

Pioneering Sputtering Routes for High-Mobility $\text{Bi}_2\text{O}_2\text{Se}$ Thin Films on Sapphire

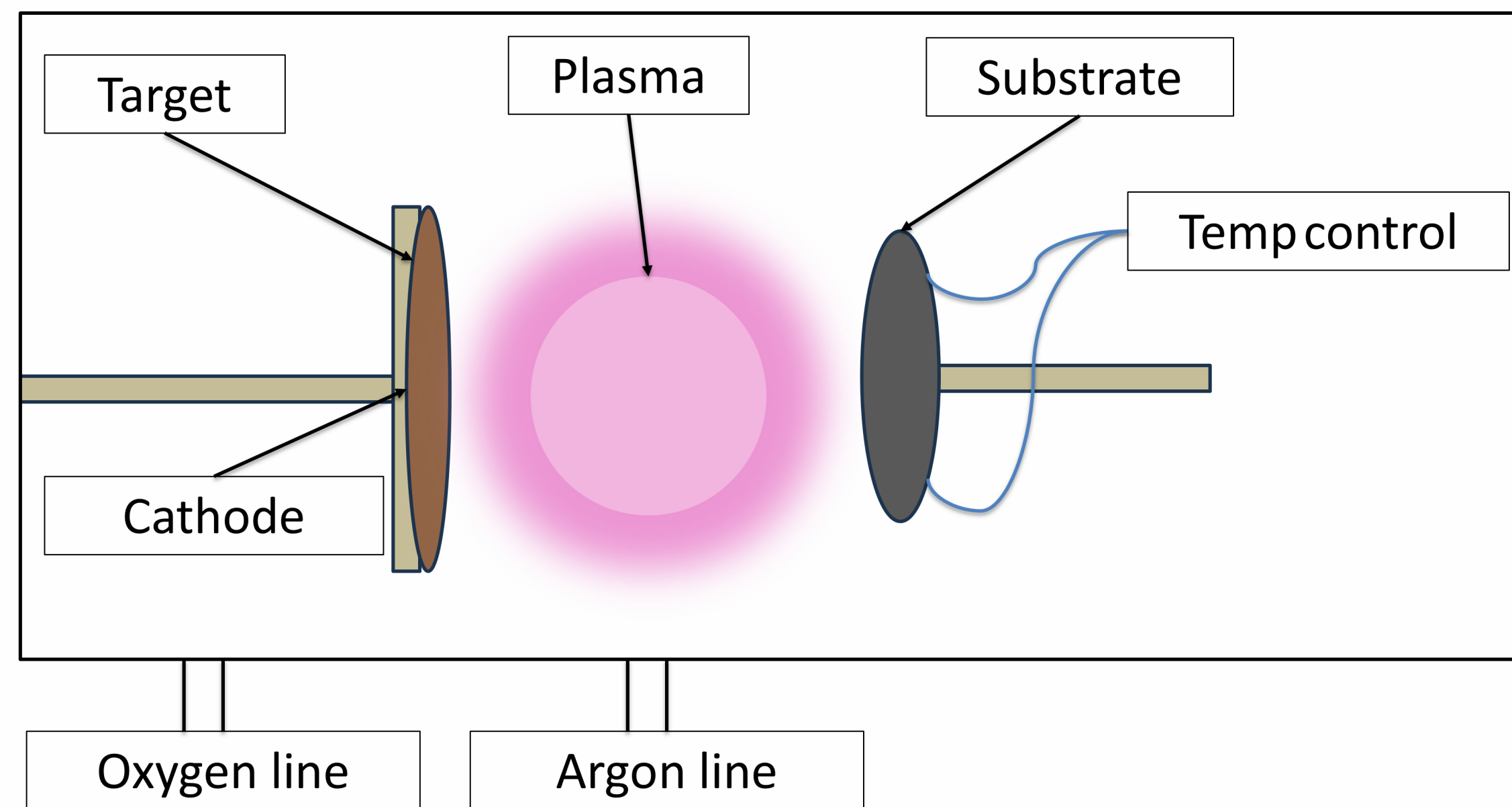
Acknowledgments: PhD students, Ângela Agra Pinto, Ethan Swonger

Blaise Faser, Material Science and Engineering
Mentor: Seth Tongay, PhD,
School for Engineering of Matter, Transport, and Energy



Research Questions: Which sputtering parameters most strongly influence $\text{Bi}_2\text{O}_2\text{Se}$ crystal quality and morphology? How can we conclusively verify that $\text{Bi}_2\text{O}_2\text{Se}$ has formed, rather than competing bismuth selenide or oxide phases?

