Copper Oxide Thin Films Deposited on FTO and ZnO/AZO Substrates for Photovoltaic Technology

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Introduction

Heterojunction Cu_2O solar cells could serve as a cheap, environmentally friendly, alternative to common photovoltaic cells on the market. Heterojunction solar cells consist of a p-n junction, formed from an n-type and p-type semiconductor. Cu_2O, which has a direct band gap of 2.17 eV making it ideal for optoelectronic use, functions as a p-type semiconductor due to Cu vacancies. FTO, which has been utilized in other optoelectronic applications, and, used to produce other heterojunction solar cells, were used as n-type semiconductors. This project analyzes whether or not these materials result in functional solar cells, and the effects that the production techniques have on Cu_2O thin film properties.

Background

Functional heterojunction Cu_2O solar have been built by using ITO and AZO/ZnO as the n-type semiconductors. An ITO/ZnO/Cu_2O solar cell was produced to have an efficiency of 2.01%, and a AZO/ZnO/Cu_2O solar cell was produced to have an efficiency of 3.83% [1].

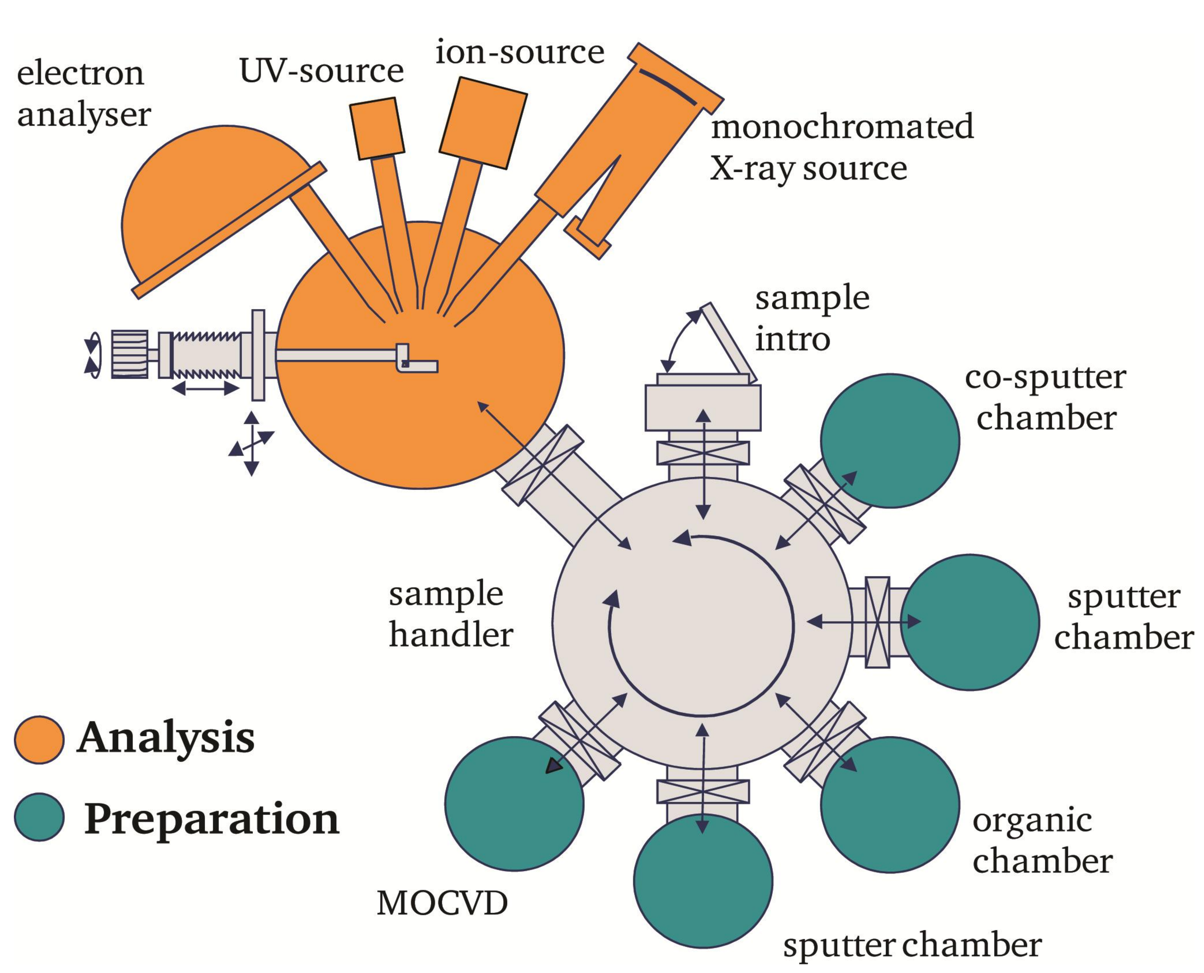

Figure 1: The DAISY MAT is an integrated system that was used to prepare the Cu_2O thin films.

