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Growth of WS_2 Thin Photovoltaic Films

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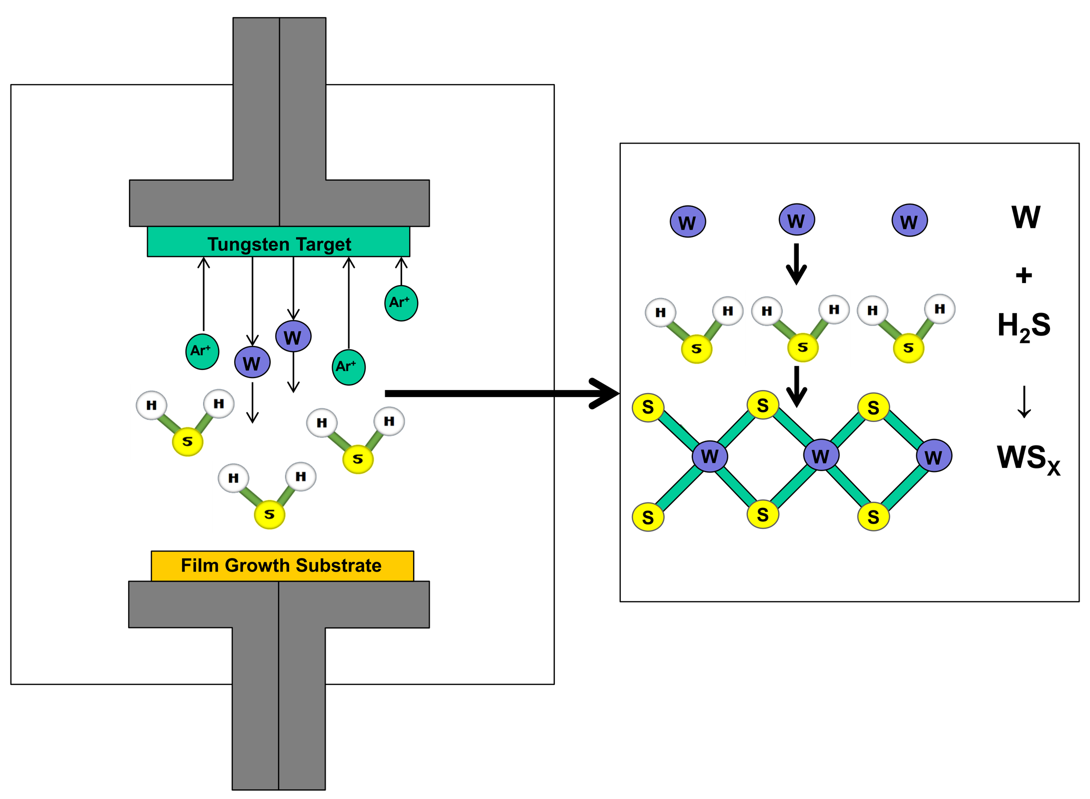
Introduction

Through research for a material that is low cost, earth abundant, and highly efficient, Tungsten Sulfide (WS_2) has been identified as a promising solution. From literature, it has been shown that WS_2 possesses a band gap of 1.9 eV, which is ideal for a top layer heterostructure cell. While this is a favorable value, other properties needed to understand its value as a photovoltaic material are unknown. Through research, WS_2 films will be grown through a sputtering deposition process and electrical characterization measurements will be performed to study these missing properties.

Deposition Process



To grow WS_2 films, a reactive sputtering process is implemented. In reactive sputtering, Argon atoms are ionized causing them to accelerate towards a negatively charged target. Upon hitting the Tungsten target, Tungsten atoms will be discharged and they will react with the gas in the chamber, Hydrogen Sulfide (H_2S). This will then react and form WS_X molecules that will be uniformly deposited onto a quartz slide. Between 1-5% H_2S to Argon concentration and a pressure between 5-30mT will be tested. These values are adjusted to optimize the production process.

Baking

The WS_X films will be baked in a tube sealed at a pressure of 4.5E-7 Torr. This will be done to prevent oxygen from being present during this process so the films will be baked to the lowest energy state of hexagonal WS_2. Baking temperatures will be experimentally tested between 800 and 900°C.

