Abstract
The interest of a better semiconductor for highly specialized electronic devices, such as photo couplers, gas sensors, solar cells, e-papers, non-volatile memory, etc., has recently shifted to a group of Transitional Metal Dichalcogenides (TMDCs), specifically Tungsten Diselenide (WSe₂), because of its unique characteristics in the monolayer form. Finding a standardized method to synthesize high quality monolayer WSe₂ should push the study forward and promote the application of such material.

Monolayer Tungsten Diselenide (WSe₂)
- Transitional Metal Dichalcogenides (TMD/TMDCs)
- Monolayer “sandwich” structure: Se/W/Se
- Trigonal Prismatic geometry
- Thickness of one layer: ~0.9 nm
- A direct band gap makes monolayer WSe₂ a promisingly good semiconductor for LEDs, optoelectronics, touchscreen, etc.

Motivation
- The need of a reliable, consistent and low-cost synthetic method that is compatible with the current literature of monolayer WSe₂
- Use Physical Vapor Deposition (PVD) method to synthesize monolayer WSe₂
- Study how the input parameters affect the growth
- Find an optimal set of parameters that give consistent results

Project Objectives
- Advantages of Physical Vapor Deposition (PVD):
  - Ability to produce high quality thin WSe₂ films in large quantity
  - Straight-forward, simple experiment setup
  - Low-cost
  - Scalable

Characterization
- Raman Spectroscopy: Detects the vibrational, rotational, low-energy modes, gives a unique “fingerprint” for each different materials
- Photoluminescence (PL): Observes light emission after photon excitation, detects band gaps

Experimental Data
- Good Parameters
  - 150 sccm of Ar
  - 0.05 g of WSe₂
  - 10 min at 1040°C
  - Problem

- Distance Control Approach #1
  - Figure 1a, 1b. Two different experiments with the same parameters and same distance control
  - Figure 2a, 2b. Optical image and Photoluminescence (PL) spectra of the results

- Distance Control Approach #2
  - Figure 3a, 3b, 3c. The results of three experiments with different temperatures

- Project Results
  - The distance between the source material and the target substrate is critical to the growth of WSe₂
  - The following parameters should result in good growth (thin flakes in dense population):
    - Temperature profile: 1040°C/950°C
    - Time: 10/20 minutes (respectively)
    - Gas flow: 150 standard cm³/min of Argon
  - Distance: 1.6 mm

Further Study
- Deeper characterization of the material
- Application of the thin films WSe₂ to the next generation electronic devices