Method

Cu_2O was deposited on pre-manufactured FTO and ZnO/AZO substrates by magnetron sputtering in the sputter chamber next to the MOCVD chamber of the DAISY MAT, shown in Figure 1. X-ray photoelectron spectroscopy (XPS) was used to determine the ratio of Cu to O in the deposited layer. SEM was used to determine the grain sizes in the deposited layer. Layer thickness was measured by a profilometer, and photoelectric activity was analyzed by I-V curve measurements.

Sample	Stoich-iometry (Cu:O)	Layer Thickness (nm)	Deposition Temperature	Deposition Time (minutes)	Oxygen in Deposition Atmosphere	Substrate
LS0629	1.96	1788.9	RT	165	5%	FTO
LS0701	2.96	2168.6	RT	120	5%	FTO
LS0704 A	2.05	657.8	RT	60	10%	FTO
LS0704 B	1.69	647.7	RT	60	15%	FTO
LS0706 A	1.89	1661.9	RT	150	12.5%	FTO
LS0712	1.69	630.6	400˚C	60	5%	FTO
LS0713	1.45	627.8	300˚C	60	5%	FTO
LS0726	1.51	1228.5	RT	120	5%	ZnO/AZO

Table 1: Properties of the thin films, including layer thickness, stoichiometry, and grain size, can be manipulated by changing the deposition parameters, including deposition time, oxygen in deposition atmosphere, and deposition temperature.

Results

Functional Solar Cells could not be obtained from the Cu_2O thin films sputtered on FTO or on ZnO/AZO substrates.

However, I-V curves for Cu_2O deposited on ZnO/AZO, shown in Figure 2, display strong diode-like behavior.

For Cu_2O deposited on FTO, only weak diode-like behavior was shown, and most of the samples were short circuited.

