Chemical Vapor Deposition of Atomically Thin Films of MoS2 for Electro-Optical Devices

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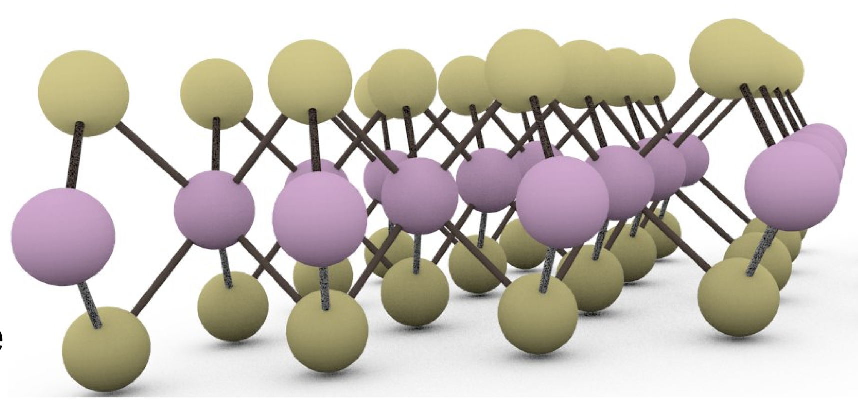
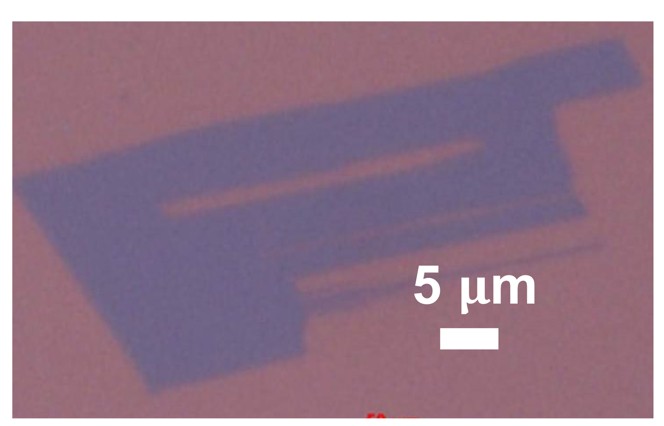
INTRODUCTION

Monolayer MoS_2, like graphene, is a molecularly thick, two dimensional material that has promising electrical, mechanical, and optical properties. These properties will allow mono- and few layer MoS_2 to be used in the creation of electronic, optoelectronic, and MEMS devices. A main obstacle to the adoption of MoS_2 devices is an inability to produce large scale, uniform films.



Why Chemical Vapor Deposition (CVD)?

Mechanical exfoliation yields MoS_2 flakes of high quality but small area, while CVD films cover several square centimeters.

