Growth Mechanism of Atom-Thin MoS_2 by CVD Method

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Abstract

2D materials, which are usually between one and a few atomic layers thick, possess many novel properties due to dimensional confinements. Because of their extreme thickness, they could potentially revolutionize many industries, including consumer electronics. However, finding a controllable and scalable synthesis method has been challenging.

This research investigated several of the factors influencing the chemical vapor deposition (CVD) synthesis method of atomically thin molybdenum disulfide (MoS_2, a 2D transition metal compound with semi-conducting properties).

It was found that the granularity of the prepared MoO_3 precursor materially impacted the synthesis of MoS_2. Additionally, changes to the flow rate during the 'growth' and cool-down stages altered the shape of the synthesized MoS_2 layers.

Method and Parameters

Furnace Setup

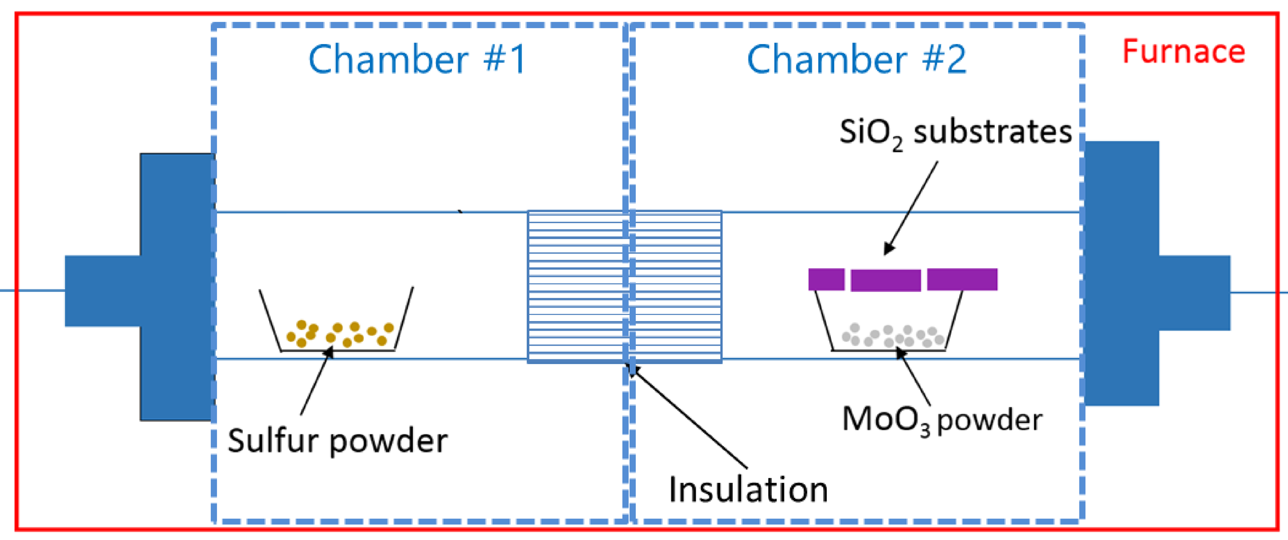

Fig 1 Furnace diagram with reactants in separate insulated chambers to allow different temperature settings

