Growth of WS\textsubscript{2} Thin Photovoltaic Films

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Hilfiker, Matthew J.; Ediger, Aaron; and Ianno, Natale, "Growth of WS\textsubscript{2} Thin Photovoltaic Films" (2016). UCARE Research Products. Paper 64.  
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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$_2$S). This will then react and form WS$_x$ molecules that will be uniformly deposited onto a quartz slide. Between 1-5% H$_2$S to Argon concentration and a pressure between 5-30mT will be tested. These values are adjusted to optimize the production process.

Baking

The WS$_2$ 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.

Conclusion

It was determined that 900°C for 20 hrs with an Al$_2$O$_3$ 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

We acknowledge the UCARE program, the Department of Electrical Engineering, and the University of Nebraska-Lincoln for funding the research. I also thank Dr. Natale Ianno and his graduate students for their guidance and expertise throughout this summer research program.

References

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