Studying Non-Trivial Atomic-Scale Heterostructures

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1 Introduction

The goal of this project is to create thin-film heterostructures. This will be done by using pulse laser deposition (PLD). A thin-film can range in different thicknesses. This range can be from nanometers to several micrometers. An example of a thin-film that is more commonly known includes soap bubbles and a type of anti-reflection coating on eyeglasses. [1]

The properties of thin-films can change based on the amount of oxygen in the structure. Some thin-film heterostructures have semiconductive behaviors. [3] Semiconductors are very common today because they can be found in many electronic devices. This includes phones, laptops, tablets, calculators, game systems, Televisions, radios, smart devices, and more. It is important for these semiconductors to be thin in size. The reasoning behind this is that our technology today continues to get thinner and thinner in size. If smart devices and technology continue to get thinner, the materials that make up these devices would also need to get smaller and thinner. This is why thin-film heterostructures are so important. The crystal structure of $SrCoO_{2.5}$ is important because of its semiconductive behaviors. There is a lot of interest in the field of thin-film heterostructures because of its potential of out preforming conventional semiconductors. [2]

This experiment will focus on creating thin-film $SrCoO_{2.5}$ by using pulse laser deposition. Using the substances Strontium Carbonate, $SrCO_3$, and Cobalt (II, III) Oxide, Co_3O_4, this will be used to create $SrCoO_{2.5}$. Using the Strontium Carbonate and Cobalt (II, III) Oxide in the correct ratios, conditions, and equipment, Strontium Cobaltite will form. The correct ratios can be determined by balancing a chemical equation and the mixture of the Strontium Carbonate and Cobalt (II, III) Oxide to create the Strontium Cobaltite. The chemical formula for Strontium Cobaltite is $SrCoO_{2.5}$. The ratio of what is needed to create the Strontium Cobaltite from the Strontium Carbonate and the Cobalt (II, III) Oxide is 3:1 which is three parts Strontium Carbonate and one part Cobalt (II, III) Oxide. The $SrCoO_{2.5}$ becomes a polycrystalline after the use of PLD.

After the Strontium Cobaltite crystal is formed and then different techniques will investigate the crystal and its properties. One technique used is called X-ray diffraction (XRD). X-ray diffraction can find the crystallographic structure of a crystal. It can also determine any impurities in the structure. This includes its crystal structure, size, and what type of crystals are present. This method can be done by using incident X-rays and measuring the waves present and the different scattering angles of the X-rays that leave the material.

After using XRD, another technique will be used called Atomic Force Microscopy (AFM). This is used to measure the surface topology of a substance or material and view how the surface looks, or its topology. For example, the AFM can determine if the surface of a material is hilly, smooth, etc. This allows imaging of many different types of surfaces. It can do this by using three methods. The methods are contact mode, non-contact mode, and tapping mode. Contact mode is done when the tip of the cantilever makes very close contact with the surface. This method is used when measuring surface force. Non-contact mode is done by keeping the probe several nanometers away from the surface in a spot with interaction forces. The last method and the method that will be done for this project is tapping mode. This method is done by vibrating near the fundamental resonance frequency and the tip of the probe moves up and down. The tip only sometimes comes into close contact with the surface.

There is a lot of interest and research in the field of semiconductors and thin-film heterostructures. The formations, physical properties, and structural properties of these crystals and their potential applications as solid-state fuel cells. [3]

References

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[3] Youwen Long. "Synthesis of cubic SrCoO3 single crystal and its anisotropic magnetic and transport properties". In: *Journal of Physics: Condensed Matter* (2011).