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CaO Thin-Film Preparation using Chemical Bath Deposition

Jamal A. Rasho **Ayad J. Jarjees**

Department of physics/ College of Science/ University of Mosul/ Iraq

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corresponding author:
Jamal A. Rasho
Jamal.23scp163@student.uomosul.ed

ABSTRACT

Calcium oxide (CaO) thin films were created using the chemical bath deposition process on glass substrates (slides). The optical and structural characteristics of films have been examined using contemporary testing methods, such as x-ray spectroscopy, field emission scanning electron microscopy, and spectrophotometers.

The effect of deposition temperature, deposition period and potassium hydroxide (KOH) concentration has been investigated, the optical and structural characteristics of the CaO films clearly vary throughout all experiments.

The film's transmittance, absorbance and energy gap varied clearly with wave length. For films created using solutions with (1.702 and 3.92)g of KOH concentration, the energy gap rises from (2.38 to 2.58) eV, but for films made at (50 and 70)°C, it rises from (2.7 to 2.9)eV. The energy gap decreases from 2.6eV to 2.4eV for the films prepared at deposition periods (20 and 30) min. the scanning electron microscope images and x ray spectrums for all samples agree with the variation in the optical properties.

Keywords: CaO thin films, TCO, chemical bath deposition, optical properties of semiconductors.

INTRODUCTION

One important inorganic substance with excellent physical characteristics and the ability to withstand challenging processing conditions is calcium oxide (CaO) (Zul *et al*., 2021). CaO is especially significant because it is always stable in difficult process conditions and is generally considered a safe substance for both humans and animals (Xu, *et al*., 2022). The white solid CaO nanoparticles are a member of the metal oxide group (Kumar *et al*., 2021). Calcium oxide nanoparticles have drawn a lot of interest due to their unique characteristics and their uses in a variety of industries (Astruc, 2020). CaO is a very significant wide-band gap (Albuquerque and Vasconcelos, 2008) and having the advantage of not being toxic (Kazemi *et al*., 2015). As opposed to homogenous base catalysts, calcium oxide is a low-cost catalyst that has high basicity and non-corrosive properties (Hussein *et al*., 2022). Hence CaO is important of potential applications in different fields, such as catalysts (Mirghiasi *et al*., 2014), Medicine (Wu *et al*., 2023), adsorption (Ahmadi and Aminshahidy, 2018), cement and glass as building materials (Aliabdo *et al*., 2016). Researchers have been used chemical and physical techniques in the preparation of CaO including sol-gel (Prabhavathi *et al*., 2014), chemical precipitation process (Jan *et al*., 2024), thermal decomposition (Butt *et al.,* 2015) Chemical spray pyrolysis (Abdullah, 2025). In this work, CaO thin films were prepared on a glass substrate using the chemical bath deposition approach. Research has been done on the effects of deposition duration, KOH concentration, and solution temperature on the absorbance, transmittance, and band gap of CaO films.

EXPERIMENTAL METHOD

CaO thin films were produced on a glass substrate using the chemical bath deposition process. Various cleaning and solvent solutions were used to clean the substrates (Nirmala *et al*., 2013; Ezzat *et al*., 2014; Uonis *et al*., 2014). Ca was obtained from KOH and $Cacl_2$. KOH and $CaCl_2$ were both melted in 100 mm of distilled water. Solutions were mixed using magnetic stirrer deposition process were performed at 90°C and 10min deposition period. The other deposition process had been accomplished with constant chemical compound concentration, temperature and deposition period (Table 1) (Qassim *et al*., 2023; Abdulkaleq and Al Taan, 2022).

Table 1: Parameters that changed during the preparation of solutions.

$CaCl_2$ concentration (G)	KOH concentration (g)	Deposition Temp. (°C)	Deposition period (min)
5.5	1.702	90	10
	3.92		
5.5	1.702	50	10
		70	
5.5	5.07	90	20
			30

RESULTS AND DISCUSSIONS

Chemical bath deposition has been used to create calcium-oxide (CaO) thin films on glass substrates. The effects of temperature, concentration, and deposition time on the absorbance, transmittance, and band gap of CaO films have been investigated.

Effect of KOH concentration

The optical properties of CaO thin films have been investigated using transmittance and absorbance; the transmittance is inversely proportional to the KOH concentration, while absorbance of these films decreases as a result Fig. (1).