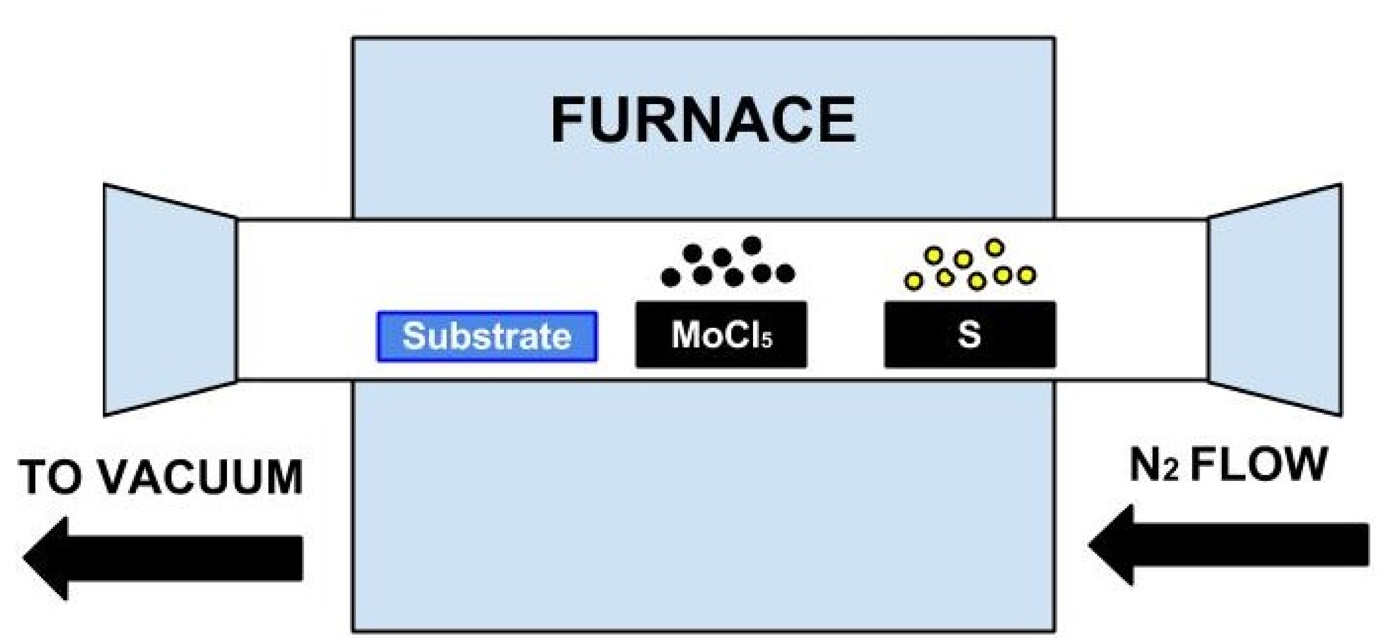


Right: Large Exfoliated Flake < 50 µm in length

The CVD Method:

Following the work of Yu et al.[1] :

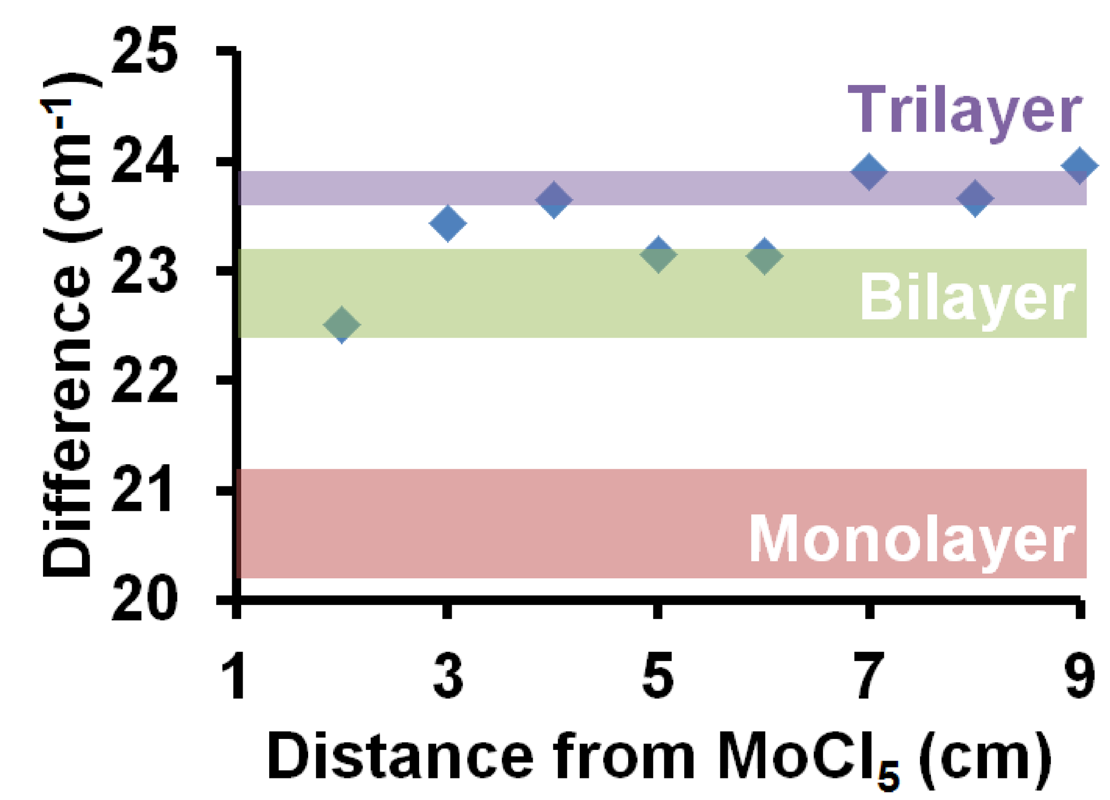
- Materials are loaded
- System is placed under vacuum
- N2 is introduced at a rate of 50 sccm
- Furnace vaporizes precursor substances
- Precursors form gaseous MoS2
- A film of MoS2 forms on the substrate



