Analysis of the properties of CuO:Sn prepared by pulsed laser deposition.

تحليل خصائص CuO:Sn المحضرة بتقنية الترسيب بالليزر النبضي

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Abstract

In this work, tin doped copper oxide films have been manufactured by PLD. The films were examined by UV-VIS-NIR spectrophotometer, X-ray diffraction and their thickness by utilizing optical interferometer technique. Pulsed Nd:YAG laser was used for arranging $CuO_{0.9}:Sn_{0.1}$ on a glass substrate with varying number of laser pulses at a substrate temperature (673K). The optical properties of as-grown film, for example, optical transmittance, absorption coefficient, refractive index, extinction coefficient and energy gap have been measured tentatively and the influences of a number of laser pulses on it were studied. An inverse relationship between energy gap and the number of laser pulses was observed.

Key words: Thin films, Pulsed laser deposition, CuO, Sn, Optical properties of thin films, XRD.

الخلاصة

في هذا البحث تم تحضير اوكسيد النحاس المطعم بالقصدير بتقنية الترسيب بالليزر النبضي، وتم تحليلها ودراسة خواصها باستخدام مطياف UV-VIS-NIR وXRD. اما سماكات الاغشية قيست بطريقة interferometer. استخدم ليزر Nd:YAG النبضي لتحضير اغشية $CuO_{0.9}:Sn_{0.1}$ على قواعد زجاجية مع تغيير عدد نبضات الليزرعند درجة حرارة 673K. اما ا لخصائص البصرية للاغشية المتكونة مثل طيف النفاذية ومعامل الامتصاص ومعامل الخمود ومعامل الانكسار وفجوة الطاقة فقد درست هي الاخرى . لوحظ العلاقة عكسية بين فجوة الطاقة وعدد نبضات الليزر.

Introduction

Copper oxide is of great interest in semiconductor physics. Copper practices two well-known stable oxides, cuprous oxide (Cu_2O) and cupric oxide (CuO) or Copper (II) oxide or tenorite is also called black Copper [1]. These two oxides have different physical kind of stuff, colors, crystal structure and optical properties. The CuO films are p-type is a semiconductor with optical band gap of around 1.9-2.1 eV [2]. CuO is a promising material for various applications because of the abundance of its fragments
in nature, great thermal dependability, ease generation and electrochemical properties. Therefore, CuO thin films to be a serious candidate for several applications are consider as solar cells [3], gas sensors [4], magnetic storage media [5], varistors and catalysis, antimicrobial activity, high-temperature superconductors, photoelectron Chemical cell and Li batteries. There are many different techniques utilized for depositing CuO films such as, sputtering [4], thermal evaporation [5] and oxidation, molecular beam epitaxial, and electrode position. Although pulsed laser deposition (PLD) [6,7] is approximately used for the improvement of oxide films as a result of its favorable position in the stoichiometry conservation of complex materials, just few reviews have grown cupric oxides by this technique. The PLD of CuO can yield films with enhanced qualities regardless. Tin, symbol Sn. The Sn element is n- sort semiconductor with an indirect optical. As an individual of group (IV) of the Periodic Table and an individual from sub-group containing germanium and lead, has atomic number 50, atomic weight 118.7.

The aim of this work is to study the effect of the number of laser pulses on some optical properties of $CuO_{0.9}Sn_{0.1}$ thin films Deposited by Pulsed Laser Deposited (PLD) Technique at 673K.

Experimental

A thin film of tin doped copper oxides have been prepared by pulsed laser deposition. The mixed powder ($CuO_{0.9}Sn_{0.1}$) was mixed mechanically so that the blend is consistently disseminated. The resultant powder was ground again and was pressed under a 5 ton press to form a target with 2.5cm Diameter and 0.4 cm thickness. The acquired target was as thick and homogenous as conceivable to guarantee a decent nature of the deposit. Nd:YAG laser was used for the deposition of $CuO_{0.9}Sn_{0.1}$. The system consists of light route system, power supply system, computer controlling system, cooling system. The light route system is introduced into the hand piece, however the power supply, controlling and cooling framework is introduced into the machine box of power supply with fundamental harmonic frequency (λ=1064nm,10ns,6Hz) was focused onto $CuO_{0.9}Sn_{0.1}$ target.

