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Optimization of Growth Parameters of WS₂ Synthesis: Effects on Crystallinity and Optical Properties

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Introduction

- Graphene (monolayer carbon) has stimulated a lot of interest in 2D materials
 - Graphene is a zero band gap material
- TMDs are 2D materials that can be semiconducting, metallic, superconducting, etc.

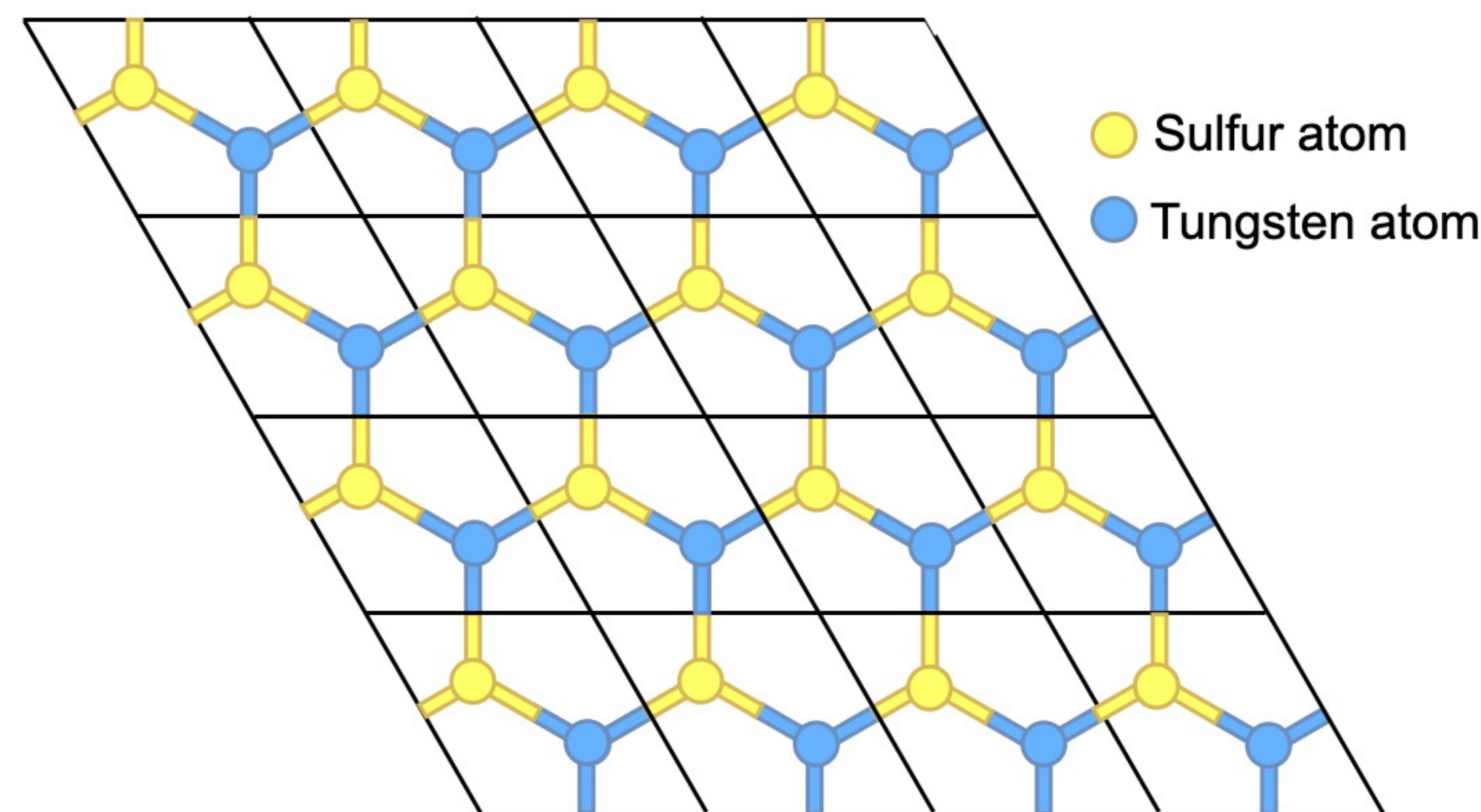


Figure 1. Arrangement of atoms in WS₂ as viewed from above. It is a layered structure, arranged in a sandwich S-W-S fashion.