Furnace Temperature

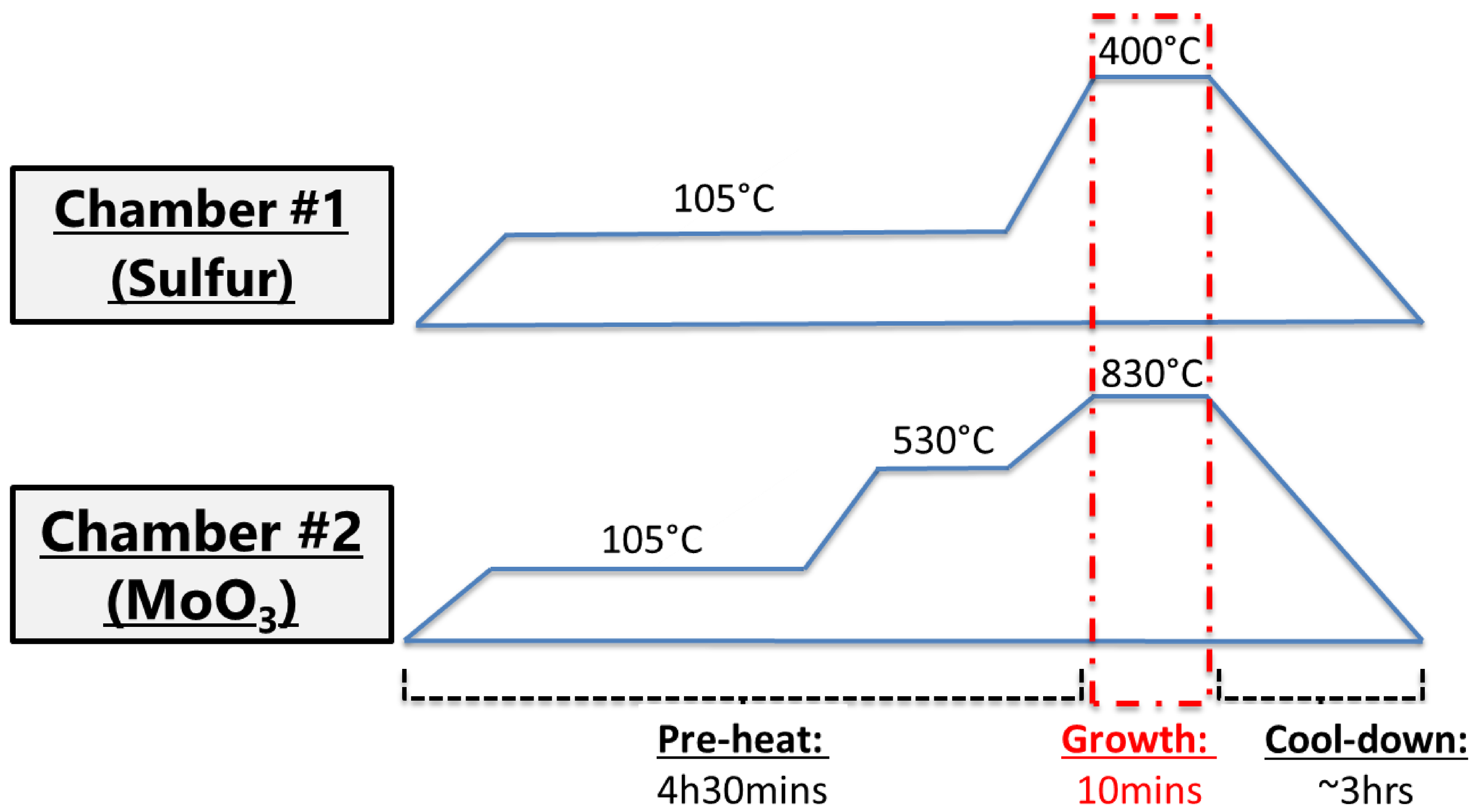

Fig 2 Optimal temperature program by chamber

Theory

