International Academic Institute for Science and Technology

International Academic Journal of Science and Engineering
Vol. 12, No. 1, 2025, pp. 1-6.

ISSN 2454-3896

International Academic Journal of Science and Engineering

www.iaiest.com

Effect of Preparation Conditions on the Structural and Optical Properties of $CoCao_3$ Thin Films Prepared by Chemical Bath

Z.B. Ibraheem [a], Saad F. Mahmood [b], Hamid A. Salih [c]

[a] *New and Renewable Department, College of Science, Mosul University, Iraq.*
[b] *New and Renewable Department, College of Science, Mosul University, Iraq.*
[c] *New and Renewable Department, College of Science, Mosul University, Iraq.*
E-mail: hamid.abdulla@uomosul.edu.iq

Abstract

Perovskite $CoCaO_3$ Thin films were deposited on glass substrates using chemical bath deposition. the effect of deposition temperature (30,70 and 85°C) and deposition periods (10,20 and 30min) on the physical properties of the films. The energy gap changed with deposition periods and temperatures, the energy varied from 3.35eV to 3eV with deposition period, while it was varied from 3.35eV to 2.4 with deposition temperature. x ray spectrum of the films prepared at 85°C with 10min deposition temperture show that the films are including amorphous and crystalline phases with grain size of about 52.67nm.

Keywords: Thin Films, Cao Semiconductors, Cao Semiconductors, Perovskite Structure, Chemical Bath Deposition Cbd.

DOI: 10.71086/IAJSE/V12I1/IAJSE1201
Received: 09 December 2024/Revised: 13 January 2025/Accepted: 10 February 2025/Published: 31 March 2025

Introduction

Perovskites offer a unique class of materials with superior photoluminescence and optical qualities. researching single domain crystals' optical characteristics at different temperatures (Fu et al., 2019). Their electrical, magnetic, and optical characteristics—which are dependent to changes in phase, pressure, and temperature—make them extremely significant. Calcium titanite, a naturally occurring mineral, is the source of the name for the broad family of crystalline minerals known as perovskites (Bai et al., 2019; Mao et al., 2018; Assirey, 2019). The first synthetic perovskite was produced in 1926 by GOLDSCHIMDT at the University of Oslo (Norway), which led to the use of the term perovskite to describe all structures similar to the compound $CaTiO_3$, represented by the chemical formula ABX3, where A is a cation generally belongs to the rare earth or alkaline earth series, B is a cation with a small ionic diameter that is generally a transition metal or noble metal [X], is an oxygen atom in the case of oxides but may be a halogen or nitrogen in other cases (Ortega-San-Martin, 2020; Bouarissa, 2017; Nikkel, 2020). Different methods can be used to prepare thin films of perovskite including chemical bath deposition CBD (Guneri & Ozpozan, 2023), spray pyrolysis method SPM (Şen et al., 2024), thermal evaporation (Du et al., 2022) and sol gel method (Kerner et al., 2016). Perovskite has been used in several fields including, solar cell (Jung & Park, 2015), light-emitting diodes (Cao et al., 2018) and capacitors (Dimos & Mueller, 1998). In this study the effect of deposition time and temperature on the optical and structural properties of $CoCaO_3$will be studied.

Experimental Method

Chemical bath deposition CBD was used to prepare thin films of cadmium oxide $CoCaO_3$ glass substrate. Cobalt chloride and calcium chloride were used as a source of cobalt and calcium elements for both CoO and CaO. CoO thin films have been prepared by mixing 0.4g potassium hydroxide KOH dissolved in 50ml distilled water and 0.3gm Cobalt chloride also dissolved in 50ml distilled water, while CaO thin films were prepared by mixing 0.3gm of CaCl2 dissolved in 50ml distilled water and 0.4g 0.4g potassium hydroxide KOH dissolved also in 50ml of distilled water according to the following reactions. Both solutions then mixed and stirred for 1 hr at 85°C. Finally, the glass slides immersed in the later solution at different deposition temperatures and periods.

Results and Discussion

Thin films of $CoCaO_3$ have been deposid on glass substrates using chemical bath deposition. Different parameters can be changes during the deposition but the most important parameters are the deposition temperature and deposition periods.

The transmittance and absorbance of the $CoCaO_3$ films prepared with different deposition periods 10, 20 and 30 minutes were investigated. The transmittance increase with wavelength while the absorbance decrease with wavelength. The transmittance and absorbance varied with deposition time because at first the layer thickness directional proportional to deposition time, then the process is reversed with inversely proportional to deposition time due to the movement of the solution during the deposition process fig. 1.