Results and discussion

Fig.1 represents XRD patterns of ($CuO_{0.9}Sn_{0.1}$) thin films with different number of laser pulses. The XRD peaks were clearly indexed to the monoclinic CuO phase and amorphous phase is detected in (400 pulse). The intensities of major peaks at (111) and ($\bar{1}11$) increased with increasing number of laser pulses

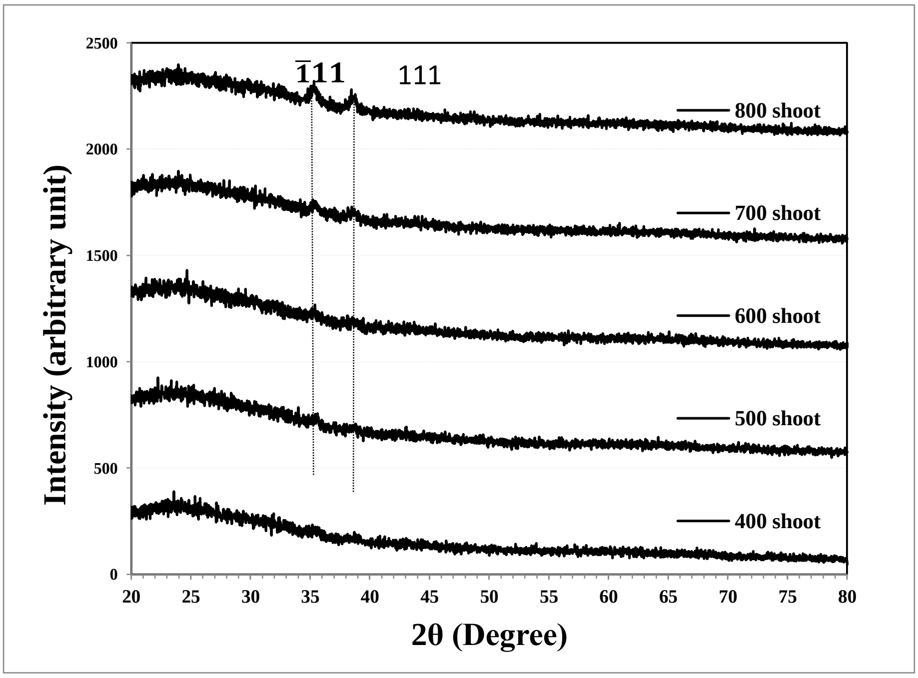

Fig. 1: XRD patterns of ($CuO_{0.9}Sn_{0.1}$) films with different number of laser pulse at 673K.

It can be noticed from Table (1) that the grain size increase with the increasing of number of laser pulses. This may be due to the improvement of crystallinity in the film.

Table 1: XRD data of ($CuO_{0.9}Sn_{0.1}$) films with different number of laser pulse at 673K

No. of pulses	2θ (Deg.)	hkl	Phase	G.S (nm)
400	Amorphous			
500	35.6290	($\bar{1}11$)	CuO	7.3
	38.8310	(111)	CuO	5.8
600	35.2478	($\bar{1}11$)	CuO	8.4
	38.5260	(111)	CuO	7.9
700	35.3240	($\bar{1}11$)	CuO	9.9
	38.6785	(111)	CuO	10.0
800	35.2478	($\bar{1}11$)	CuO	10.9
	38.5260	(111)	CuO	12.3

For the purpose of measuring the transmittance, laser pulse energy has been set constant at 700mJ, using visible near infrared transmittance spectrum in the region 300nm to 1100nm at temperatures (673K) and different number of laser pulses (400-800) have been illustrated in Fig.2.

