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Study the Effect of Deposition Location on the Optical Properties of CuO Absorption Layer Prepared by Fully Computerized Spray Pyrolysis Deposition

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Abstract

The Topography, Physical and Optical properties of as-deposited copper oxide CuO absorption layer sprayed using homemade fully computerized CNC spray pyrolysis deposition technique at different deposition speed are reported. These layers are characterized by UV-Visible spectrophotometer, optical microscope, and thickness monitor studies. The optical transmittance study indicates that these layer exhibit high absorption coefficient in the visible range. The optical band gap is found to be at about 1.5 eV at speeds (3,6 mm/s). Better homogeneity in CuO layer is found at the speed 5 mm/s. The film thickness lies within the 129-412 nm range.

Keywords: fully computerized spray pyrolysis deposition; Transmittance as a function of Positions Optical properties.

دراسة تأثير موقع الترسيب على الخصائص البصرية لطبقة امتصاص من اوكسيد النحاس المحضر بمنظومه الرش الكيميائي المحوسبة المتكاملة

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الخلاصة

الخصائص الفيزيائية البصرية وطبوغرافيه طبقة أوكسيد النحاس المطلية عند شروط التحضير وبدون معامله حرارية، باستخدام منظومه الطلاء بالتحلل الكيميائي الحراري المتكاملة المسيطر عليها بحاسب الكتروني والمصنعة محليا باعتماد سرع ترسيب مختلفة. هذه الطبقات تم فحص الخصائص لها باستخدام مطياف الأشعة (الفوق البنفسجية – المرئية)، المجهر البصري، وقياسات السمك. حيث أظهرت الدراسة الطيفية لهذه الطبقات ان لها معامل امتصاص عالي في مدى الاطوال الموجية المرئية. كذألك كانت فجوة الطاقة البصرية لطبقات أوكسيد النحاس المحضرة محصورة تقريبا عند 1.5 الكترون – فولت عند السرع 3,6 ملم/ثانيه. أفضل تجانس تم الحصول عليه من خلال فحص الصور المجهرية لطبقة أوكسيد النحاس المحضرة كانت عند السرعة 5 ملم/ ثانيه. اما سمك الطبقات المحضرة بالسرع المختلفة كانت في المدى 129–412 نانومتر.

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Introduction

Among chemical methods, spraying technique is most popular today because of its applicability to produce a variety of conducting and semiconducting materials [1–3]. The basic principle involved in spray pyrolysis deposition (SPD) technique is that, when droplets of spray solution to reach the hot substrate, owing to the pyrolytic decomposition of the solution, Spray pyrolysis is a simple and low cost technique for the preparation of metal oxide thin films. It has the capability to produce large area, high quality adherent films of uniform thickness, and in different composition and different melting point source solution but they need a lot of effort and time. A source solution is atomized in small droplets splash and vaporize on the hot substrate, and leaves dry precipitates in which thermal decomposition occurs in correct chemical vapor deposition (CVD) [4]. The SPD has the advantage that thin film and the multilayer thin film formation are possible. This simple SPD may be used to fabricate good quality thin films. The quality (better crystallinity, decrease in grain size, decrease in resistivity and lower defect density) and properties of the films depend largely on the process parameters[5 - 6].a copper oxide CuO thin film have a stable band gap of Eg (1.2-2.1) eV [7–9], no toxicity properties and relative abundance CuO was considered as an interesting material for a wide array of applications such as heterogeneous catalysts for several environmental processes [10–14], solid-state gas sensor heterocontacts [15–19], and microwave dielectric materials[20]. Their use in power sources was received special attention. Thus, in addition to photovoltaic devices [21,22], copper oxides were used as an electrode material for lithium batteries and as cathodes in lithium primary cells [23,20].

