Journal of Materials and Electronic Devices 1 (2019) 37-40

FYTRONIX
JOURNAL OF
MATERIALS AND ELECTRONIC DEVICES
JMED
http://dergi-fytronix.com/

Production and Characterization of ZnO / Cu_2O Based Devices Growing with Spin Coating Method

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In this study, p-n heterojunctuion structure (n-ZnO / p-Cu_2O) was formed by using ITO coated glass substrates, firstly by coating ZnO and then Cu_2O respectively. In this study, spin coating method is used which is simple and economical to obtain. The resulting n-ZnO / p-Cu_2O heterojunction was contacted with silver and characterized as Ag / ITO / ZnO / Cu_2O / Ag based device.X-ray diffraction (XRD) system was used for the structural analysis of the heterojunction structure, Holl measurement system for electrical properties, scanning electron microscopy (SEM) system was used for morphological analysis and coating thickness. The results showed that the coatings were uniformly distributed evenly over the entire surface and had a good crystalline structure. The thicknesses of the obtained coatings were found to be 1 μm for ZnO and 2μm for Cu_2O.

Keywords: Device, Spin Coating Method, Semiconductors, Cupper Oxide (Cu_2O), Zinc Oxide (ZnO)

Submission date:10 August 2019
Acceptance Date: 2 September 2019

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1. Introduction

With the continuous development of technology, almost every day a new device enters our lives, which increases the human need for energy day by day. The need for energy has led us to an intensive search for new energy sources. Solar cells, which are one of these new energy sources, are considered as a promising option to replace fossil fuels that will be exhausted in the near future.

In this study, metal oxides such as ZnO and Cu_2O which are simple to obtain were used. The first of these, Zinc Oxide (ZnO) is an important semiconductor material with its optical and electrical properties as well as wide exciton bond energy of 3.37 eV and a large exciton energy of about 60 meV. Because of its significant physical properties, ZnO has been used in many applications such as sensors applications [1], transparent conductor electrode in solar cells [2], laser applications [3] and light emitting diodes (LED) [4]. Another metal oxide, cuprous oxide (Cu_2O) which is an abundant, non-toxic material and it's a p-type semiconductor with a low band gap of about 2.09 eV [5]. Many methods are preferred for the production of ZnO and Cu_2O thin films. Among them are widely used in electrodeposition [6], vacuum evaporation [7], chemical bath deposition (CBD) [8] and spin coating [9]. We preferred spin coating method which does not require high pressure and can be applied in room conditions.

2. Experimental details

As a first step, ITO coated glass substrates were cut to desired dimensions. They were then cleaned in an ultrasonic bath for 10 minutes using acetone and ethyl alcohol, respectively. ZnO was first coated after cutting and cleaning. The coating process was repeated 3 times to produce the desired thickness of ZnO. The coatings were carried out at 1000 rpm for 3 seconds and 35 rpm for 4000 seconds. The coated samples were annealed at 450 ° C. After ZnO, Cu_2O was coated to form ITO / ZnO / Cu_2O heterojunction structure. Coating conditions for Cu_2O were 500 rpm for 3 seconds and 3000 rpm for 35 seconds.

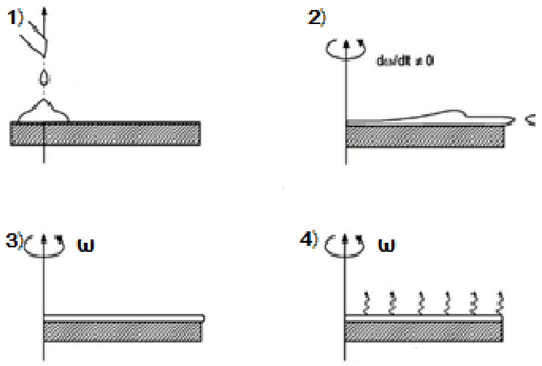

Figure 1. Four steps of spin coating method: 1) The step of dropping the solution onto the surface, 2) Acceleration step, 3) Step of dissolution of solution to whole surface, 4) Evaporation step.

Figure 1 shows the 4 steps of the spin coating method. In the first step, the solution is dropped onto the surface. The rotation about the z-axis with the preset rotation speed is shown in step 2. In step 3, the solution can be explained as spreading the whole surface. The final step can be defined as the complete evaporation step of the solvent.

3. Results and discussion:

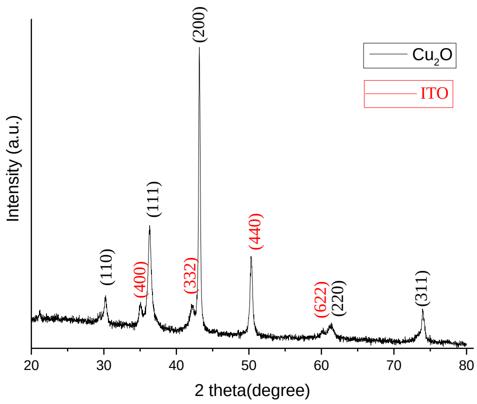

Figure 2. XRD pattern of Cu_2O grown on ITO coated glass substrate using spin coating method.