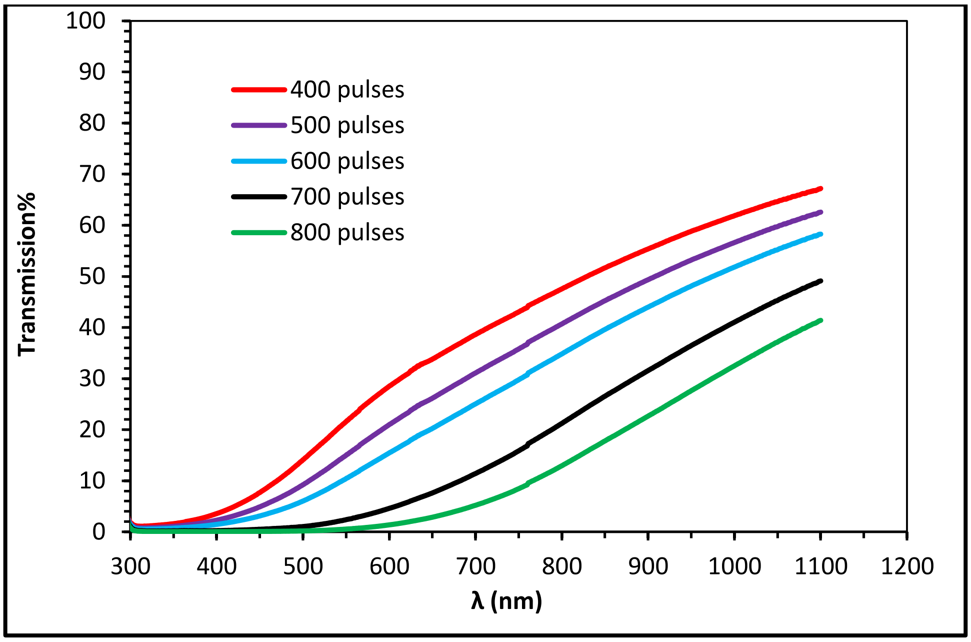

Fig.2: optical transmittance spectra of $CuO_{0.9}Sn_{0.1}$ at the different number of laser pulses by using Nd:YAG laser wavelength 1046nm,laser pulse energy 700nm, and annealing temperature 673K.

It is clear from the above figure that the transmittance decreased with increasing the number of incident laser pulses. This is probably due to the the increase in films thickness, thus the transmittance will decrease with increasing thickness.

Fig.3 shows the variations in the refractive index (n) with wavelength 400-1100nm of CuO0.9Sn0.1 thin films deposited on a glass substrate at temperatures 673K with a different number of laser pulses (400-800). Fig.5 indicates that the refractive index (n) decreases with increasing number of laser pulses and values of the refractive index of $CuO_{0.9}Sn_{0.1}$ thin films for a different number of laser pulses are ranging from (7.285-1.811).

