2-dimensional electronic materials. I spent most of my time on two projects: Raman characterization of pressure strained MoS<sub>2</sub> flakes, and the observation of tip-enhanced Raman scattering (TERS) of carbon nanotubes using a silver coated silicon AFM tip. The goal of the pressure strain experiment was to observe a shift and/or splitting of specific Raman peak properties of single layer and bulk layer MoS<sub>2</sub>. For the TERS experiment, we expected to see a strongly enhanced Raman peak of carbon nanotubes when we used a silicon AFM tip coated with silver. Our goal was that from this enhancement we could accurately correlate a Raman scan image with its corresponding AFM mapping.*

*For the MoS<sub>2</sub> measurements, we used a custom built pressurizing chamber to induce a deflection in polyimide with single-layer MoS<sub>2</sub> flakes embedded. We observed a shift to the left of for both the interested Raman peaks as we increased the strain of the film, as expected. Both single layer and bulk layer flakes showed the same response to deflection as predicted in theory.*

*For the tip-enhanced Raman scattering experiment, we observed a small but noticeable enhancement in Raman signal when we used a silver coated silicon tip. However, over time we found the silver oxidized and failed to produce any significant enhancement of the carbon nanotube peaks, so our developed method only works with a tip freshly coated with silver. This is inconvenient for practical use, as Raman scan images did not correlate to the AFM mapping as strongly as we desired.*

*I was also a part in other, smaller experiments. These include characterizing GaN samples grown in different isotopes of Nitrogen, Raman enhancement of R6g using gold fiber tips, and characterizing MoSe<sub>2</sub> samples grown at different temperatures and on different substrates (such as sapphire and AlN).*

Photos:

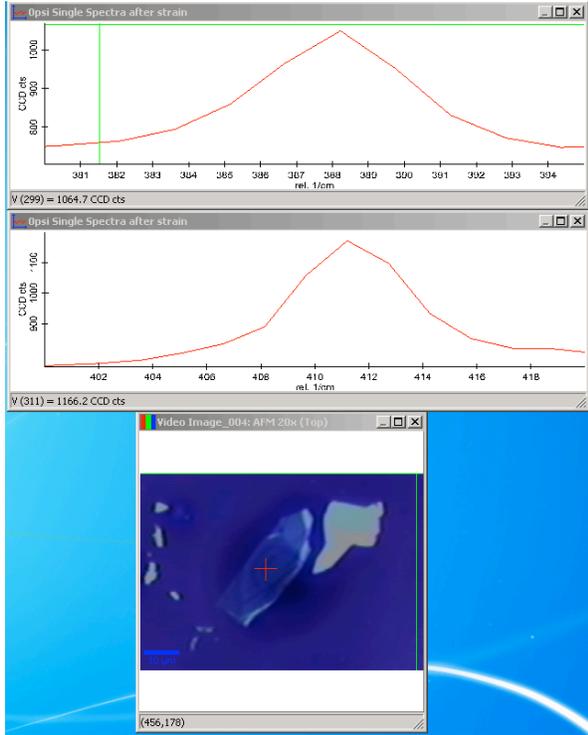


Figure 1: Raman Peak positions and MoS<sub>2</sub> flake

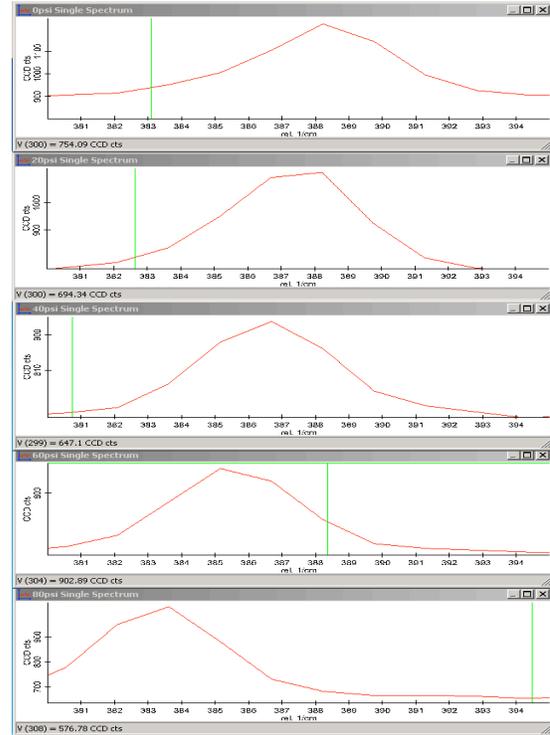


Figure 2: Raman peak shift under pressure strain

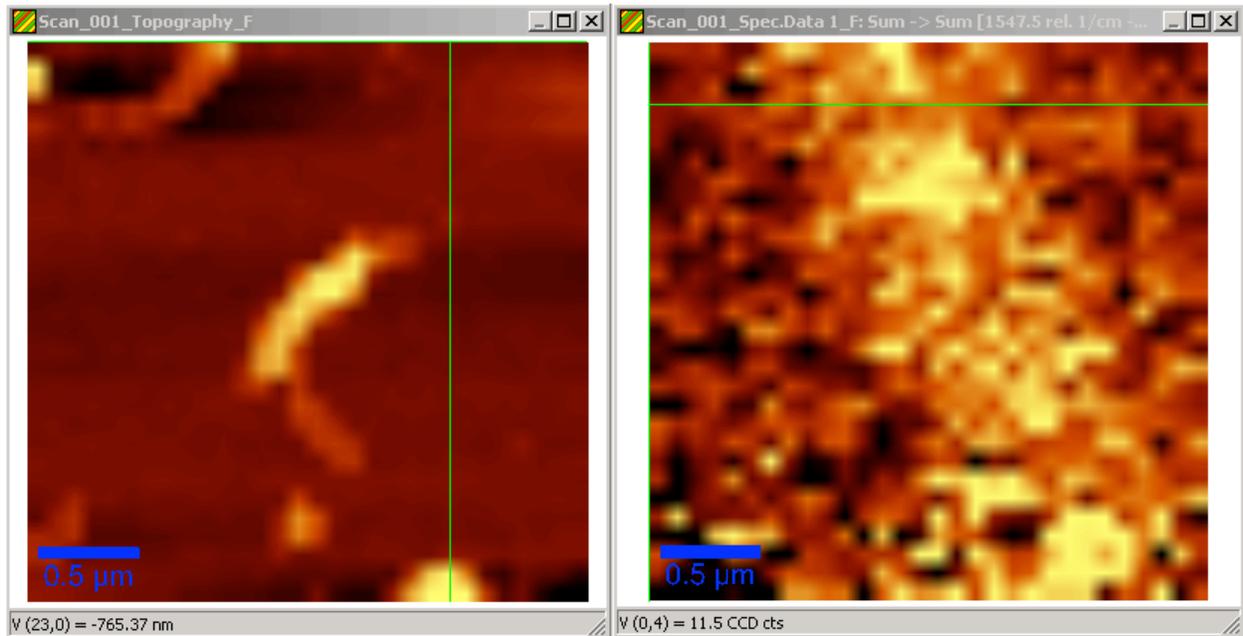


Figure 3: AFM (left) and Raman scan (right) images