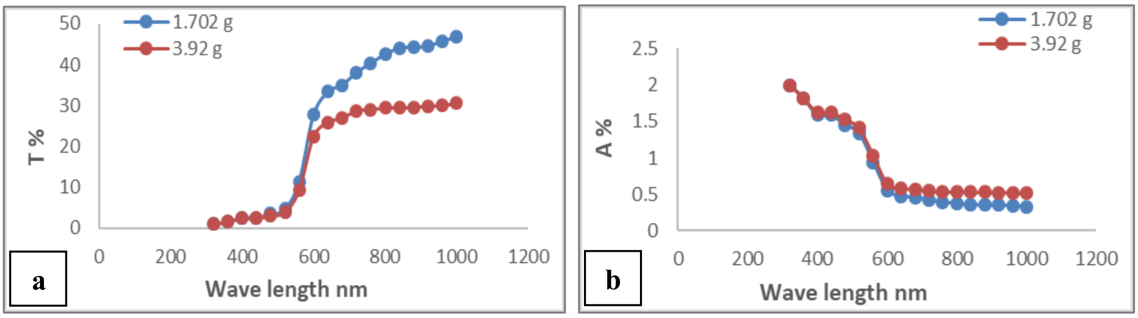

Fig. 1: (a) Shows the variation in the transmittance with KOH concentration.
(b) Shows the variation in the absorbance with KOH concentration.

The energy gap increases from 2.38 to 2.58eV for the films prepared from solutions including 1.702 and 3.92g of KOH concentration Fig. (2).

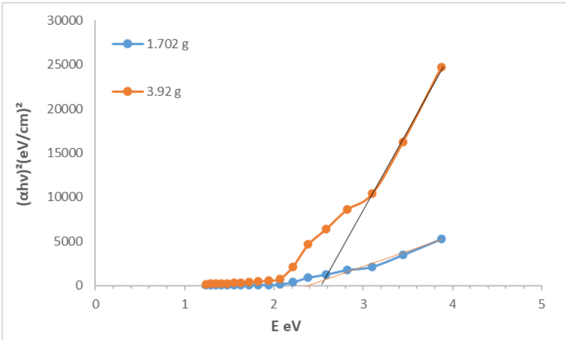

Fig. 2: Energy gaps of CaO thin films prepared with different KOH concentration.

Field emission scanning electron microscope has been used to examine CaO thin films; the image shows that the grain dimension of KOH concentration. The increase in the grains dimensions is due to the increase in the CaO production which in turn increase the grow and aggregations Fig. (3).

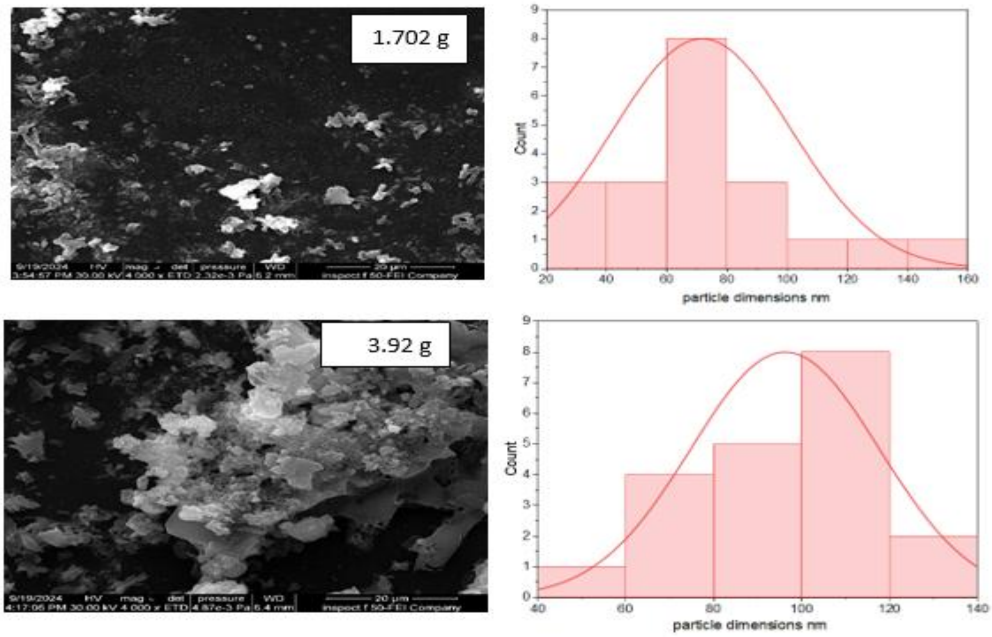

Fig. 3: FESEM images of CaO thin films prepared with different KOH concentration.