Magnetron Sputtering



Importance

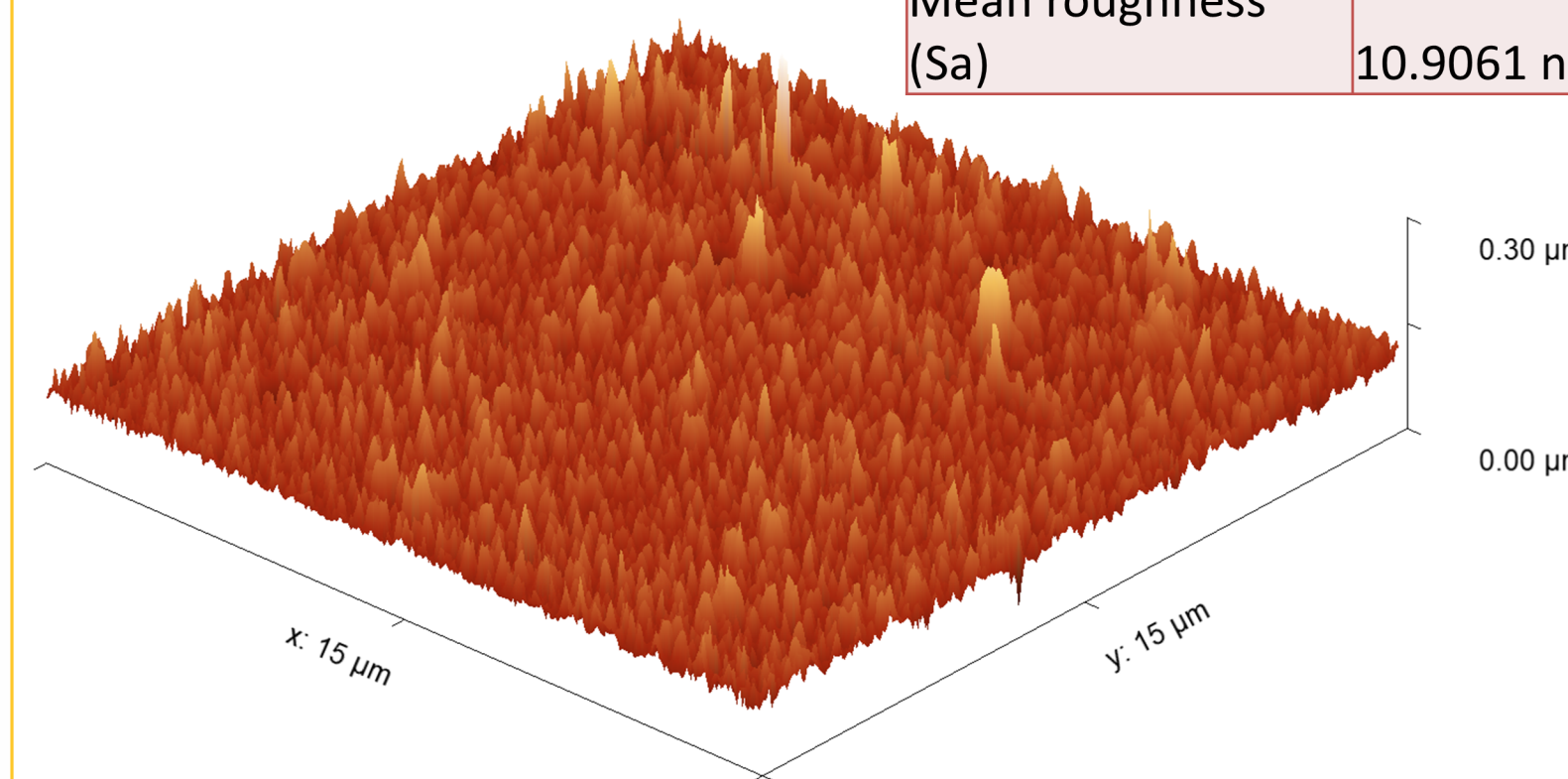
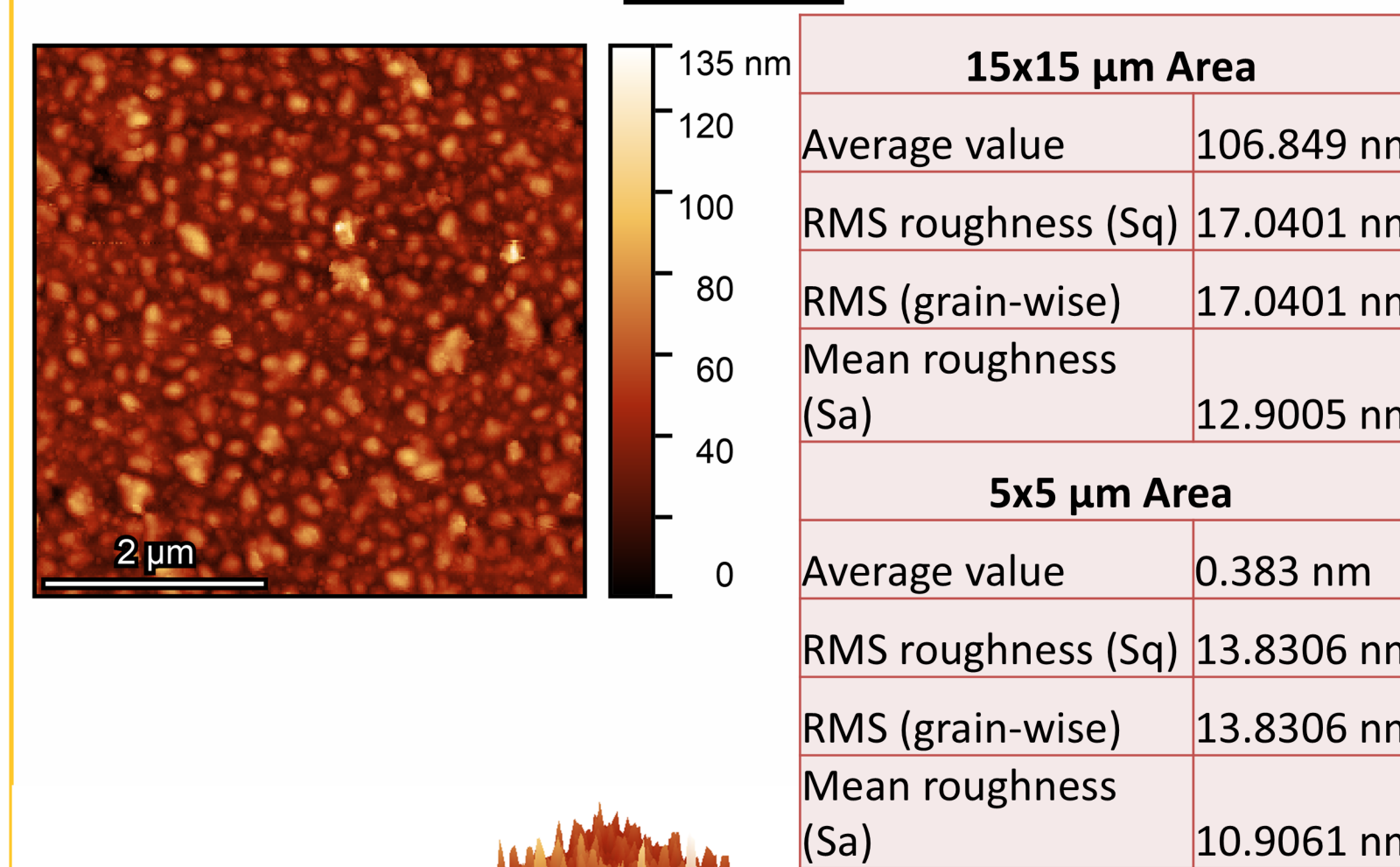