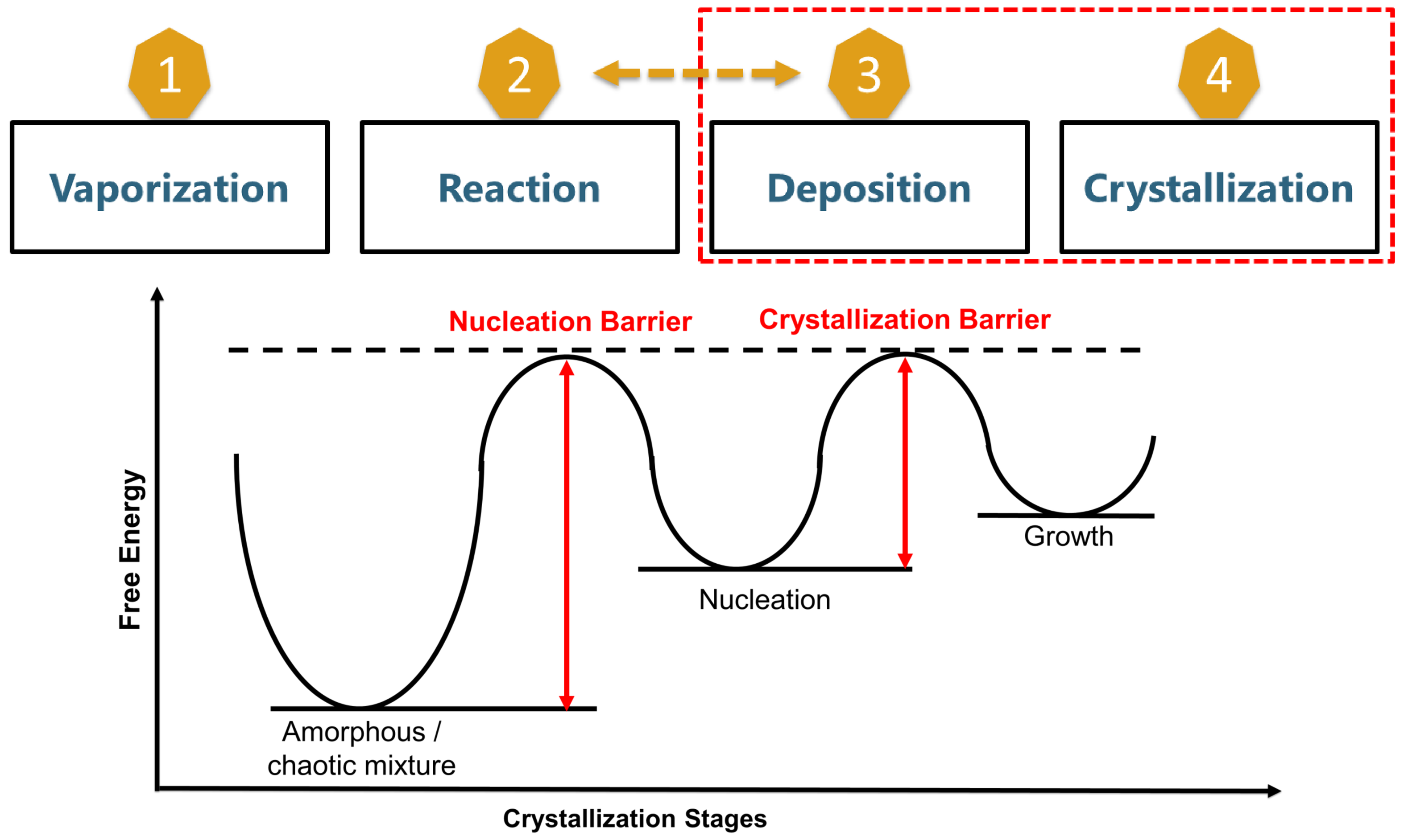

Fig 3 Energy landscape of the crystallization process

Results

Precursor's Properties

