4-2016

Fabrication and Characterization of Layered Transition Metal Dichalcogenides

Peter Kosch
University of Nebraska-Lincoln, peter.kosch72@gmail.com

Zhiyong Xiao
University of Nebraska-Lincoln, zxiao2@unl.edu

Xia Hong
University of Nebraska–Lincoln, xhong2@unl.edu

Fabrication and Characterization of Layered Transition Metal Dichalcogenides

Peter Kosch, Zhiyong Xiao, Dr. Xia Hong
•[1]Department of Physics and Astronomy, The University of Nebraska-Lincoln, NE 68588
•[2]Nebraska Center for Materials and Nanoscience, University of Nebraska-Lincoln, NE 68588

Research Goal

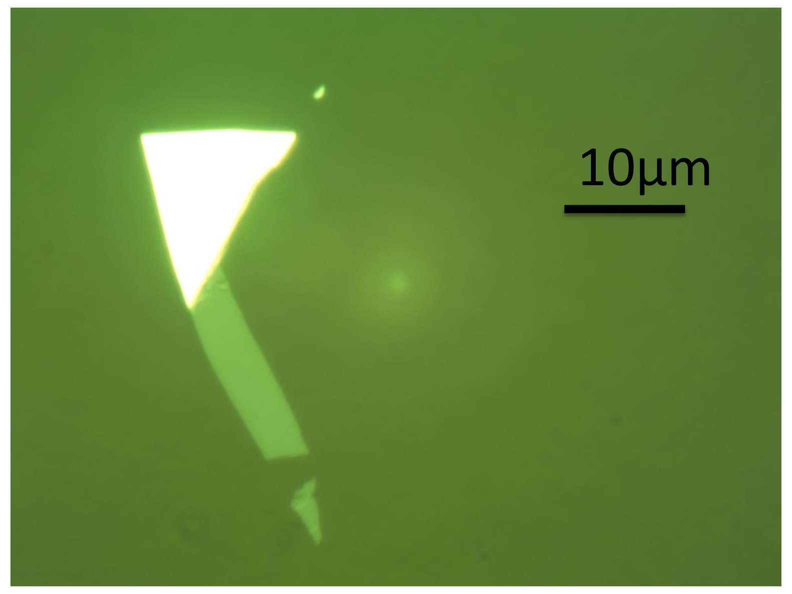
The goal of my research was to mechanically exfoliate single to few atomic layer samples of Molybdenum Disulfide (MoS_2), Tungsten Diselenide (WSe_2), and Tungsten Disulfide (WS_2) and characterize these 2D materials by multiple methods. I used Atomic Force Microscopy, Raman Spectroscopy, and Optical Microscopy to accomplish this. In addition, I measured the electrical properties of the exfoliated materials by fabricating a device and taking basic measurements.

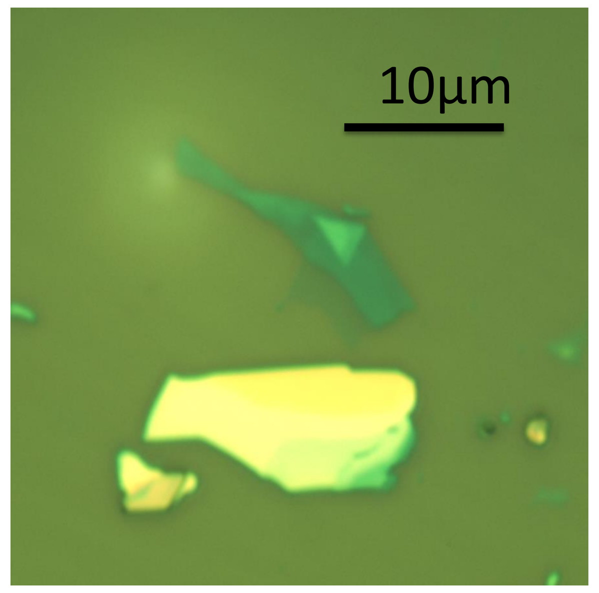
Material Preparation

Mechanical Exfoliation – Scotch Tape Method

- High quality samples are produced by adhering a bulk crystal of the desired material to a piece of scotch tape. It is then repeatedly stuck together until a fine coating of the material covers the entire face of the tape. This tape is pressed and gently rubbed against a silicon oxide (SiO_2) substrate.
- Optical Microscopy is used to locate the samples on the SiO_2 substrate.