Experimental

The Copper oxide CuO layers were deposited using a homemade fully computerized spray pyrolysis coating system showed schematically in Figure-1. The starting solution was prepared by dissolving copper (II) chloride $CuCl_2$ as precursor in distilled water. This solution with constant molar concentrations 0.1M and fixed pH value of 2 was sprayed into fine droplets of full cone nozzle aperture size 350 µm shown in Figure-2, using compressed air as a carrier gas on microscopic glass substrates, heated at a fixed temperature of 450 °C by using real time computerized control monitor system. Before the deposition of films, glass substrates were cleaned carefully and placed them on a deposition plate. Continuous spraying was done in the deposition area 10X10 cm^2 in preparation speed 3,4,5 and 6 mm/s, X to Y interval equal 4 mm, repeated mode spraying process. All these parameters set by using specially prepared program (machine program) usually called a graphical user interface (GUI), To help the non-specialist researcher in software or programing to prepare thin films in large area, homogeneous, specific deposition position can be determined. The flow chart below shows default process and condition and that appear in the Figure- 3. (System design, mechanical, electrical, electronic design, controlling program, graphical user interface GUI, under publishing patented). All experiments were done under approximately similar conditions (flow gas rate).

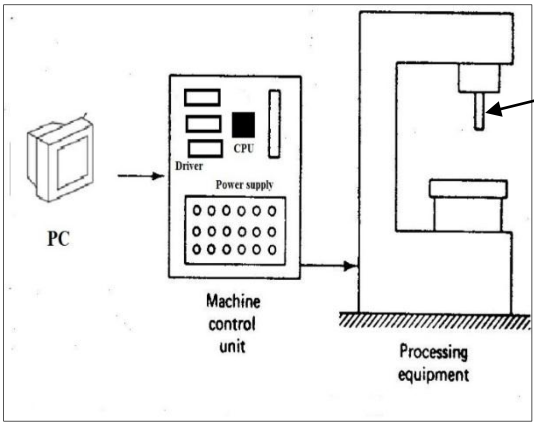

Figure 1- block daigram of FCSPD system.

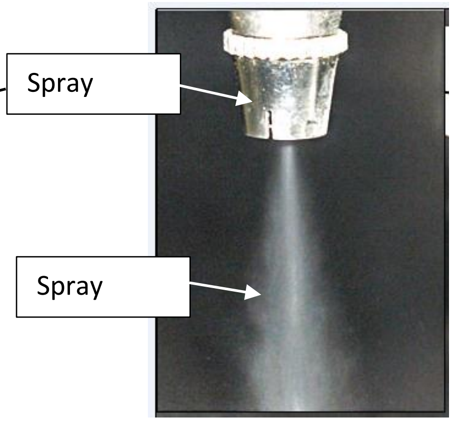

Figure 2 - penumatic spray nozzle.