X-Ray spectrum of the films prepared from solutions including different concentration of KOH have been measured, the spectrums show several peaks belong to CaO nanoparticles with different positions and intensities, the films are crystalline in both phases (crystalline and amorphous) Fig. (4).

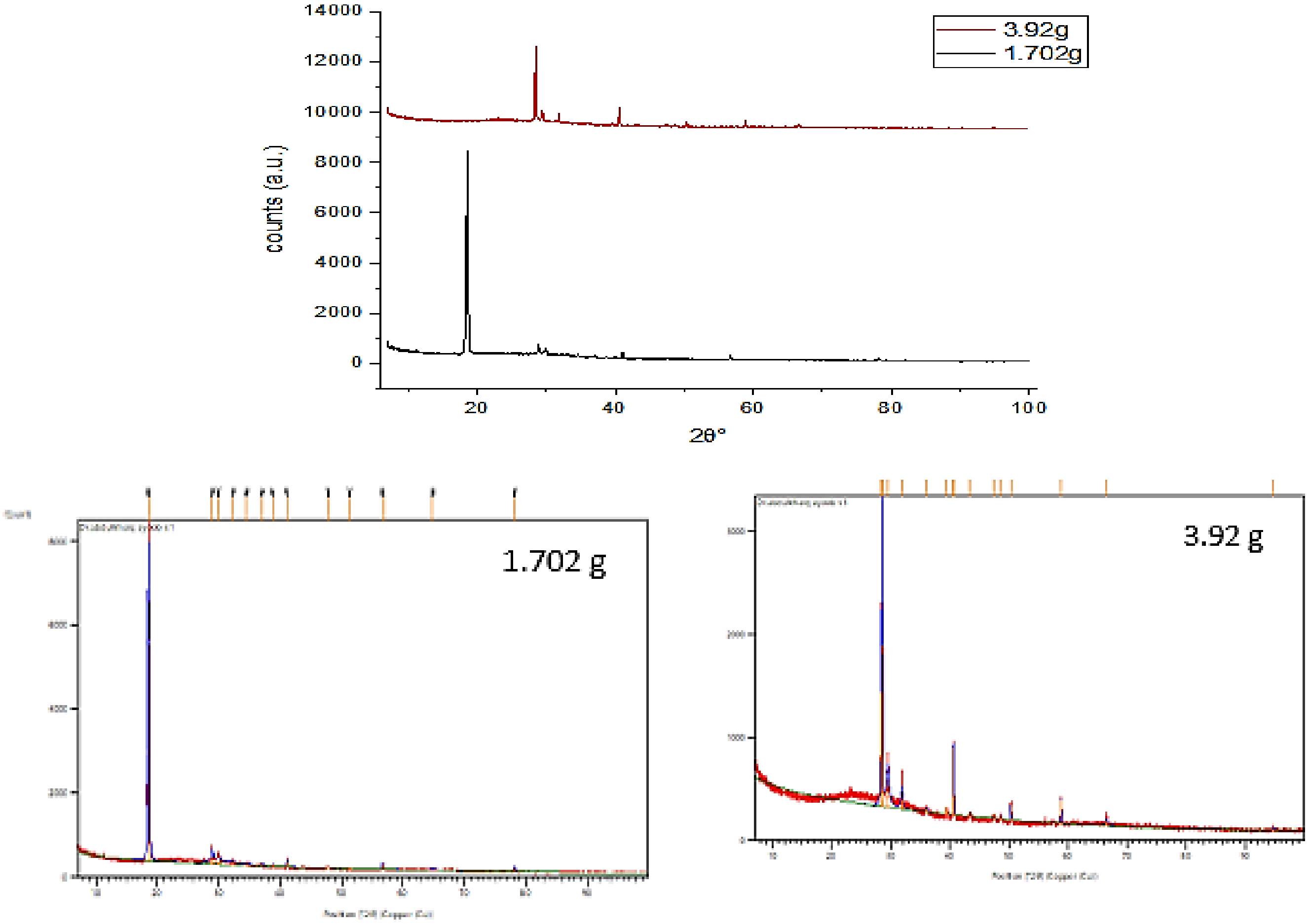

Fig. 4: X-ray spectrum of CaO thin films prepared with different deposition periods.