Results:

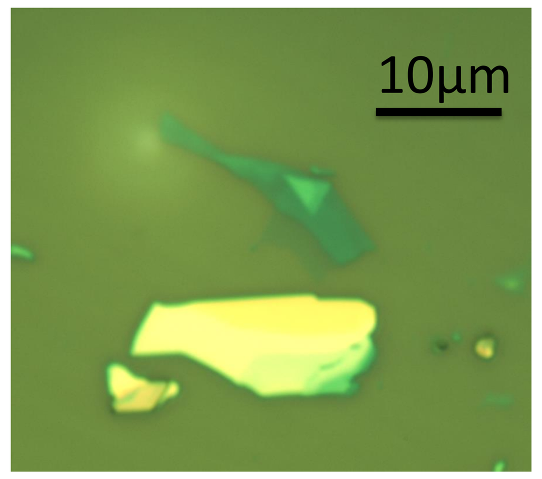




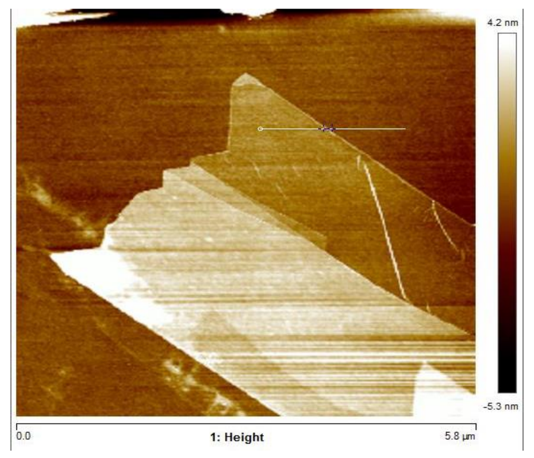
Atomic Force Microscopy (AFM)

- AFM is used to measure a number of physical properties of the sample, most notably the thickness. This is achieved by scanning a very fine tip over the sample and measuring the deflection of the cantilever as it moves across.

Optical Image



AFM Image

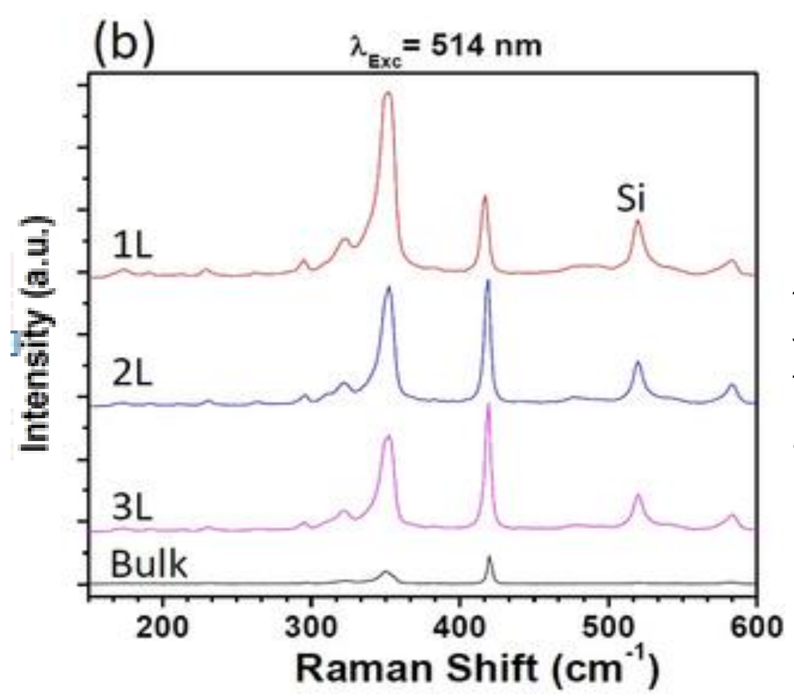


- Sample thickness is measured to be ~2.5nm (shown below)