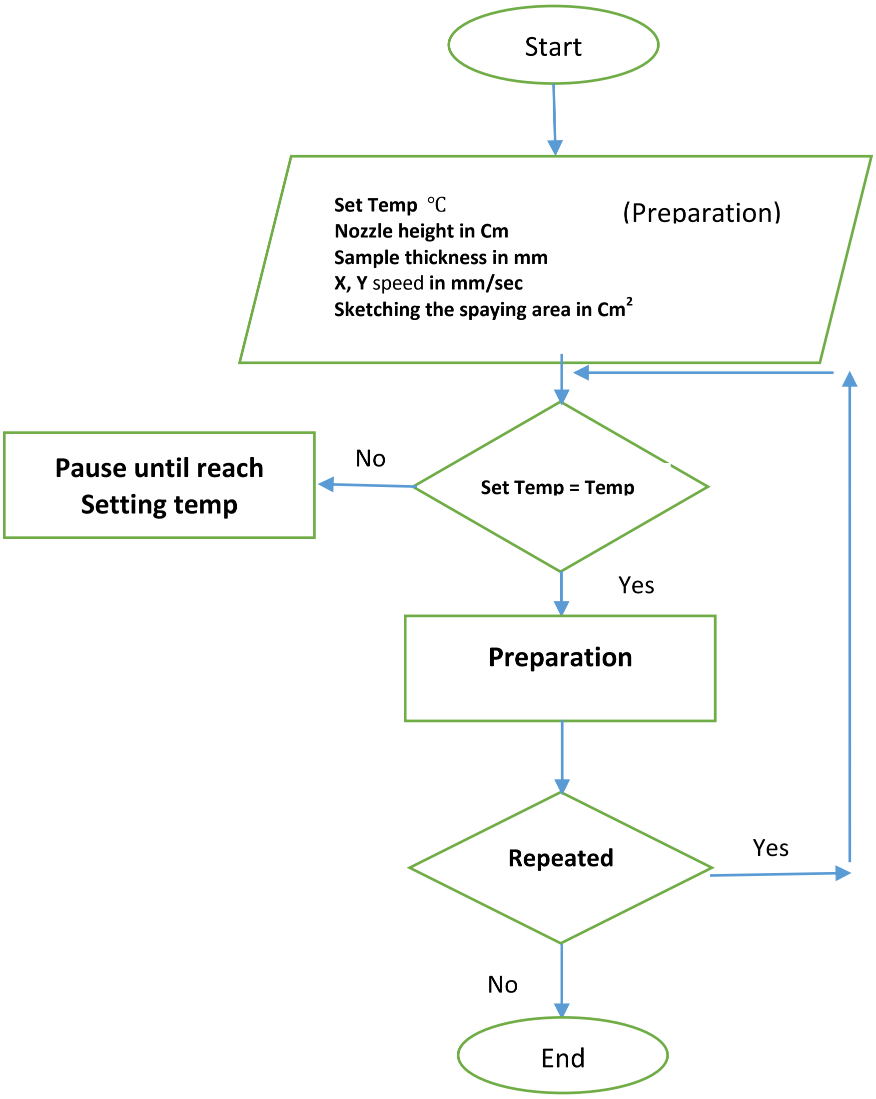

Figure 3- flow chart controlling program of FCSPD.

Result and discussion

Morphological properties

Figure- 4, shows the surface morphology images of CuO layer deposited at different preparations speed and exhibited at high deposition speed a good thickness distribution over the area of the sample and that's clear in the color depth distribution as a function of thickness because of transmittances optical microscope. As well as, linked curve also proved the change the thickness over the sample along X, Y-direction.