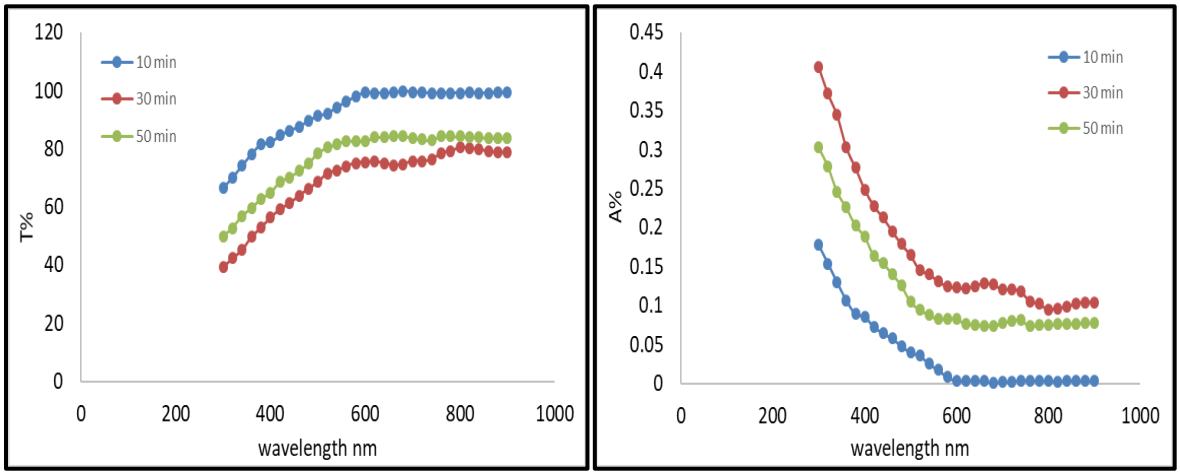


Fig. 1: The Transmittance and Absorbance of $CoCao_3$ Thin Films Prepared with Different Deposition Periods

The energy gap also changed with deposition periods, where the energy gap was about 3.35eV for the films prepared with 10min deposition period the decrease to 3eV for the films prepared with 20 min and finally increase to 3.2eV for the films prepare with 30 min deposition period fig. 2.

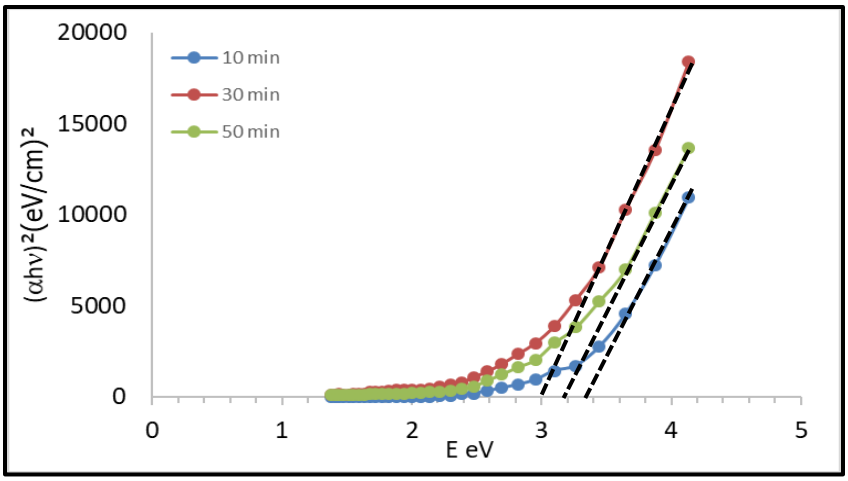


Fig. 2: Energy Gap of $CoCao_3$ Thin Films Prepared with Different Deposition Periods

films examined using SEM, the images of the films prepared with different deposition periods show a clear change in the films structure fig. 3. The grain size at first increase with deposition period then decrease. And this agree with optical properties.