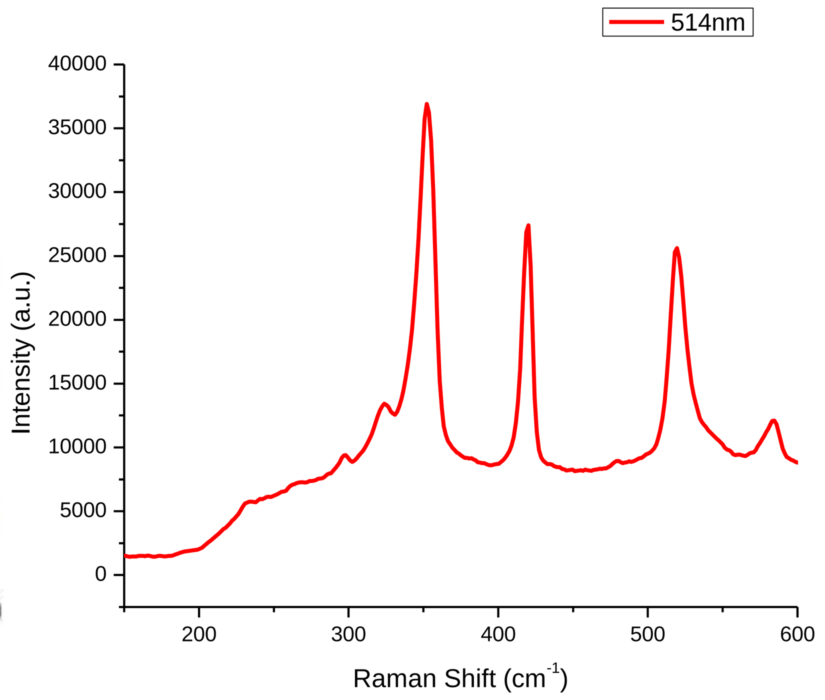
Raman Spectroscopy

- Raman Spectroscopy is carried out by using a laser to excite electrons in the target substance and measure the vibrational modes.
- Vibrational modes are unique to each material and can be used to identify both the thickness and chemical makeup of that material.

Reference Data



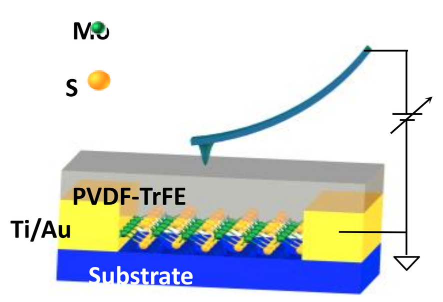
Measured Raman Data



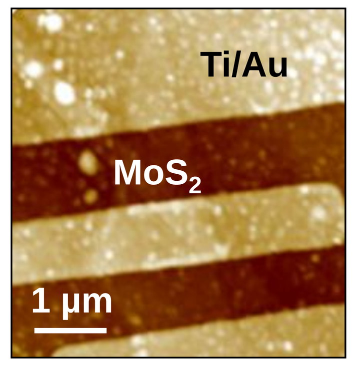
Device Fabrication and Measurements

- I designed my device using L-Edit Software, and it was fabricated by the process of electron beam lithography.

3D Sketch of Device



AFM Image of Device



- Measurements were taken using a Keithley 2400 and Physical Property Measurement System (PPMS)

Conclusions

- I successfully learned how to exfoliate materials, design devices, and perform meaningful measurements using the Keithley 2400 and PPMS.
- With the help of my mentor, I observed the process of electron beam lithography in the NCMN cleanroom.
- The results from this research suggest interesting effects could be observed if multiple layers of varying dichalcogenides are exfoliated on top of one another and then measured with a device.

References and Acknowledgements

Xiao, et. al. Programmable Schottky Junctions Based on Ferroelectric Gated MoS2 Transistors.

Berkdemir, et al. Identification of individual and few layers of WS_2 using Raman Spectroscopy.

UNL UCARE