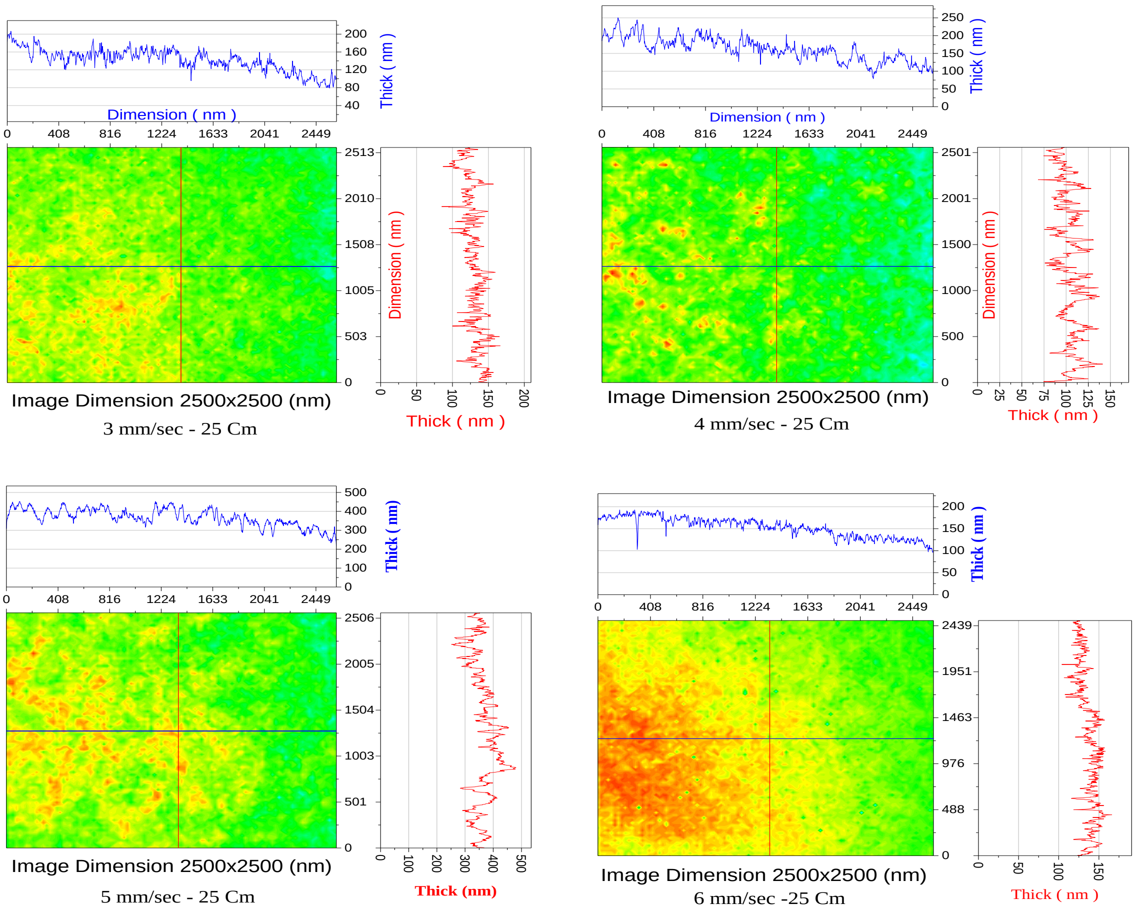

Figure 4- surface topography of CuO layers at different deposition speed

Optical properties

Figure-5 (a, b) shows the sample holder of UV-Vis spectrophotometer, and the Specific locations that have been identified for examined on CuO sample respectively. Optical transmission properties were studied within the wavelength range of 300 to 1100 nm for all sprayed CuO absorption layers match with the result of [24]. Figure-6. depicts the variation of this transmission as functions of positions tested on the substrate of copper oxide layer at different preparation speed. According to this figure we observe that transmission value decreases with an increase in the preparation speed. This result was attributed to the increase in film thickness.

The analysis of α in the visible region permits the energy gap calculation by the linear fit of $(\alpha h\nu)^2 = f\,(h\nu)$. The intercept of the tangent to the plot will give a good approximation of the band gap energy for this direct band gap material. The band gap energy corresponding to the CuO sprayed films elaborated with nozzle to substrate distance (NSD) equal 25 cm and preparation speed (3-6 mm/sec) are about 1.57 eV, 1.751 eV, 1.616 and 1.558 eV since these results coincided with those in reference [7] as shown in Figure-7. It deduces that the energy band gap in optimum value for solar energy application in the speed 3, 6.