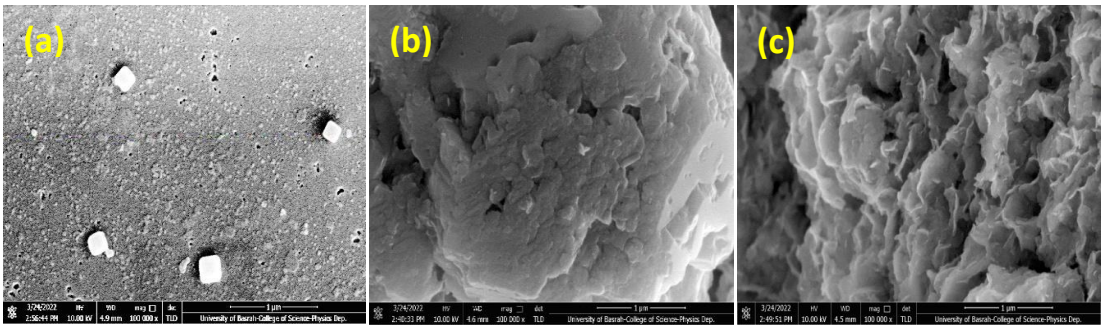


Fig. 3: SEM Images of the Films Prepared with Different Deposition Periods (A)10 Min, (B)20 Min and (C) 30 Min

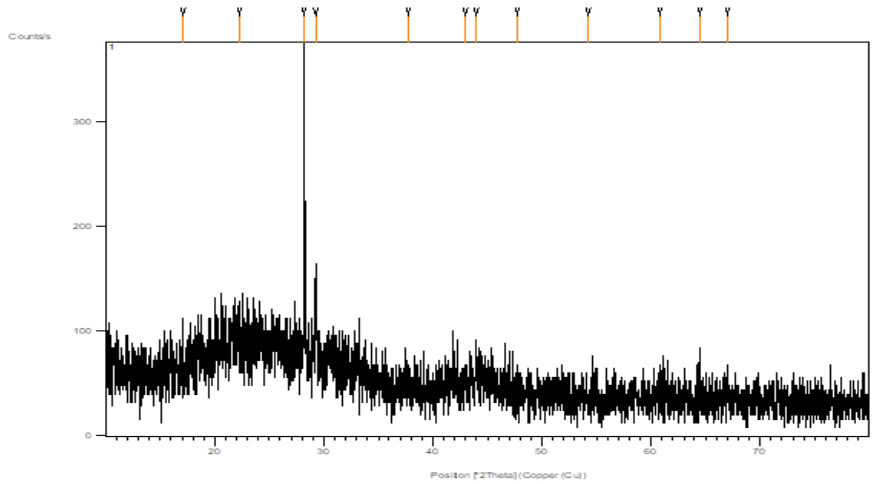


Fig. 4: X Ray Spectra of the Films Prepared with 10 Min Deposition Period at 85°c

Fig. 4 and Table 1 shows several peaks for the films prepared with 10min deposition period at 85°C. the spectrum show that the film includes both phases amorphous and crystalline. The average grain size was about 52.67 nm.

Table 1: Average Grain Size of the Films Prepared with 10 Min Deposition Period At 85°c

2-Theta (θ)	FWHM [°2Th.]	D nm	Average grain size nm
17.1453	0.059	136.1848	52.67039979
22.257	1.8893	4.285886	
28.1991	0.159	51.5205	
29.2861	0.1181	69.53153	
37.7541	0.2362	35.5477	
43.0007	0.2362	36.15071	
44.0073	0.2362	36.2775	
47.709	0.1181	73.55228	
54.2613	1.5744	5.669735	
60.7912	0.1181	77.9834	
64.4707	0.048	195.6528	
67.026	0.144	66.16327	

The transmittance and absorbance of the $CoCaO_3$ films deposited at different deposition substrate temperatures 30,70 and 85°C were investigated. The transmittance increase with wavelength while the absorbance decrease with wavelength. The transmittance and absorbance varied with deposition temperature because of the adhesion increase with temperature which in turn increase the films thickness fig. 5.