RESULTS

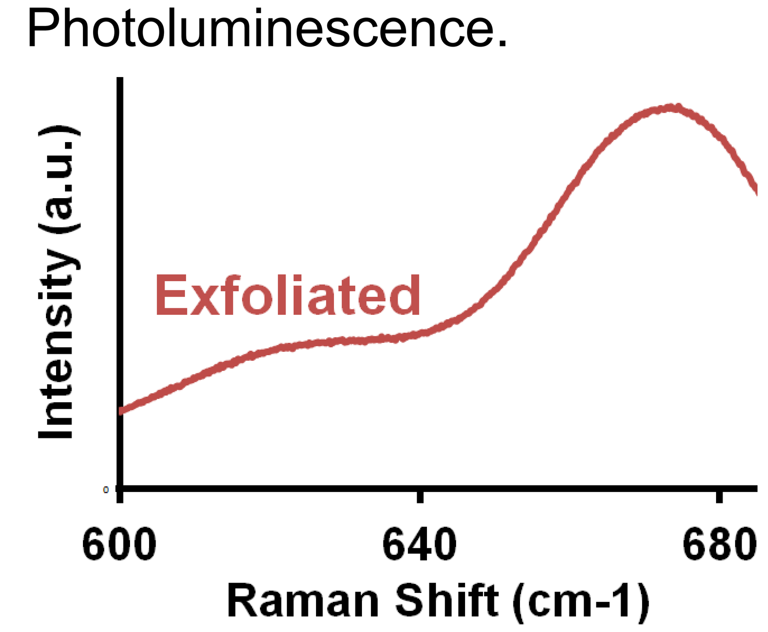
Uniformity

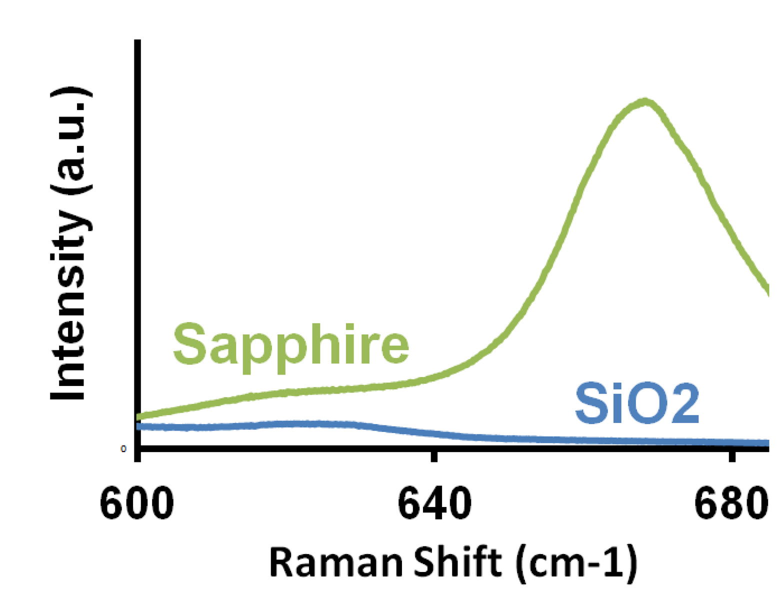
A crucial measure of film quality is how uniform the growth is over a large area. By probing the Raman spectra, which is a sensitive probe to the thickness of the MoS_2 films, on substrates placed at various locations inside our furnace we can obtain uniform layer thicknesses over distances **greater than 8 cm**.



Photoluminescence (PL)

In order for CVD films to be useful for electro-optical device creation, the characteristics of these films must be comparable to those of exfoliated flakes. This is especially true of Photoluminescence.