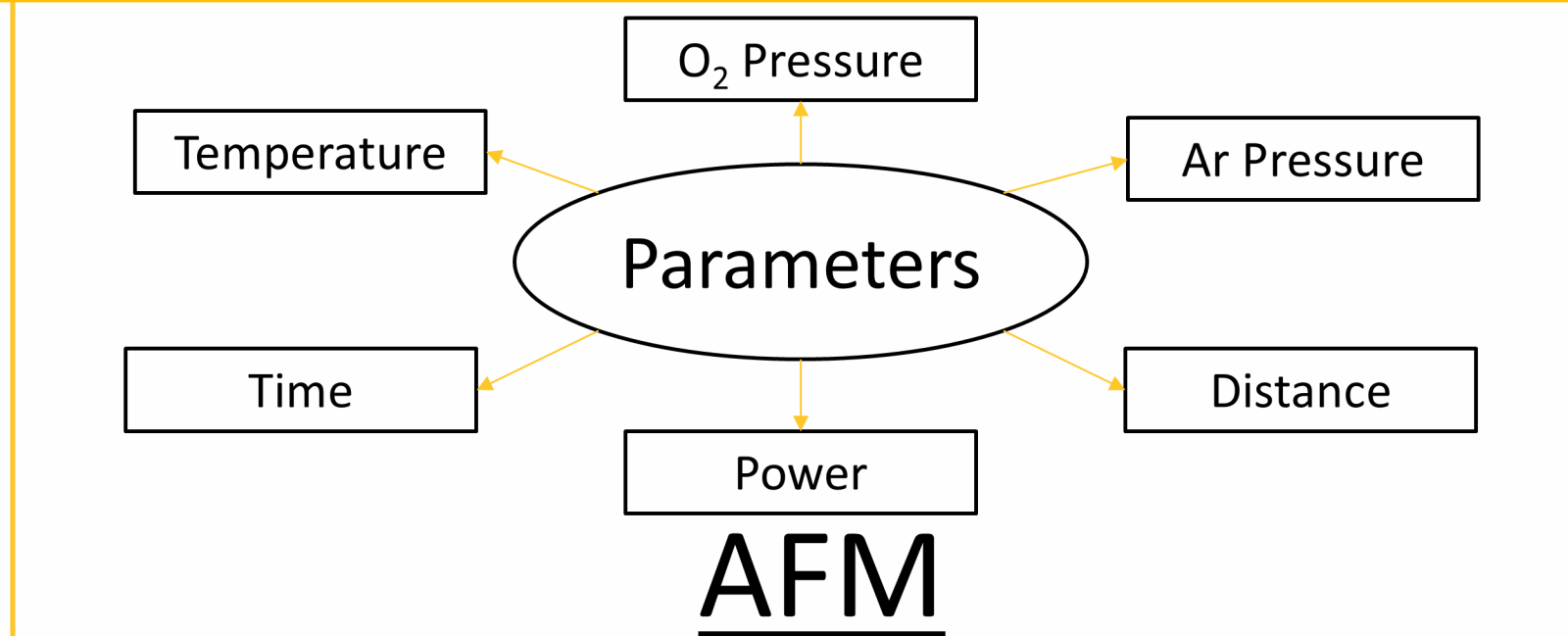
Optimizing sputtered $\text{Bi}_2\text{O}_2\text{Se}$ films on sapphire could enable scalable semiconductors for faster, more efficient electronic devices using magnetron sputtering a type of Physical Vapor Deposition (PVD) technique.