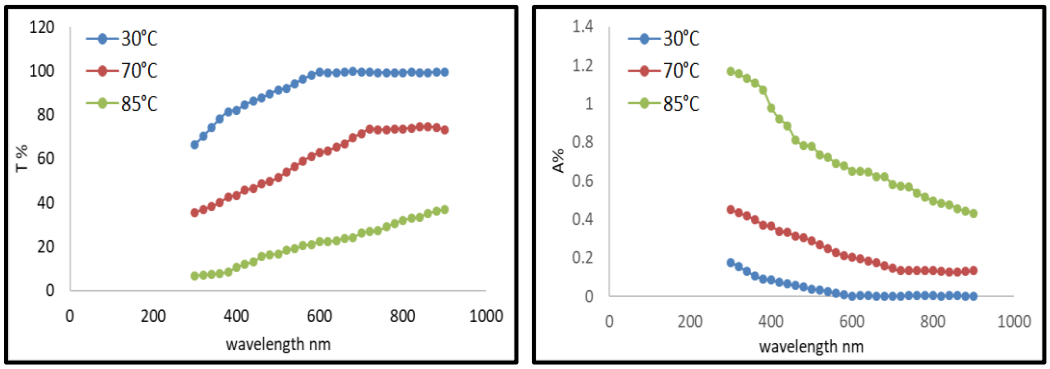


Fig. 5: The Transmittance and Absorbance of $Cocao_3$ Thin Films Deposited at Different Deposition Temperatures

The energy gap also changed with deposition periods, where the energy gap was about 3.35eV for the films prepared at 85°C then decrease to 2.6eV for the films prepared at 70°C and finally decrease to 2.4eV for the films prepare at 30°C fig. 6.

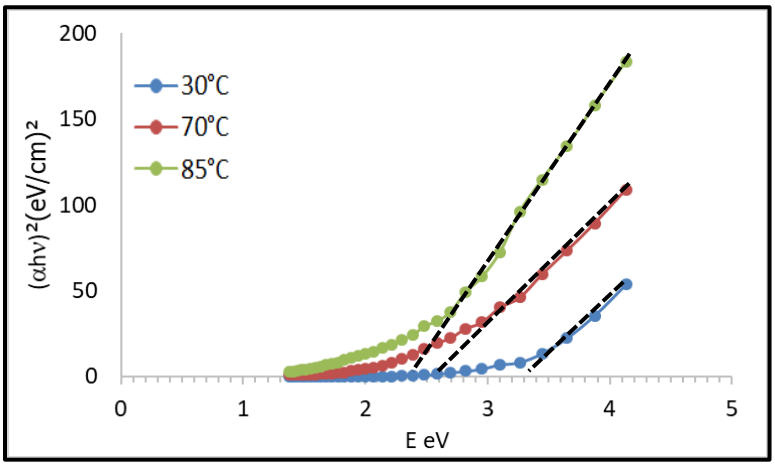


Fig. 6: Energy Gap of $CoCao_3$ Thin Films Prepared at Different Deposition Temperatures

The SEM images of the films prepared with different deposition temperatures show a clear change in the films structure fig. 7. The grain size at first increase with deposition temperatures due to the grow and aggregation process.

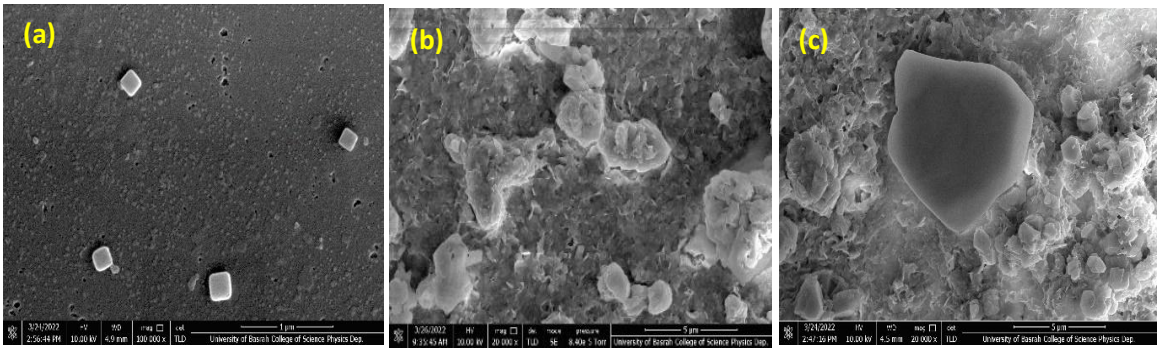


Fig. 7: SEM Images of the Films Prepared At (A)30°c, (B)70 °c and (C) 85 °c.