Effect of substrate temperature

Measurements of the transmittance and absorbance of CaO thin films show that the transmittance is directly proportional to the deposition temperature, while absorbance of these films decreases as a result Fig. (5).

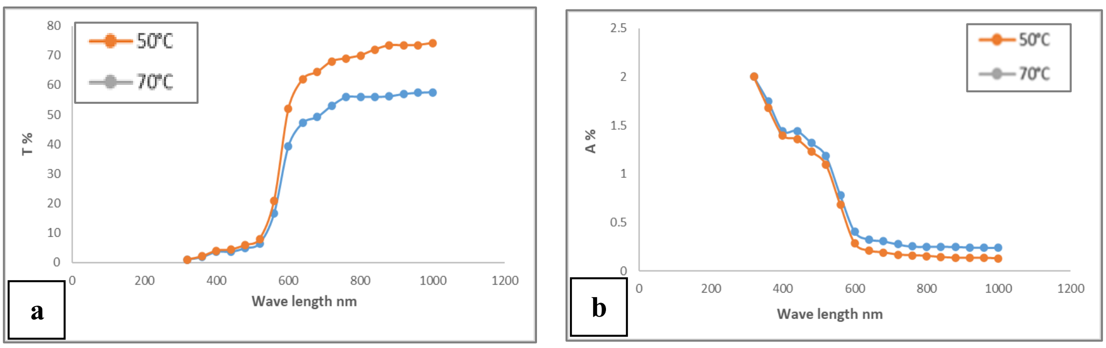

Fig. 5: (a) Shows the change in the transmittance.
(b) Shows the change in the absorbance with different deposition temperature.

The energy gap increases from 2.7 eV to 2.9eV for the films prepared at (50 and 70)°C respectively.

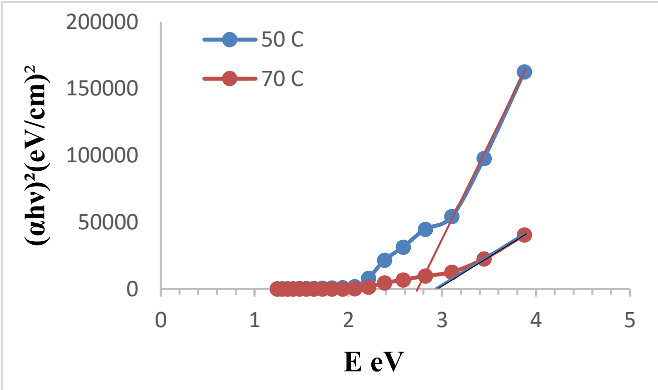

Fig. 6: Energy gaps of CaO thin films prepared of deposition temperature.

Field emission Scanning electron microscope of the samples prepared at different deposition temperature; they show that the grains dimensions decrease with films preparation temperatures. The increase in the deposition temperature try to impede the grow and aggregations process which reflected inversely on the grain dimensions Fig. (7), Where the grain size of the films prepared at 50°C was about 55nm, while it was about 37nm for the films prepared at 70°C.

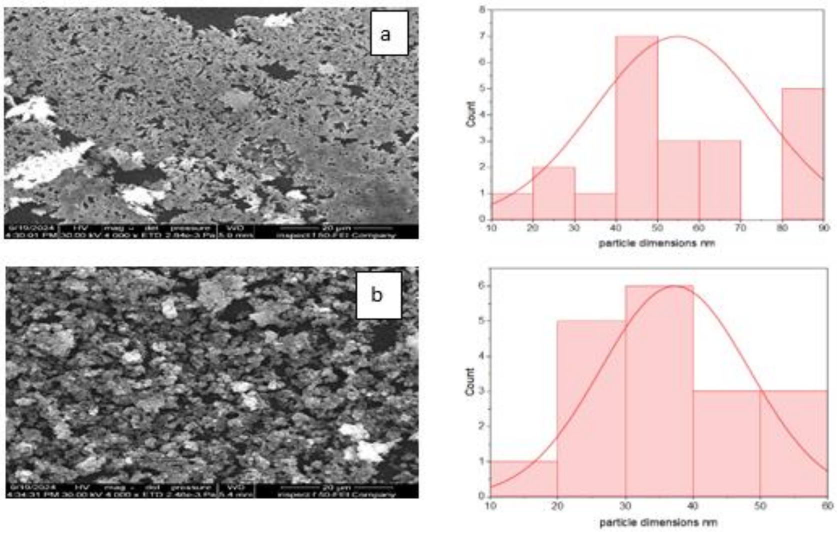

Fig. 7: FESEM images of the CaO thin films prepared at different deposition temperatures. (a) 50°C. (b) 70°C.