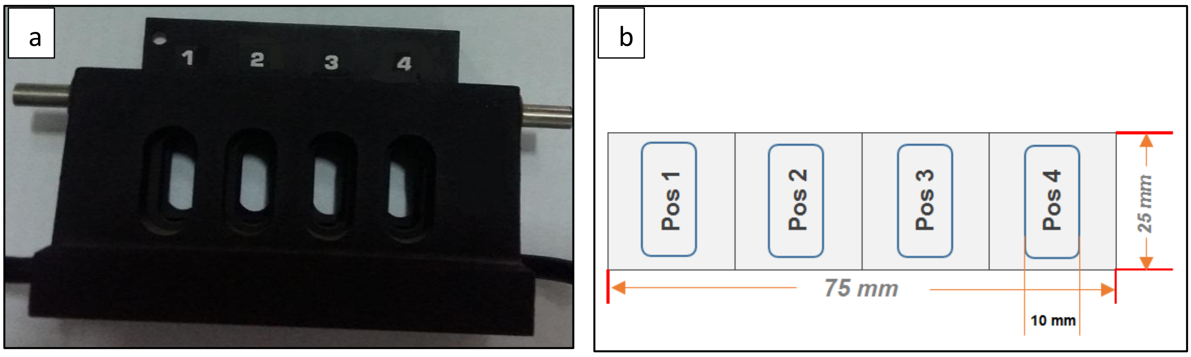

Figure 5- (a,b). ***A*** sample holder of UV-Vis spectrophotometer**.** ***b*** Specific locations on CuO sample identified by examined positions number (Pos)**.**

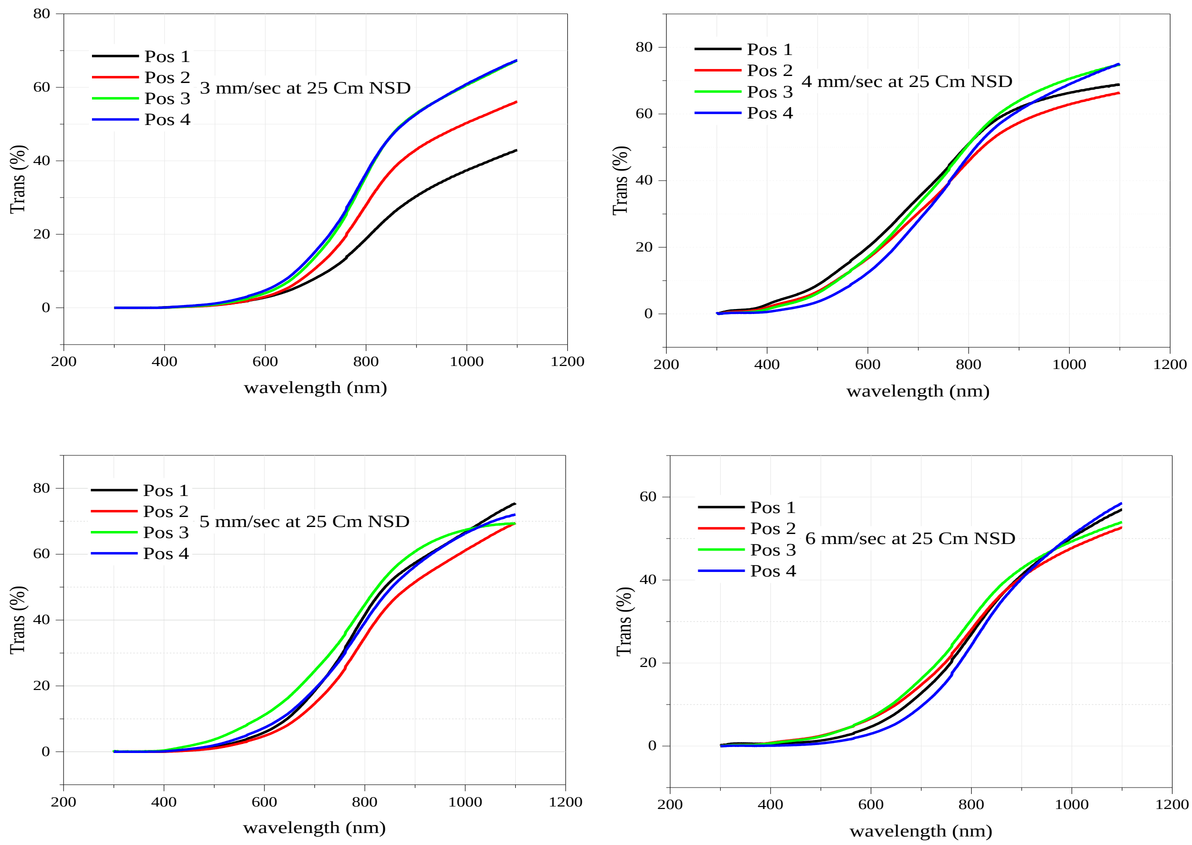

Figure 6- transmitance spectra of CuO absorption layer at different deposition speed &examined positions.