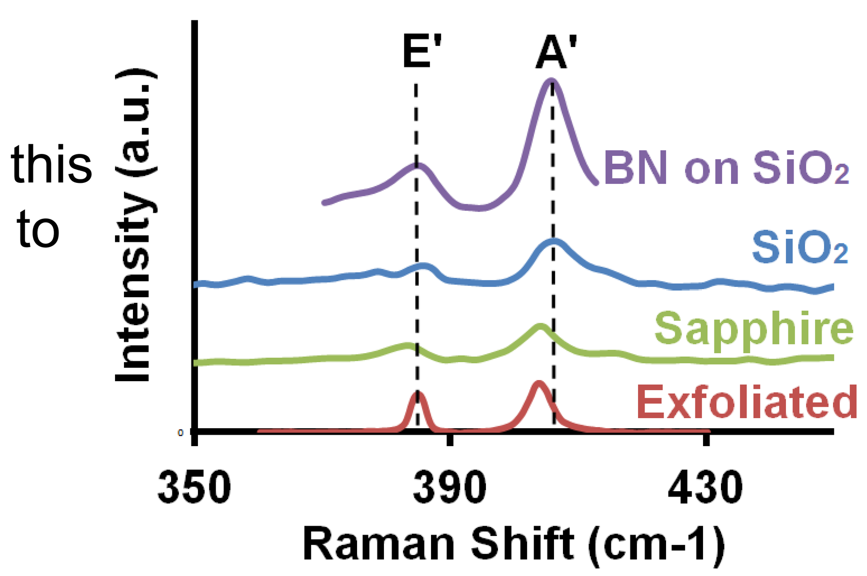




Films grown on clean crystalline Sapphire produced a much stronger PL signal than ones grown on SiO_2, however these signals are still weaker than those from exfoliated flakes.

Substrate Variety

By observing the Raman peaks, we have determined this growth method can be used to create films on a variety of substrates with reasonable similarity to their exfoliated counterparts.



CONCLUSION

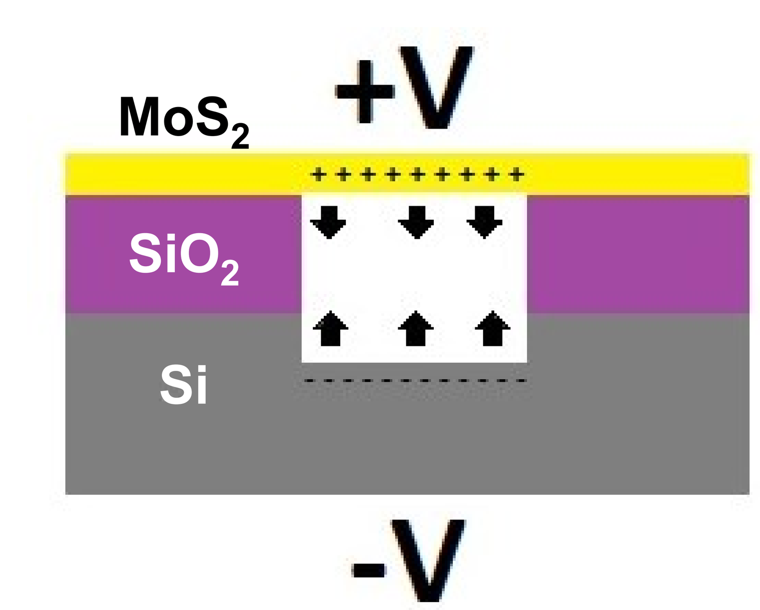
Analysis

The CVD method…

- Produces large, uniform films
- Creates films with PL spectra with peaks similar to exfoliated flakes but a weaker signal
- Works with a variety of substrates including: Sapphire, Quartz, SiO_2, and BN film on SiO_2

Next Steps

Our present goal is to transfer these films onto a substrate containing microcavities. By applying a gate voltage to the substrate we will be able to deflect the membrane inward. This design will allow us to create electro-optical devices with tunable strain and, therefore, tunable band gap energy[2].



[1]Yu, Y., Li, C., Liu, Y., Su, L., Zhang, Y., & Cao, L. (2013). Controlled Scalable Synthesis of Uniform, High-Quality Monolayer and Few-layer MoS2 Films. *Scientific reports*, *3*, 1866. doi:10.1038/srep01866
[2]Conley, H. J., Wang, B., Ziegler, J. I., Jr, R. F. H., Pantelides, S. T., & Bolotin, K. I. (n.d.). Bandgap Engineering of Strained Monolayer and Bilayer MoS 2, 1–4.