Figure 2 shows the XRD pattern of Cu_2O grown on ITO coated glass using the spin coating method. According to XRD results, all peaks belong to Cu_2O and ITO and the absence of phases such as CuO indicates high crystallinity of the structure.

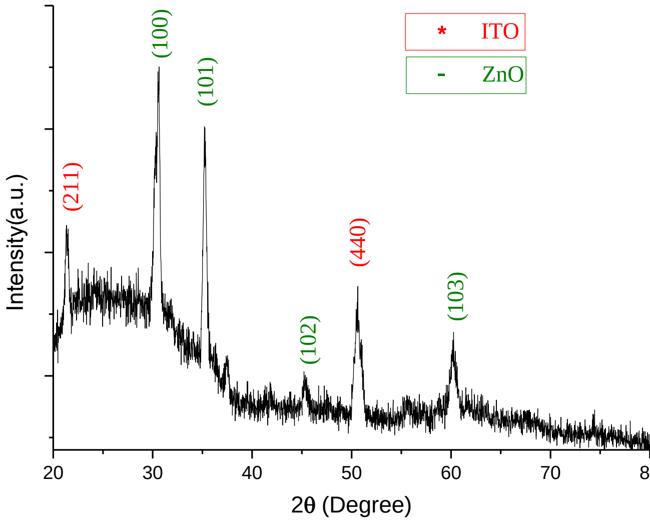

Figure 3. XRD pattern of Cu_2O grown on ITO coated glass substrate using spin coating method.

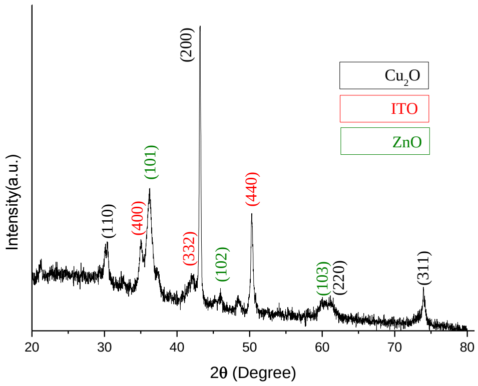

Figure 4. XRD pattern of ITO/ZnO/Cu_2O heterojunction structure using spin coating method 275 ° C

Figure 4 shows the XRD results of the ITO / ZnO / Cu_2O structure. All observed peaks belong to ITO, ZnO and Cu_2O. Annealing temperatures for coatings are 400 ° C for ZnO and 275 ° C for Cu_2O.

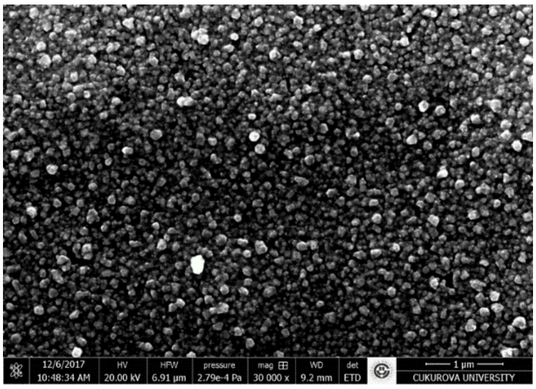

Figure 5. SEM image of ITO / ZnO / Cu_2O heterostructure produced by spin coating method.

The SEM image of the ITO / ZnO / Cu_2O structure is given in Figure 1. According to the results of SEM, there were no defects or pores in the structure and it was found to be extremely homogeneous. Particle sizes were determined to range between 50 and 90 nm.

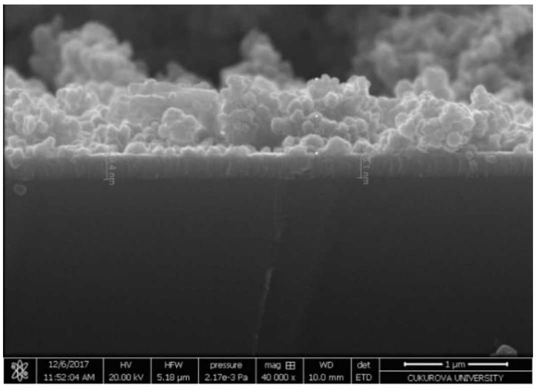

Figure 6. Surface-cross section view of ITO / ZnO / Cu_2O structure produced by spin coating method.

Figure 6 shows the surface-section view of the ITO / ZnO / Cu_2O heterostructure. In the surface-cross section view, the lowest layer is ITO having a thickness of 200 nm. Above the ITO, there is a ZnO thickness of approximately 1 µm. The top layer of the structure is Cu_2O approximately 2 µm thickness.