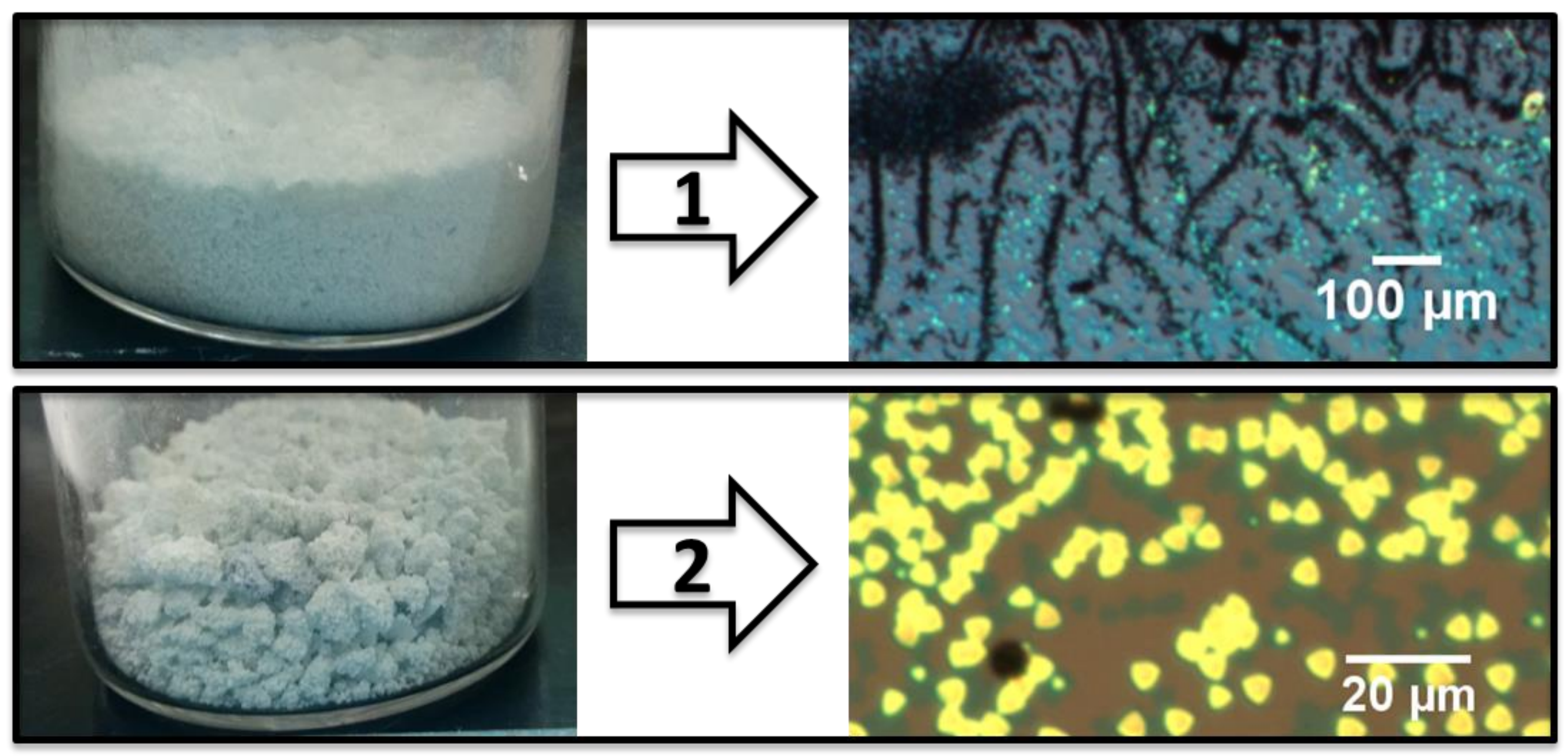

Fig 4 (1) Unreacted MoO_3 precursor deposition (black) (2) Multiple layer MoS_2 growth (yellow)