Background

- Physical properties change when thickness of a semiconducting TMD (sTMD) is reduced to few-layer or monolayer¹
 - Indirect to direct band gap from bulk to monolayer²
- sTMDs have applications in optoelectronic devices such as solar cells³, phototransistors⁴, and gas sensors⁵.

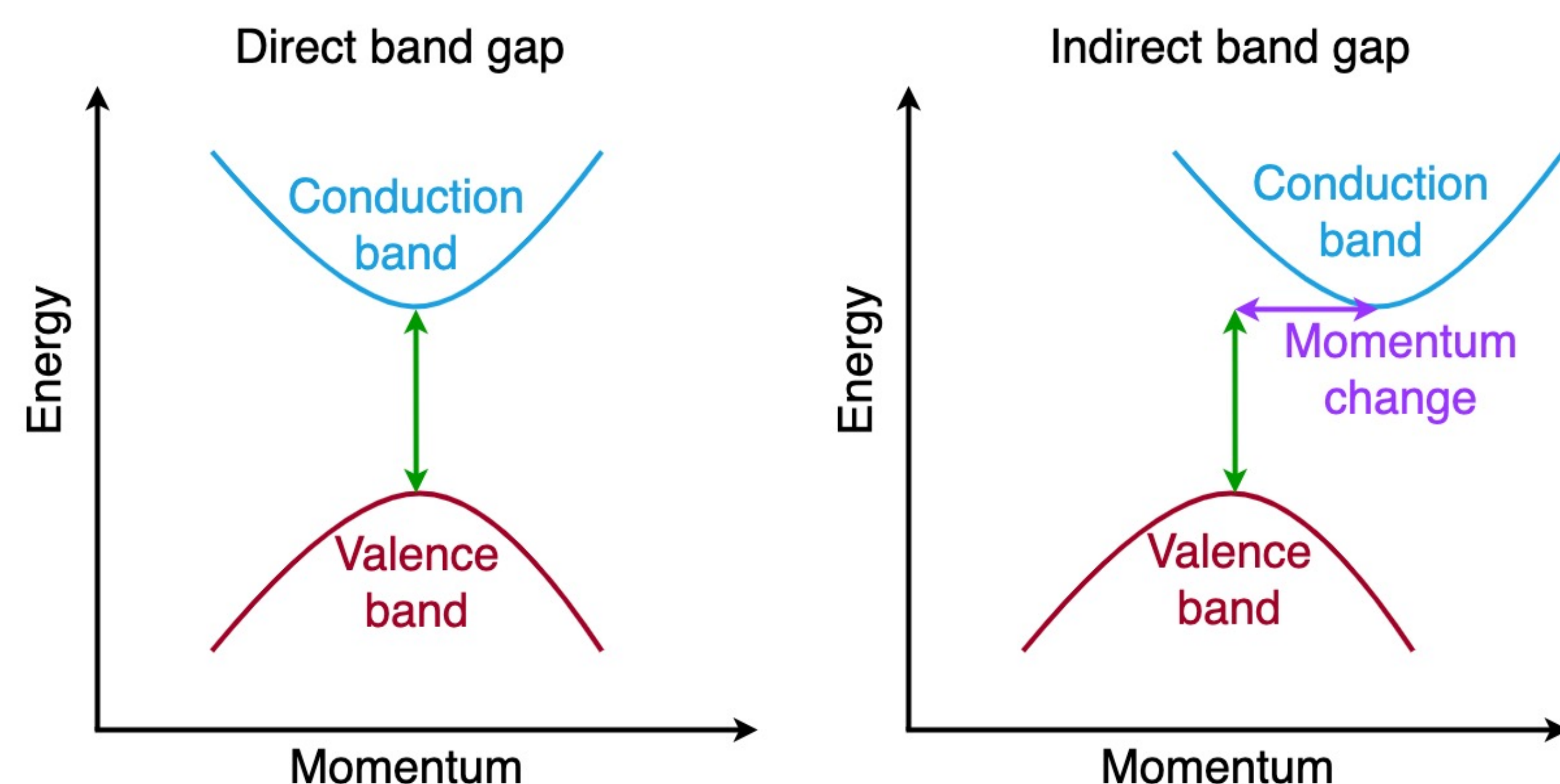


Figure 2. Comparison between direct and indirect band gap. Indirect band gap involves momentum change.