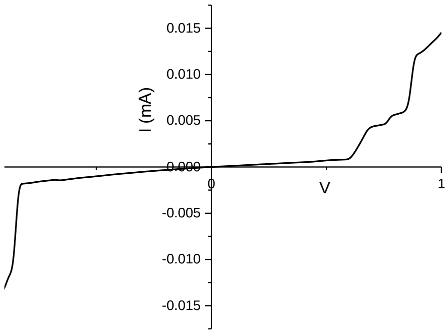

Figure 7. Dark I-V characteristics of ITO/ZnO/Cu_2O heterojunctions.

After the structure formed with low molarity does not show diode characteristics, after determining the molarity which provides optimum conditions as 1M, the structure obtained between -1 and +1 Voltage and the current-voltage graph in dark environment is given in Figure 1. As can be easily understood from the figure, it was found that the structure we obtained shows diode characteristics. However, it was observed that it showed a slightly curved increase rather than a straight increasing curve directly.

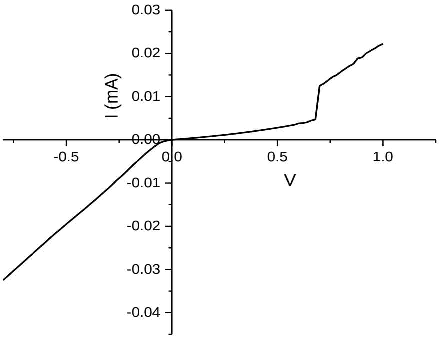

Figure 8. Illumination I-V characteristics of Cu_2O/ZnO heterojunctions.

Figure 8 shows the I-V results of the ITO / ZnO / Cu2O heterojunction structure in illumination conditions. According to the I-V results, the I-V results in the illumination are similar to the I-V results in the dark. It is also expected that the refraction voltage will drop under light. In the dark, open circuit voltage is 0.8 V, while in Figure 2 open circuit voltage in the bright environment is reduced to 0.1 V.

Conclusions

In conclusion, p-type Cu_2O and n-type ZnO thin films were optained successfully by using spin coating method which is very easy to apply. This study showed that ZnO / Cu_2O heterojunction structure can be formed by using materials such as ZnO and Cu_2O which are abundant in nature and simple to obtain. Structure, morphological and electrical properties of the thin films were examine using, XRD, SEM and I-V. The average particle size of ITO/ZnO/Cu_2O was deceted in the range of 50-90 nm from the SEM measurement. According to XRD results, coated samples had high crystallinity. This study is very low cost because it is performed without using pricey laboratory conditions such as vacuum and high temperature. Furthermore, according to I-V results, efficient solar cell could not be obtained from the p-n joint produced. This is due to problems with the interface. After these problems are overcome, it will be possible to obtain efficient solar cells. However, the obtained ZnO / Cu_2O heterojunction structure can be used as light detector.

Acknowledgement: This project has been supported by Cukurova University under the project number FYL-2017-8409.

References:

[1] A.N. Afaah, Z. Khusaimi, M.R. Mahmood, A Review on Zinc Oxide Nanostructures: Doping and Gas Sensing, Advanced Materials Research 667 (2013) 329-332.

[2] W. Shen, J. Zhang, S. Wang, H. Du, Y. Tang, J. Alloy. Comp., 787 (2019), 751.

[3] K. Govender, D.S. Boyle, P. O'Brien, D. Brinks, D. West, D. Coleman, Room temperature lasing observed from ZnO

nanocolumns grown by aqueous solution deposition, Advanced Materials 14 (2002) 1221.

[4] S.J. An, G. Yi, Near ultraviolet light emitting diode composed of n-GaN/ZnO coaxial nanorod heterostructures on a p-GaN layer, Applied Physics Letters, 91 (2007) 123109.

[5] Y.E. Gu, X. Su, Y.L. Du, C.M. Wang, Preparation of flower like Cu2O nanoparticles by pulse electrodeposition and their electrocatalytic application, Appl. Surf. Sci., 256 (2010), 5862-5866.

[6] R.P. Wijesundera, L.K.A.D.D.S. Gunawardhana, W. Siripala, Electrodeposited Cu2Ohomojunction solar cells: Fabrication of a cell of high short circuit photocurrent, Sol. Energy Mater. Sol. Cells, 157 (2016), 881-886.

[7] J.S. Tawale, A. Kumar, G. Swati, D. Haranath, S.J. Dhoble, A.K. Srivastava, Mater. Chem. Phys., 205 (2018), 9

[8] H. Xu, J. Dong, Ch. Chen, One-step chemical bath deposition and photocatalytic activity of Cu2O thin films with orientation and size controlled by a chelating agent, Mater. Chem. Phys., 143 (2014), 713-719.