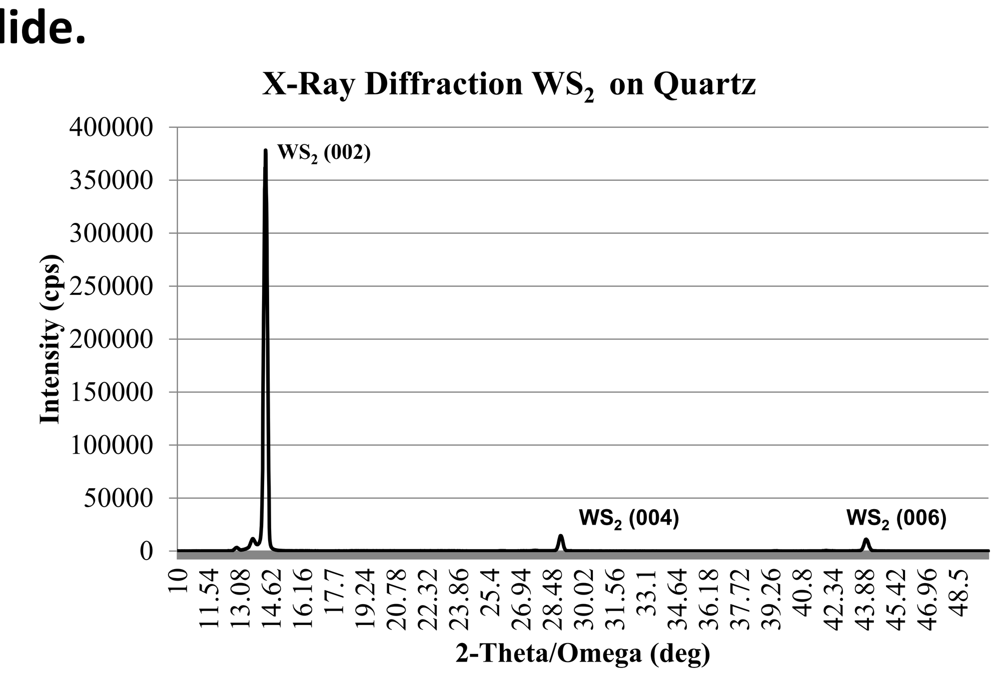
Electrical Characterization Measurements

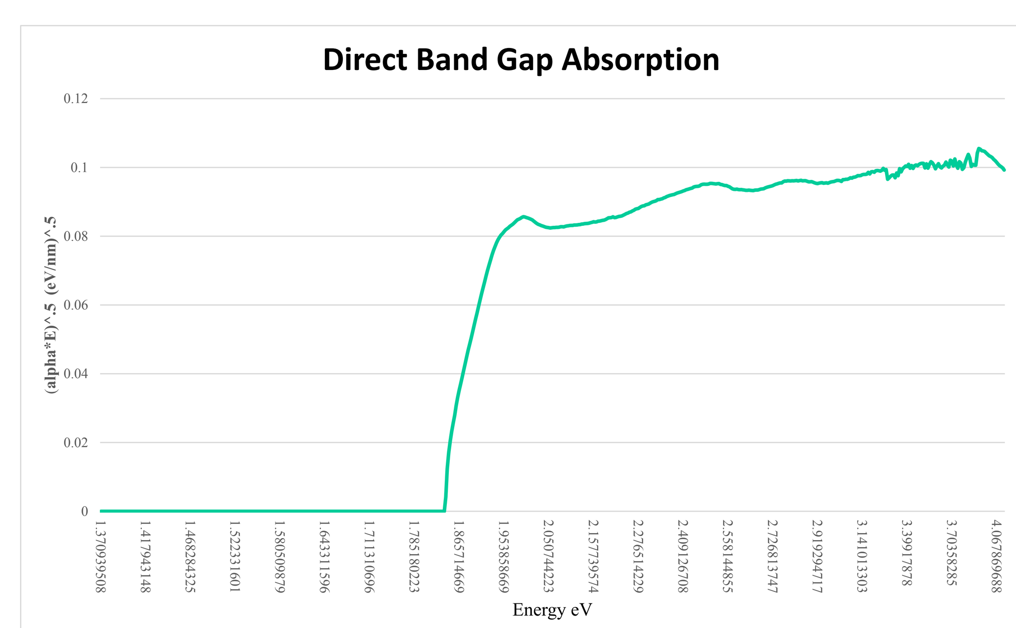
X-Ray Diffraction (XRD) allows us to verify our film microstructure. By calculating the intensity in which x-rays diffract across the sample, we can determine the size and shape of the unit cell, which is unique for each compound.