Materials & Methods

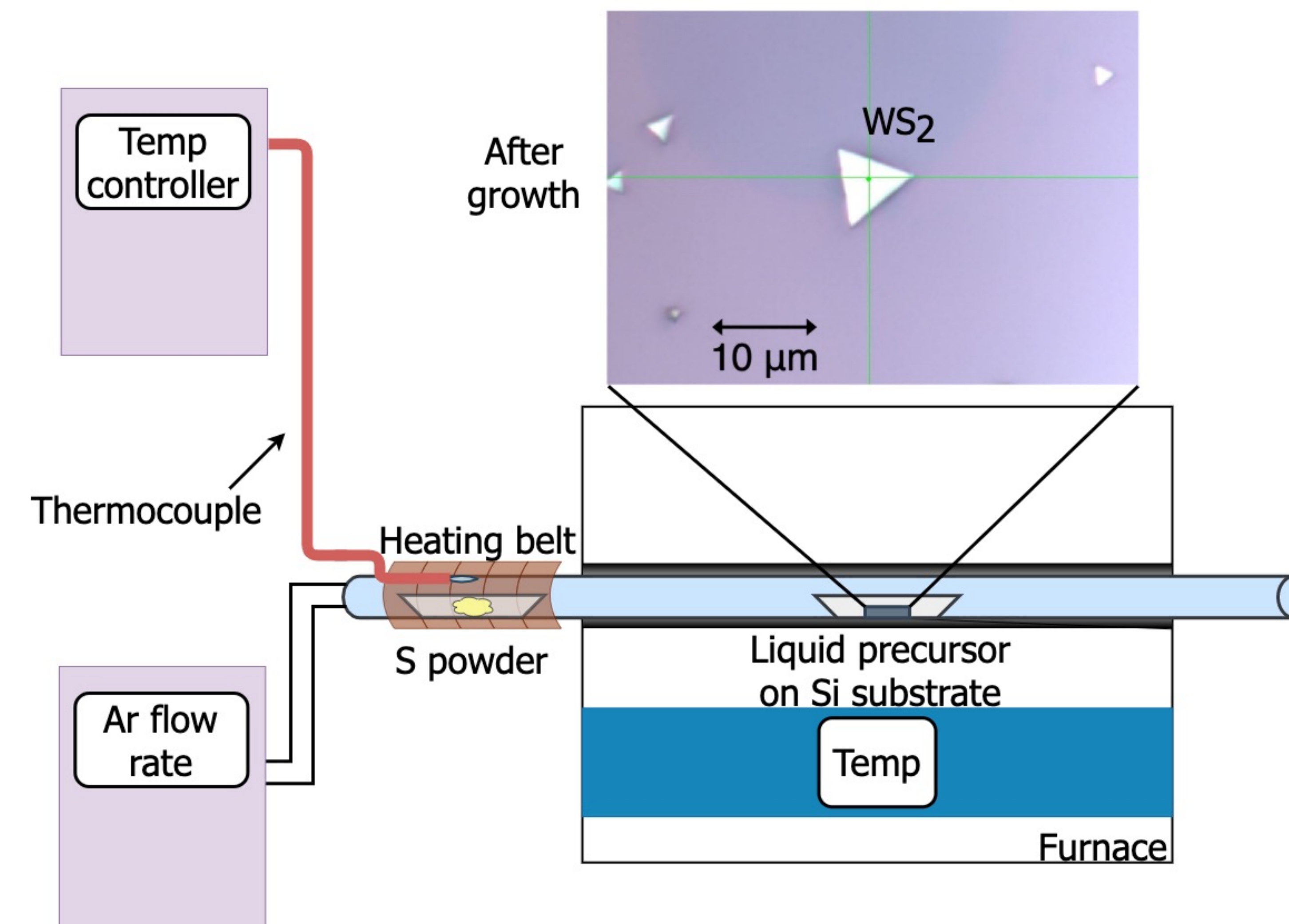


Figure 3. Experimental setup for synthesis of WS₂. Different parameters for growth include peak sulfur boat temperature, peak substrate boat temperature, ramping rates, and argon gas flow rate.