X-Ray spectrum of the films prepared at different deposition temperature have been measured Fig. (8).

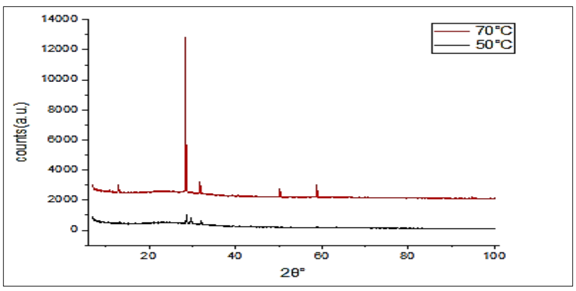

Fig. 8: X-ray spectrum of CaO thin films prepared with different deposition temperatures.

Effect of deposition period

The transmittance is directly proportional to the deposition period, and the absorbance of films decreases as a result Fig. (9).

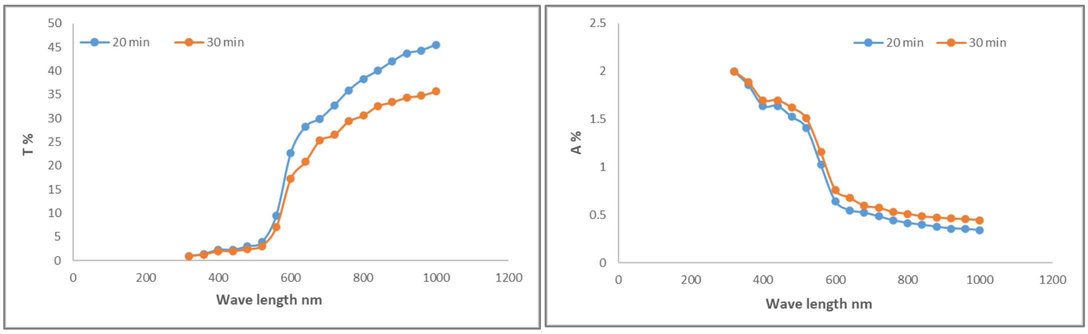

Fig. 9: Shows the variation in the transmittance and absorbance with different deposition period.

The energy gap decreases from 2.6eV to 2.4eV for the films prepared at 20 and 30min respectively Fig. (10).

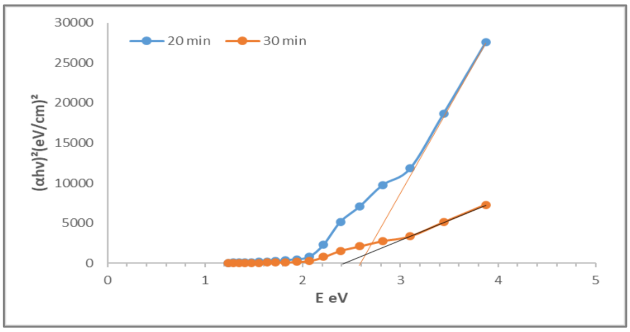

Fig. 10: Energy gaps of CaO thin films prepared of deposition period.

Field emission scanning electron microscope of the samples prepared with different deposition periods show that the grains dimensions increase with deposition periods 20-30min. In the deposition period 20min, the grains grow and aggregate continuously and reach out to the saturation or the maximum grain size at 30min Fig. (11).