The UV-VIS spectrophotometer will be used to measure the absorption of the material. This will be used to verify the band gap of the material and quality WS_2 is being produced.

Results

The best results were produced by baking at 900°C for 20hrs. The XRD results are shown below along with the absorption plot. The peaks seen in the XRD correspond with the (002), (004), and (006) lattice for WS_2 confirming WS_2 was produced. The absorption plot verifies the band gap of WS_2 of 1.85eV and no absorption is occurring below band gap indicating the absence of defect states in our material. The problem with these films is they do not stick to the quartz slide.



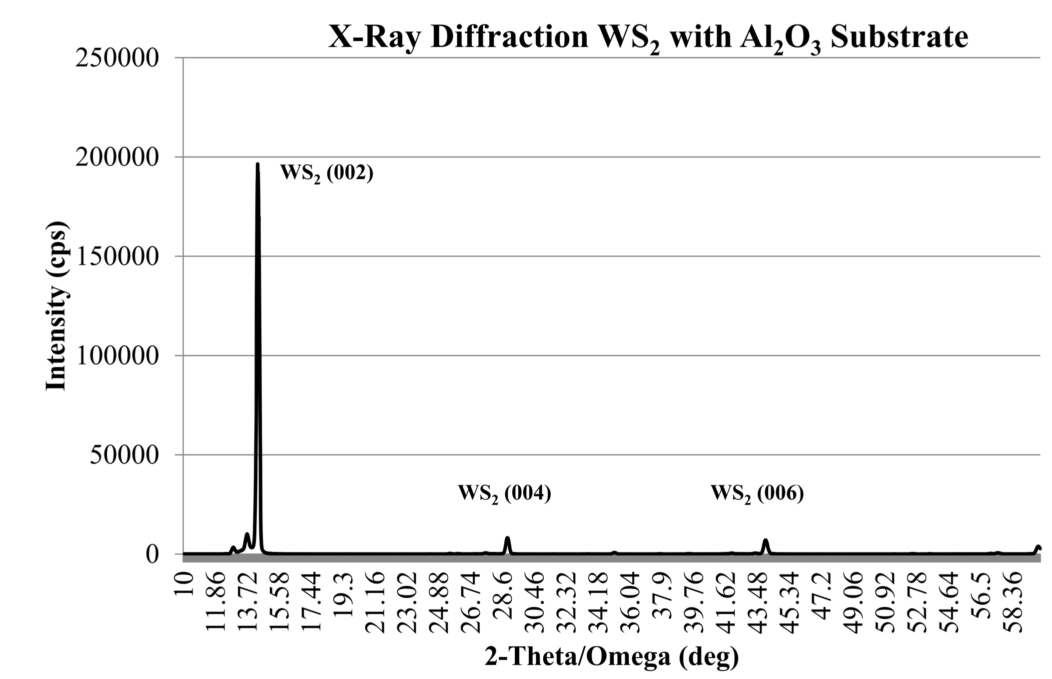


Aluminum Oxide (Al_2O_3) Substrate

Aluminum Oxide substrates will be used instead of quartz to help the film in sticking. This is because Al_2O_3 has a thermal expansion coefficient of $8.1 * 10^{-6}$/°C which is closer to the expansion coefficient of WS_2 than quartz which doesn't expand.

Al_2O_3 Substrate Results

The XRD results are shown below for 20 hrs. at 900°C with an Al_2O_3 substrate. The XRD verifies that we can produce the same results as before but with the different substrate. Using these substrates a film that was able to fully stick to the substrate was produced.



Conclusion

It was determined that 900°C for 20 hrs with an Al_2O_3 substrate was necessary to produce the highest quality WS_2 films. Lower baking temperatures caused defects to be seen in both the XRD and absorption data. This production process is the first essential step into better understanding the properties of WS_2 as a photovoltaic material. Work will be continued to perform electrical characterization measurements on these samples and the process of creating a WS_2 solar cell device will be researched.

Acknowledgments

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Interlock Safety Inc.; 11 April 2015; Web; 10 April 2016; Image.