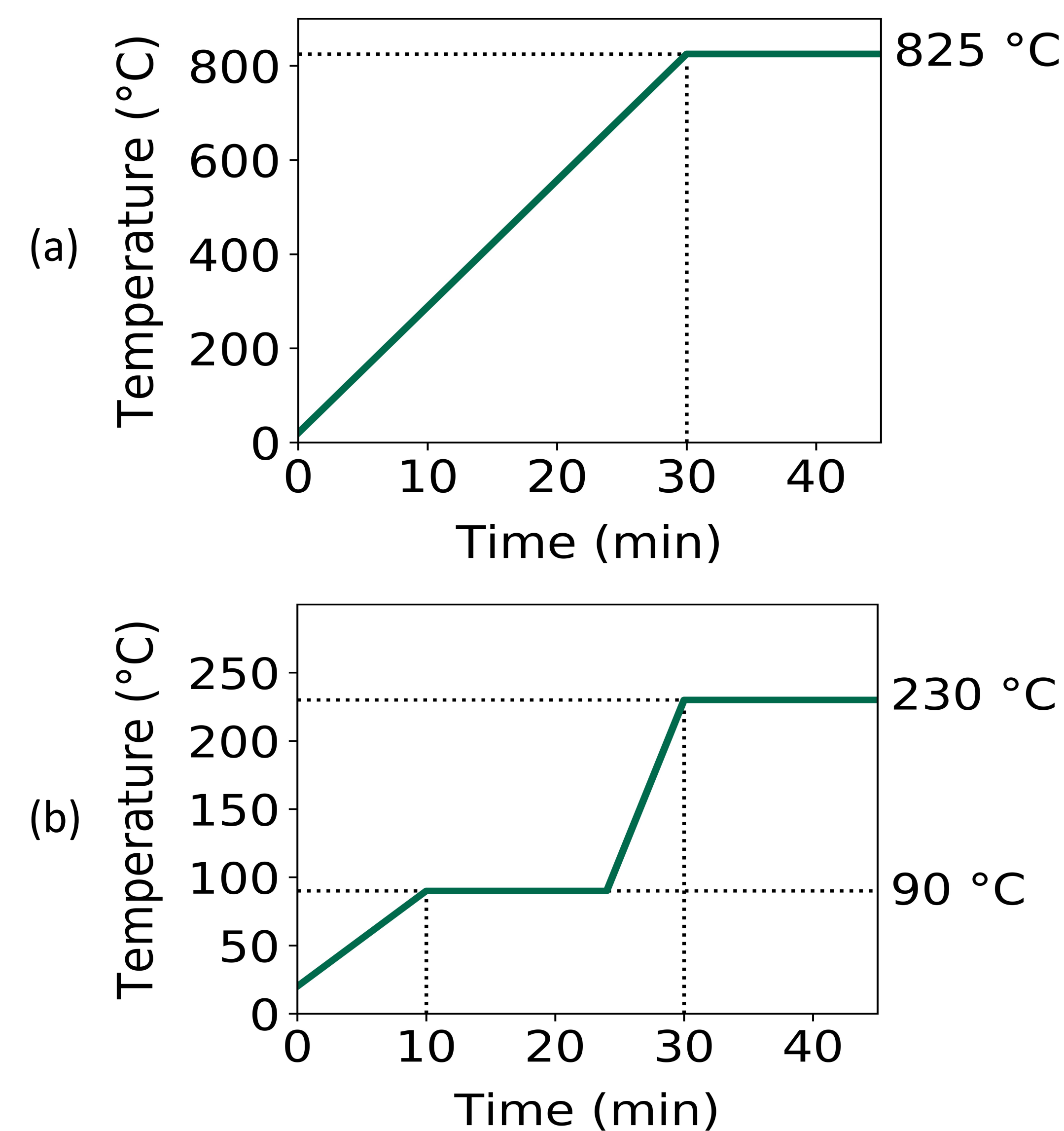


Figure 4. Temperature ramping for (a) furnace and (b) heating belt. Furnace peak temperature can range from 800-850 °C, and heating belt peak temperature can range from 200-250 °C.