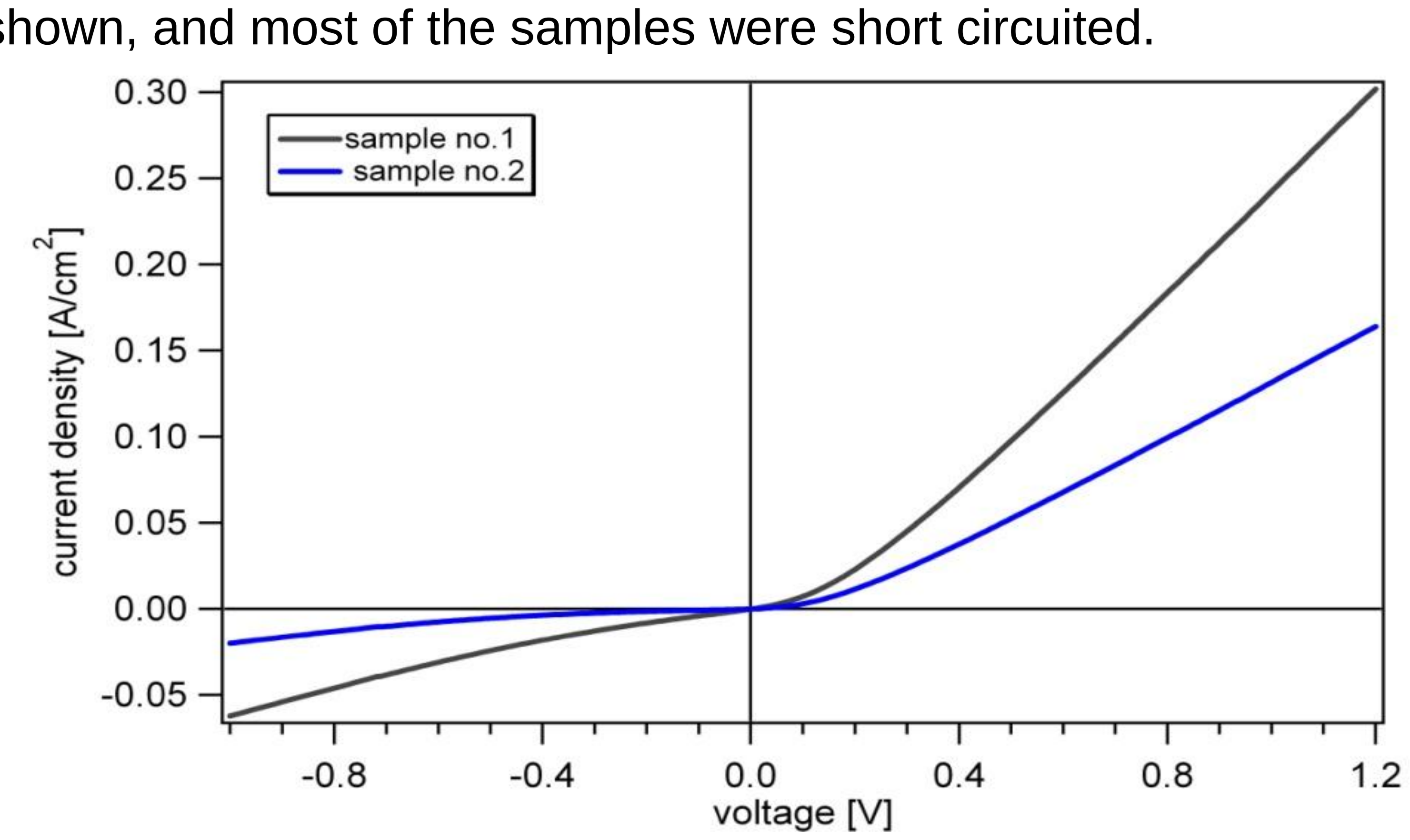

Figure 2: These curves show weak diode like behavior in sample LS0726, because current only flows in one direction with increasing voltage. However, the y-intercept remains at 0 A/cm^2, when the sample was illuminated; hence, this sample did not produce a functional solar cell.

Further Analysis of Thin Films

Varying certain deposition parameters in the sputter chamber gave thin films different properties, as shown in Table 1. For instance, different amount of oxygen in the deposition atmosphere allowed thin films with differing Cu to O ratios to be produced. Also, a higher deposition temperature led to the growth of larger grains in the thin film layer, shown in Figure 3. Deposition time, varied the layer thickness. These different properties can both determine whether or not a functional solar cell is produced, and how efficiently it harvests energy.

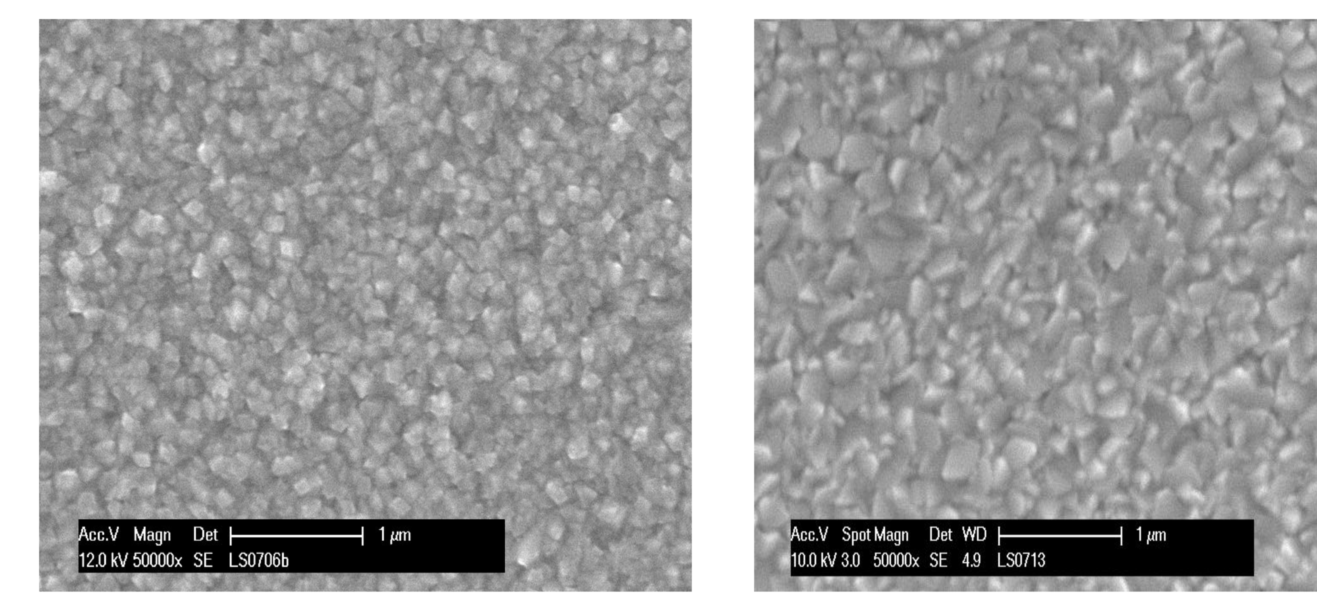

Figure 3: The SEM picture on the left shows a thin film deposited at room temperature. The SEM picture on the right is a thin film deposited at 300°C.

Conclusions

For the thin film Cu_2O layers deposited on FTO, the addition of a buffer layer between the Cu_2O and the FTO may have yielded a sample with more diode-like behavior or a functional solar cell, because a buffer layer would help block tunneling, which may have prevented the samples from functioning as solar cells.

For the thin film Cu_2O layer deposited on AZO/ZnO, improvements could have been made, by sputtering with a lower percentage of oxygen in the deposition atmosphere, since the stoichiometry between Cu and O is not ideal.

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References

1. Minami, T., *High-Efficiency Oxide Solar Cells with ZnO/Cu_2O Heterojunction Fabricated on Thermally Oxidized Cu_2O Sheets.* Applied Physics Express, 2011.

Surface Science