Carrier Gas Flow Rate

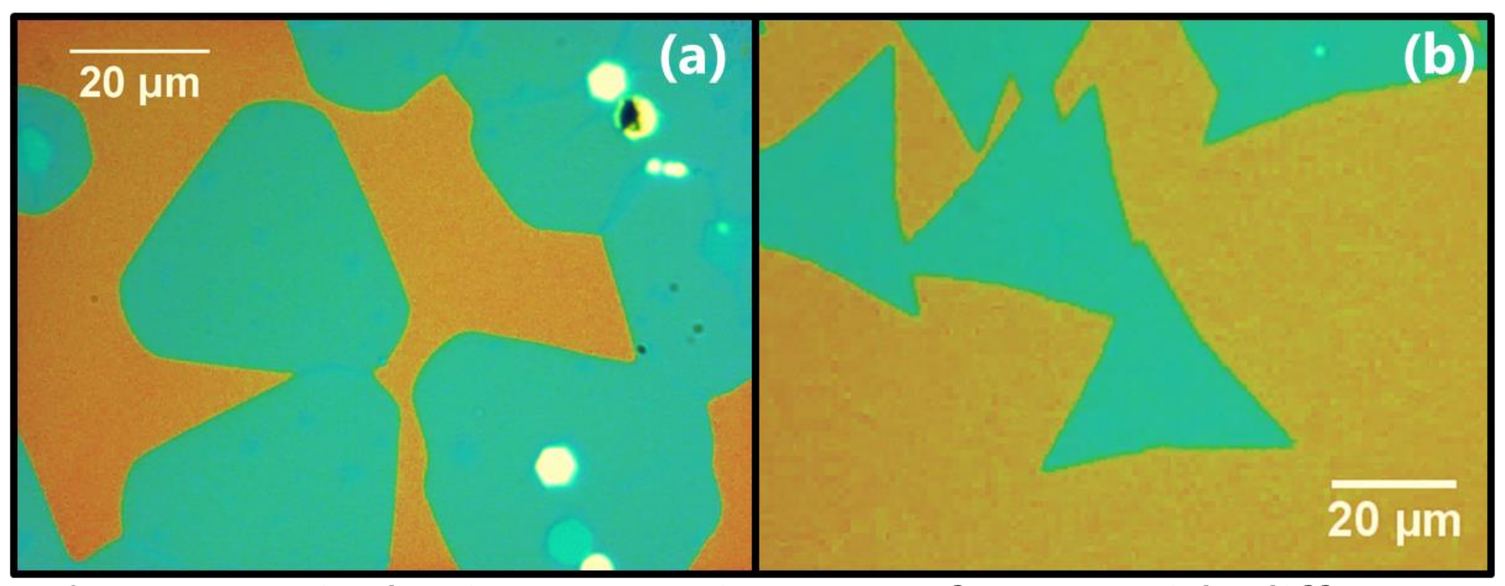

Fig 5 Optical microscope images of MoS_2 with different Nitrogen flow rates: (a) 1.05 sccm, (b) 20 sccm

Characterization

Physical Properties

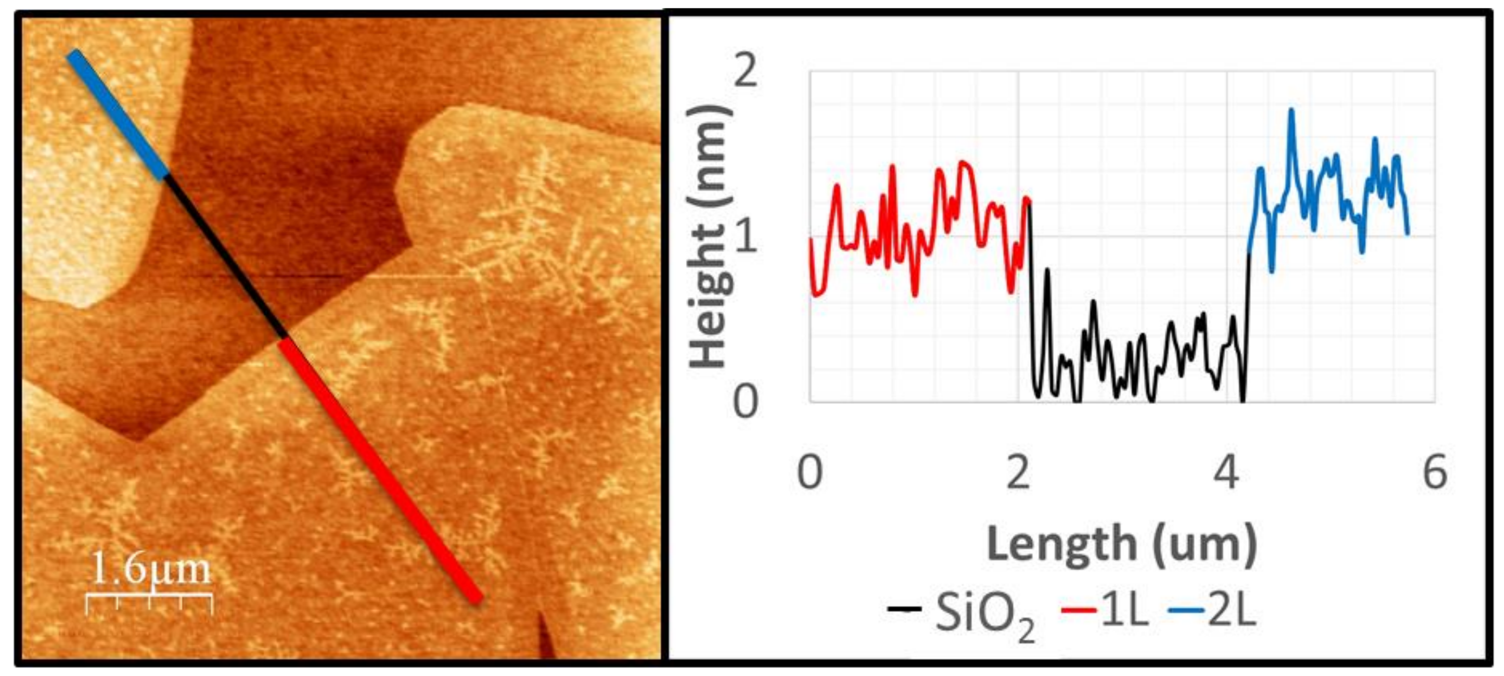

Fig 6 AFM image and height profile of mono-layer MoS_2 (1L) and double-layer MoS_2 (2L)