Results

- Raman spectroscopy is a powerful nondestructive characterization method used for TMDs that does not require elaborate sample preparation.
- Laser power is kept at 2.5% in order to prevent sample damage

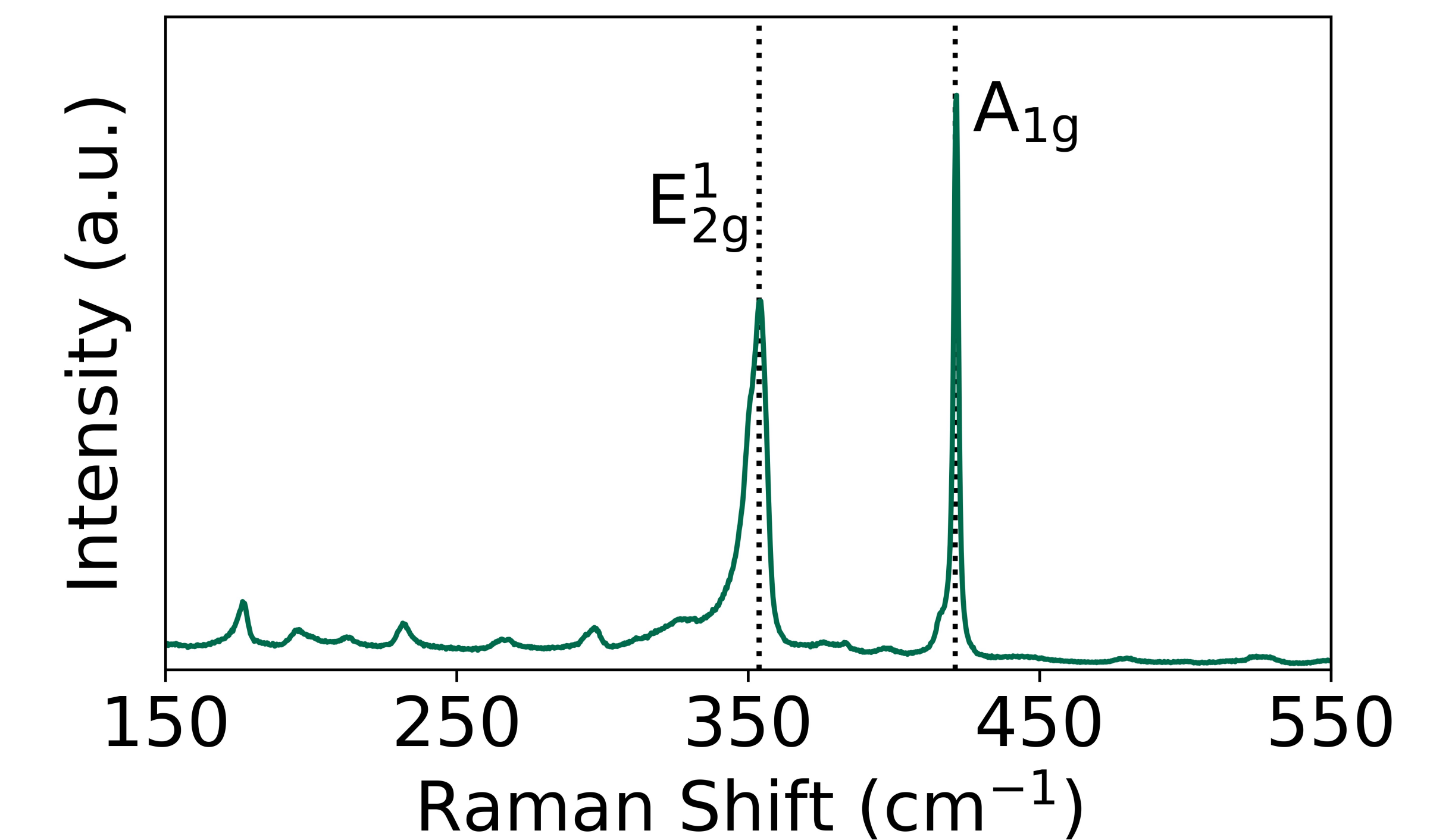


Figure 5. Raman spectrum for sample. Different phonon modes are labeled.

Conclusions & Future Work

- The temperature needs to be kept above 800 °C to obtain growth
- Timing between sample/substrate temp and sulfur source temperature is important factor
- Photoluminescence (PL) will be explored
- Future work will focus on growing WS₂ on highly ordered pyrolytic graphite (HOPG)
- Fe-WS₂ will also be grown on HOPG

References

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