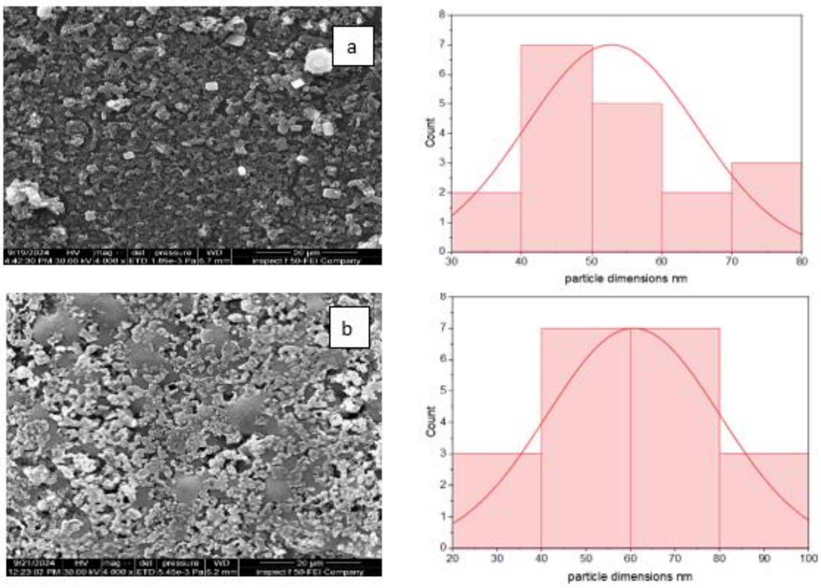

Fig. 11: FESEM images of the CaO thin films prepared with different deposition period. (a) 20min. (b) 30min.

X-Ray spectrum of the films prepared at different deposition period agree with the results of FESEM.

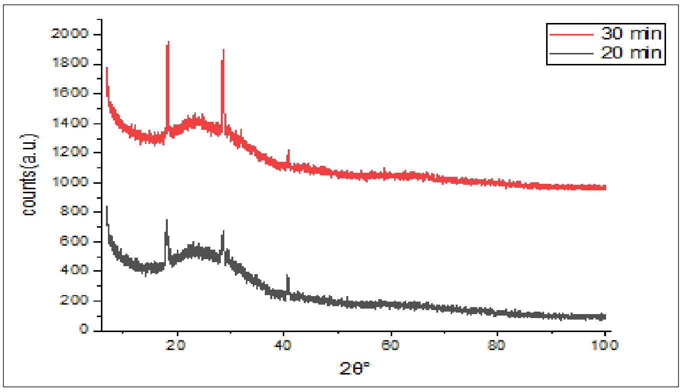

Fig. 12: X-ray spectrum of CaO thin films prepared with different deposition periods.

CONCLUSIONS

Calcium oxide thin films were prepared using chemical bath deposition, the transmittance decrease with KOH concentration, the energy gap also inversely proportional with KOH concentration. X-ray and SEM images show that the grains size and film structure varied with KOH concentration. The increase in deposition temperature will decrease the grain size and hens increase the transmittance of the films. Finally, the deposition period was also affected on the energy gap and film's structure where the increase in the deposition period will result more thick films.

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تحضير أغشية رقيقة CaO باستخدام بطريقة الترسيب بالحمام الكيميائي

جمال عبد العزيز رشو **اياد جياد جرجيس**

قسم الفيزياء/ كلية العلوم/ جامعة الموصل/ العراق

الملخص

تم استخدام تقنية الترسيب بالحمام الكيميائي لإعداد أغشية رقيقة من أكسيد الكالسيوم على ركائز زجاجية (شرائح). كما تم استخدام تقنيات الاختبار الحديثة للتحقيق في الخصائص البصرية والبنيوية للأغشية، بما في ذلك جهاز قياس الطيف الضوئي، ومجهر مسح الانبعاث الإلكتروني الميداني، ومطيافية الأشعة السينية. وقد تم التحقيق في تأثير درجة حرارة الترسيب وفترة الترسيب وتركيز هيدروكسيد البوتاسيوم، وأظهرت جميع الاختبارات تباينًا واضحًا في الخصائص البصرية والبنيوية لأغشية أكسيد الكالسيوم. كما تختلف نفاذية الفيلم وامتصاصه وفجوة الطاقة بشكل واضح مع طول الموجة. تزداد فجوة الطاقة من 2.38 إلى 2.58 إلكترون فولت للأغشية المحضرة من محاليل تتضمن 1.702 و3.92 جرام من تركيز هيدروكسيد البوتاسيوم، بينما تزداد فجوة الطاقة من 2.7 إلكترون فولت إلى 2.9 إلكترون فولت للأغشية المحضرة عند 50 و70 درجة مئوية على التوالي. تنخفض فجوة الطاقة من 2.6 إلكترون فولت إلى 2.4 إلكترون فولت للأغشية المحضرة عند 20 و30 دقيقة. وتتفق صور المجهر الإلكتروني الماسح وأطياف الأشعة السينية لجميع العينات مع الاختلاف في الخصائص البصرية.

الكلمات الدالة: أغشية CaO الرقيقة، TCO، الترسيب الكيميائي، الخواص البصرية لأشباه الموصلات.