Working Principle

Ionize Ar \rightarrow Plasma (Ar^+) \rightarrow Ar^+ ions bombard target \rightarrow Ejecting Bi_2Se_3
 \rightarrow Thin Film growth

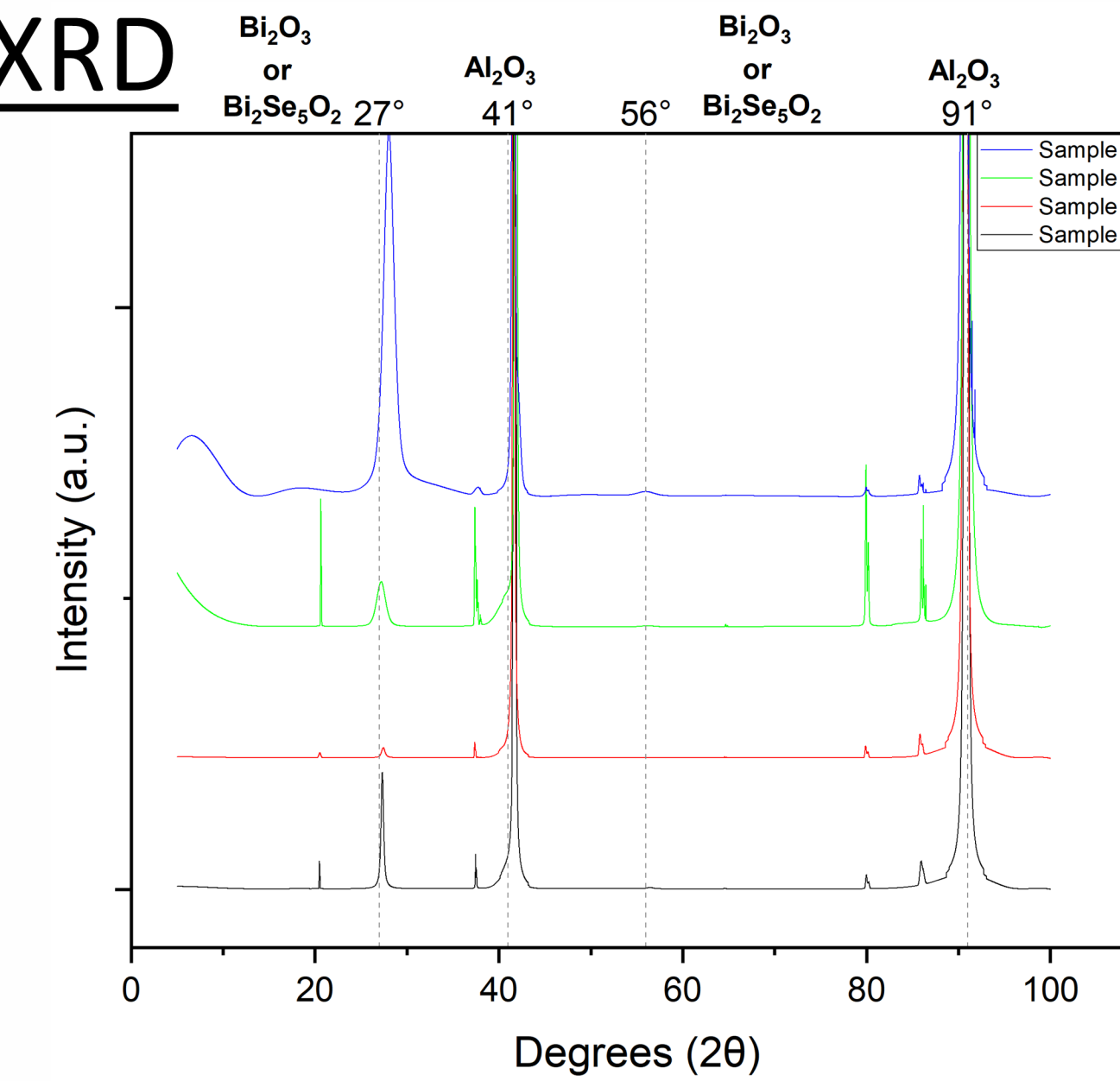
Methods

- Prepare Substrates: with polar organic compounds
- Thin Film Growth: Sputtering of Bi_2Se_3 w/ O_2 Ar^+ / O_2 plasma
- Characterization: Structural, optical, and morphological analysis (XRD, Raman, AFM)
- Data Analysis: Correlate growth conditions \rightarrow film quality & phase formation
- Optimization Parameters: Change parameters (power, O_2 pressure, temperature, distance, etc...)



- The surface morphology shows the formation of a polycrystalline thin film.
- SEM cross-section would be needed to determine exact thickness of the film deposited
- Small grain sizes can be seen; polycrystalline structure can be seen in both the 15x15 μm and 5x5 μm images.

XRD



- Phase separation is shown by the signature peaks of Bi_2O_3 and SeO_2
- Unusual phase δ - Bi_2O_3 was deposited shown by the signature peak at $\sim 622 \text{ cm}^{-1}$
- Progress towards the growth of $\text{Bi}_2\text{O}_2\text{Se}$

Conclusions

- δ - Bi_2O_3 without laser assistance was grown, while not the intention of the study was an interesting finding that was confirmed in this research
- Next Steps: Anneal the phase separated growth to see if the increased surface energy will cause diffusion, which could lead to the possible growth of $\text{Bi}_2\text{O}_2\text{Se}$

- Peaks show the possibility of Bi_2SeO_5 and Bi_2O_3 , though indistinguishable through XRD characterization alone
- A thin layer is indicated by the small peaks alongside the large substrate peaks

Raman

