Transfer Process with 2D Transitional Metal Dichalcogenides Materials

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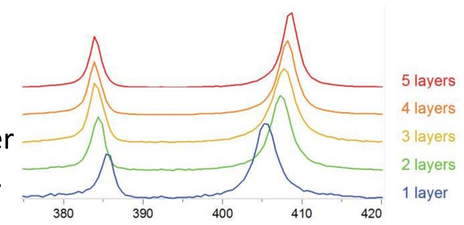
Project Objectives

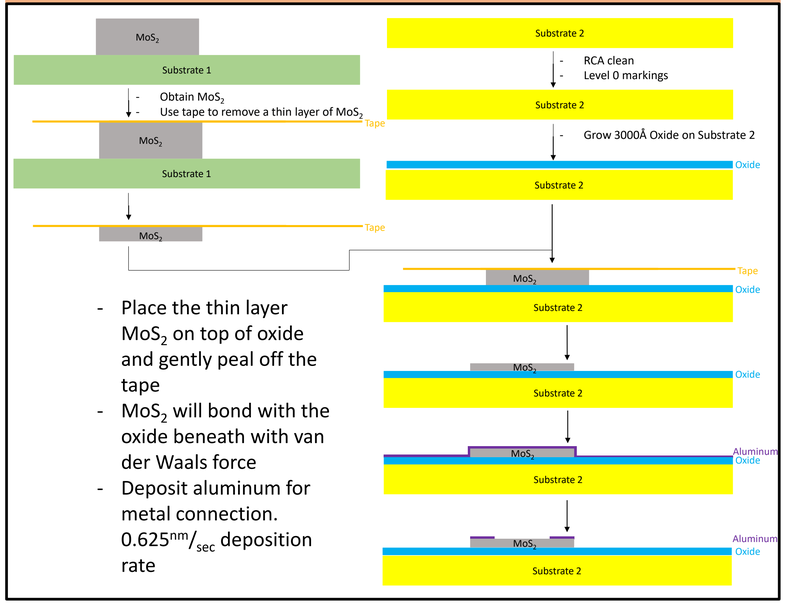
This project is to expand RIT's knowledge on non-traditional 2D materials and to develop a tape-transfer process for single to double atomic layers of Molybdenum Disulfide from a substrate containing bulk MoS_2 to a blank substrate. The exfoliated materials will be inspected and characterized through both optical microscope and Raman Spectroscopy. The ultimate goal is to build it into devices to conduct electrical testing for its material and electrical properties. Material and electrical properties of the exfoliated materials will further be investigated and compared to MedeA simulation results.

Introduction

Transitional Metal Dichalcogenides (TMD) consists of transitional metal M groups 4, 5, 6, and 7 and chalcogen Q group 16. General chemical formula is MQ_2. It is still currently under research stage. However the material has a great potential for its flexible and printable material properties to replace organic semiconductors and even graphene. The figure demonstrates peak difference in Raman Shift as the atomic layer increases or decreases.



Process Schematic



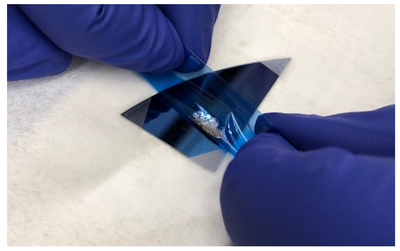
- Place the thin layer MoS_2 on top of oxide and gently peal off the tape
- MoS_2 will bond with the oxide beneath with van der Waals force
- Deposit aluminum for metal connection. $0.625^{nm}/_{sec}$ deposition rate

Tape Transfer Process and Result

Due to the immature state of CVD process to obtain monolayer materials, tape transfer seemed to be the most feasible method to obtain single atomic layer material.

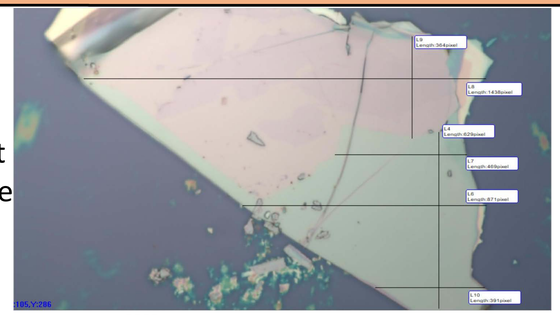
A sample of single crystal MoS_2 supplied from SPI.

Secure the sample on glass slide with Kapton tape.

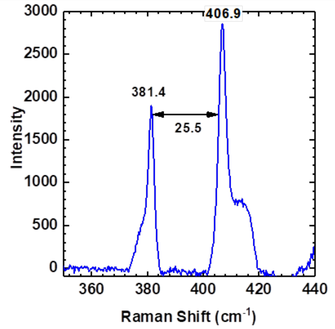


MoS_2 Monolayer

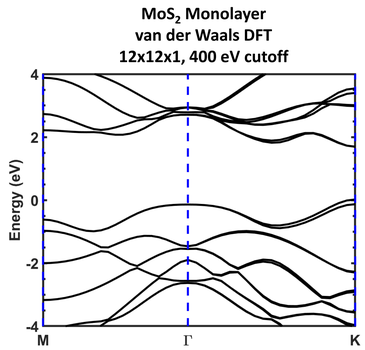
Gently peal off the material to complete exfoliation process. The van der Waals force will keep the material on the transferred substrate.

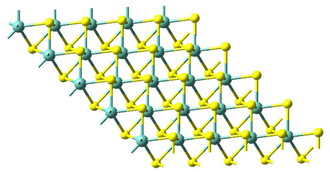


A preliminary visual check on the transferred material for its location, dimension as well as the result of exfoliation.

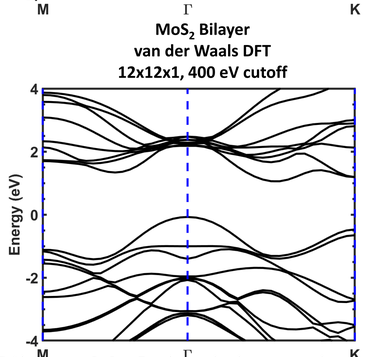


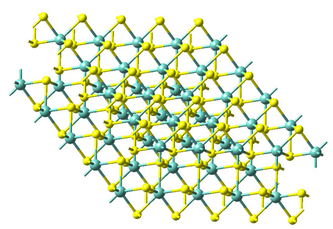
The Raman spectrum has two peaks, in plane (E_{2g}) located around $383cm^{-1}$ and out-of-plane (A_{1g}) located around $407cm^{-1}$. Typical monolayer MoS_2 has a peak difference in Raman shift around $22cm^{-1}$ to $23cm^{-1}$.





Monolayer MoS_2 simulated through VASP simulation with P6m2 space group orientation.





Bilayer MoS_2 both layers bonded together with van der Waals force. Simulated through VASP simulation with P63mm3 space group orientation. Similar band structure comparing to mono-layer but with few extra bands. Splitting can be observed due to new energy level created.

Conclusions

The tape transfer result were proved to be promising. Achieving for a bi-layer transfer is possible and a mono-layer exfoliation is also doable but with restriction on the inspection tool, a mono-layer transfer can only be assumed by visual inspection.

Future Work

To build a working device through exfoliated materials to conduct electrical testing for its material and electrical properties and to confirm the simulation results.

References

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