Conclusions

thin films of $CoCaO_3$ have been deposid on glass substrates using chemical bath deposition. Different parameters can be changes during the deposition but the most important parameters are the deposition temperature and deposition periods. The layer thickness increases with increasing deposition time, then the process is reversed with increasing deposition time. The energy gap also changed with deposition periods, The SEM images of the films prepared with different deposition periods show a that the grain size at first increase with deposition period then decrease, X-ray spectrum show that the film include both phases amorphous and crystalline with average grain size was about 52.67 nm. The transmittance of the $CoCaO_3$ films prepared at different deposition tempertures 30,70 and 85°C were investigated increase with wavelength while the absorbance decrease with wavelength. The energy gap also changed with deposition temperture, where the energy gap was about 3.35eV for the films prepared at 85°C then decrease to 2.6eV for the films prepared at 70°C and finally decrease to 2.4eV for the films prepare at 30°C The SEM images show that the grain size at first increase with deposition temperatures.

Acknowledgments

I would like to extend my sincere thanks to the Presidency of the University of Mosul, the College of Science, and the Department of New and Renewable Energy for their support.

References

Fu, Y., Zhu, H., Chen, J., Hautzinger, M. P., Zhu, X. Y., & Jin, S. (2019). Metal halide perovskite nanostructures for optoelectronic applications and the study of physical properties. *Nature Reviews Materials*, *4*(3), 169-188. https://doi.org/10.1038/s41578-019-0080-9

Bai, F., Bian, K., Huang, X., Wang, Z., & Fan, H. (2019). Pressure induced nanoparticle phase behavior, property, and applications. *Chemical reviews*, *119*(12), 7673-7717. https://doi.org/10.1021/acs.chemrev.9b00023

Mao, H. K., Chen, X. J., Ding, Y., Li, B., & Wang, L. (2018). Solids, liquids, and gases under high pressure. *Reviews of Modern Physics*, *90*(1), 015007. https://doi.org/10.1103/RevModPhys.90.015007?_gl=1*10j4uwe*_ga*OTYzMzg4NjA5LjE3MzQwNzIwMDg.*_ga_ZS5V2B2DR1*MTczOTk0OTY5MS4yLjAuMTczOTk0OTY5MS4wLjAuNjA5NDQ3OTQ

Assirey, E. A. R. (2019). Perovskite synthesis, properties and their related biochemical and industrial application. *Saudi Pharmaceutical Journal*, *27*(6), 817-829. https://doi.org/10.1016/j.jsps.2019.05.003

Ortega-San-Martin, L. (2020). Introduction to perovskites: A historical perspective. *Revolution of Perovskite: Synthesis, Properties and Applications*, 1-41. https://doi.org/10.1007/978-981-15-1267-4_1

Bouarissa, N. (2017). Pressure dependence of refractive index, dielectric constants and optical phonon frequencies of indium arsenide. *Optik*, *138*, 263-268. https://doi.org/10.1016/j.ijleo.2017.03.082

Nikkel, J. W. (2020). Designing Dielectric Materials through Complex Metal Oxides.

Guneri, E., & Ozpozan, N. K. (2023). The Structural and Optical Properties of Perovskite Thin Films. *European Journal of Formal Sciences and Engineering*, *6*(1), 13-21.

Şen, E., Kaleli, M., Aldemir, D. A., & Lapa, H. E. (2024). Investigation of MASnI x Br3− x (x= 3, 2, 1, 0) Perovskite Thin Films Produced by Ultrasonic Spray Pyrolysis Method. *Arabian Journal for Science and Engineering*, 1-10. https://doi.org/10.1007/s13369-023-08536-8

Du, P., Wang, L., Li, J., Luo, J., Ma, Y., Tang, J., & Zhai, T. (2022). Thermal evaporation for halide perovskite optoelectronics: fundamentals, progress, and outlook. *Advanced Optical Materials*, *10*(4), 2101770. https://doi.org/10.1002/adom.202101770

Kerner, R. A., Zhao, L., Xiao, Z., & Rand, B. P. (2016). Ultrasmooth metal halide perovskite thin films via sol–gel processing. *Journal of Materials Chemistry A*, *4*(21), 8308-8315.

Jung, H. S., & Park, N. G. (2015). Perovskite solar cells: from materials to devices. *small*, *11*(1), 10-25. https://doi.org/10.1002/smll.201402767

Cao, Y., Wang, N., Tian, H., Guo, J., Wei, Y., Chen, H., ... & Huang, W. (2018). Perovskite light-emitting diodes based on spontaneously formed submicrometre-scale structures. *Nature*, *562*(7726), 249-253. https://doi.org/10.1038/s41586-018-0576-2

Dimos, D., & Mueller, C. H. (1998). Perovskite thin films for high-frequency capacitor applications. *Annual Review of Materials Science*, *28*(1), 397-419. https://doi.org/10.1146/annurev.matsci.28.1.397