Photo-Electrical Properties

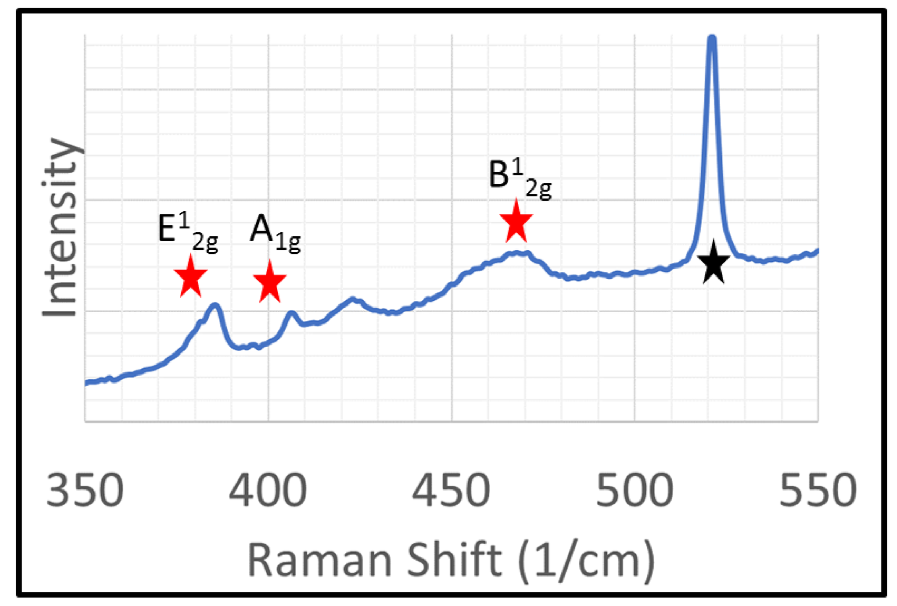

Fig 7 MoS_2 peaks (red), Silicon peaks (black) using a 633nm excitation laser

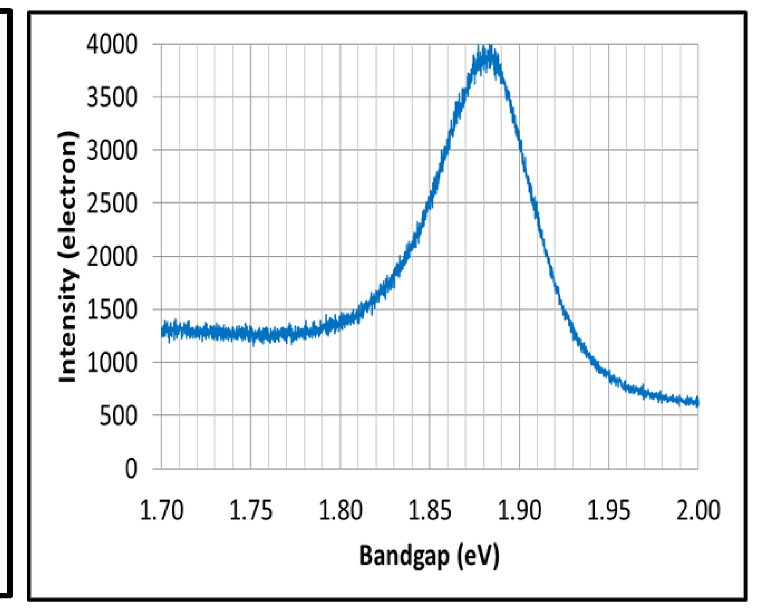

Fig 8 MoS_2 optical bandgap at 1.89 eV

Future Work

- Investigate additional MoS_2 CVD growth parameters
- Synthesize hetero-structure based on MoS_2 (CoS_2 + MoS_2), and investigate their electrical and physical properties
- Synthesize larger and more uniform MoS_2 layers

References and Acknowledgment

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