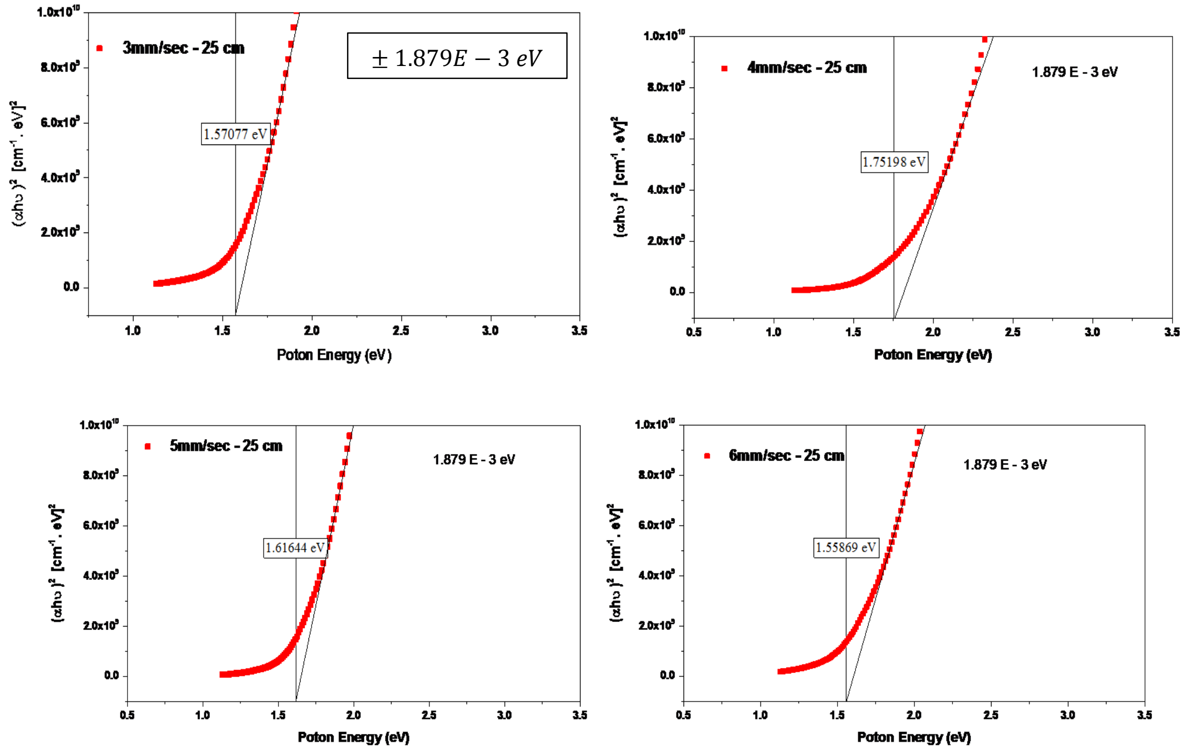

Figure 7- Optical band gap of CuO layer at different deposition speed.

Conclusion

CuO thin films were prepared by using a fully computerized spray pyrolysis technique. Structural, morphological and optical properties were investigated. The obtained results reveal that the preparation speed of copper oxide has an influential role in the sprayed CuO thin film properties. A preparation speed of 6 mm/sec at 25 cm nozzle to substrate height was found to be better homogeneity for preparing CuO thin films. Also that the band gap was varied between the value 1.75 to 1.55 eV depending on deposition speed were used

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