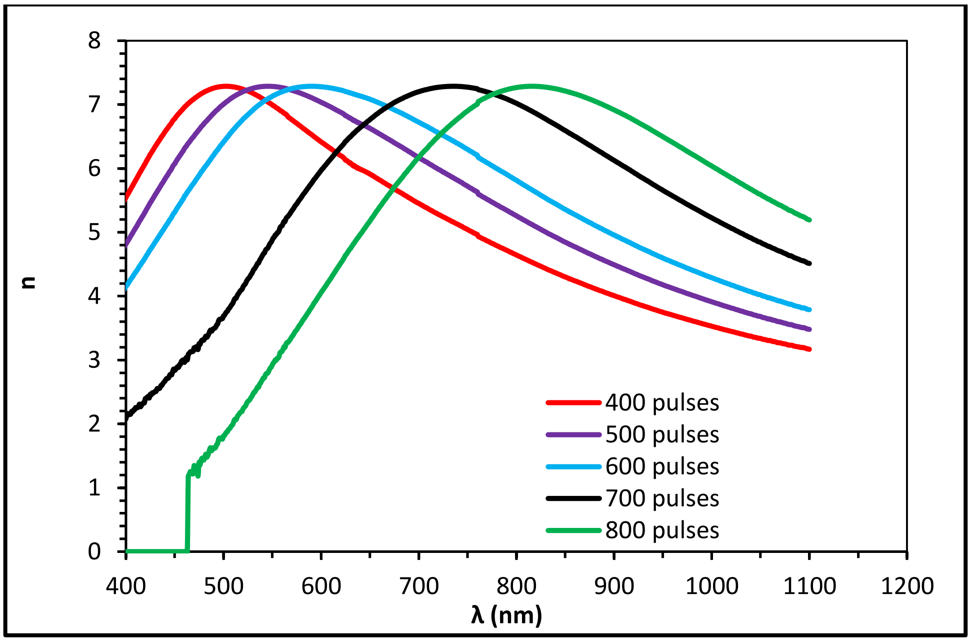

Fig.3: Refractive index of $CuO_{0.9}Sn_{0.1}$ at the different number of laser pulses by using Nd:YAG laser wavelength 1046nm,laser pulse energy 700nm, and annealing temperature 673K.

Fig.4 shows the graphical relationship between the absorption coefficient and wavelength for all films prepared to 673K the results showed that the absorption coefficient gradually increasing with decreases number of laser pulses also showing that the absorption coefficient values of prepared films were (α > 104cm-1) which indicate that the films are owned direct energy.

The plot of (αhν)2 as a function of the energy of incident radiation (hν) of CuO films with different number of laser pulses was shown in the Fig.5. The energy band gap was estimated from the capture of the extrapolated straight part of the curve with the vitality axis at $(\alpha h\nu)^n$ =0 figure refers to direct allowed transition for $CuO_{0.9}$ $Sn_{0.1}$ thin films energies values decreases from (2.7-2.1) with increasing number of laser pulses from 400 to 800 for each $CuO_{0.9}Sn_{0.1}$ film prepared by PLD technique. Fig. 6 shows the influence of the number of laser pulses on band gap energy of the $CuO_{0.9}Sn_{0.1}$ thin films produced by PLD technique.

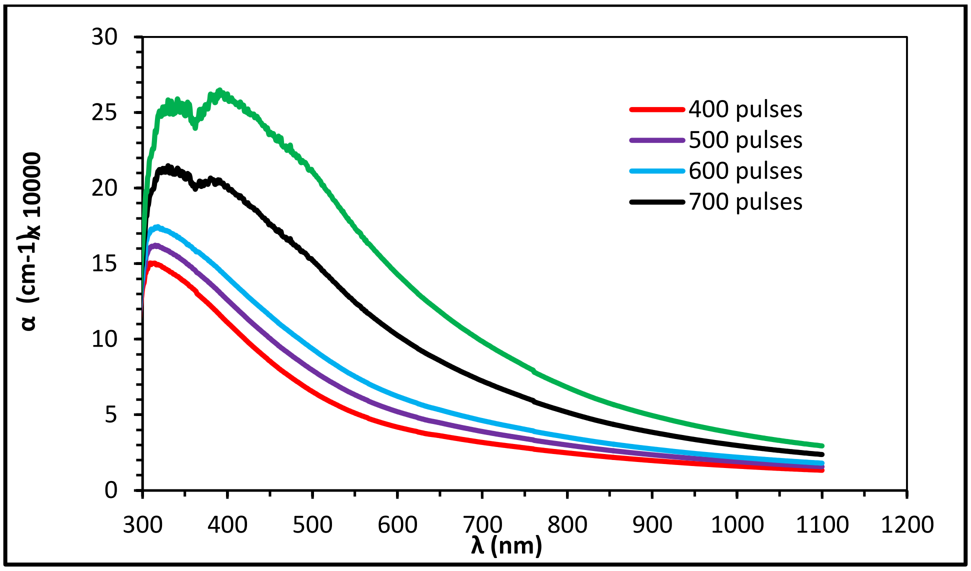

Fig. 4: Absorption coefficient for $CuO_{0.9}Sn_{0.1}$ thin films with various values of laser pulses and annealing temperature 673K.

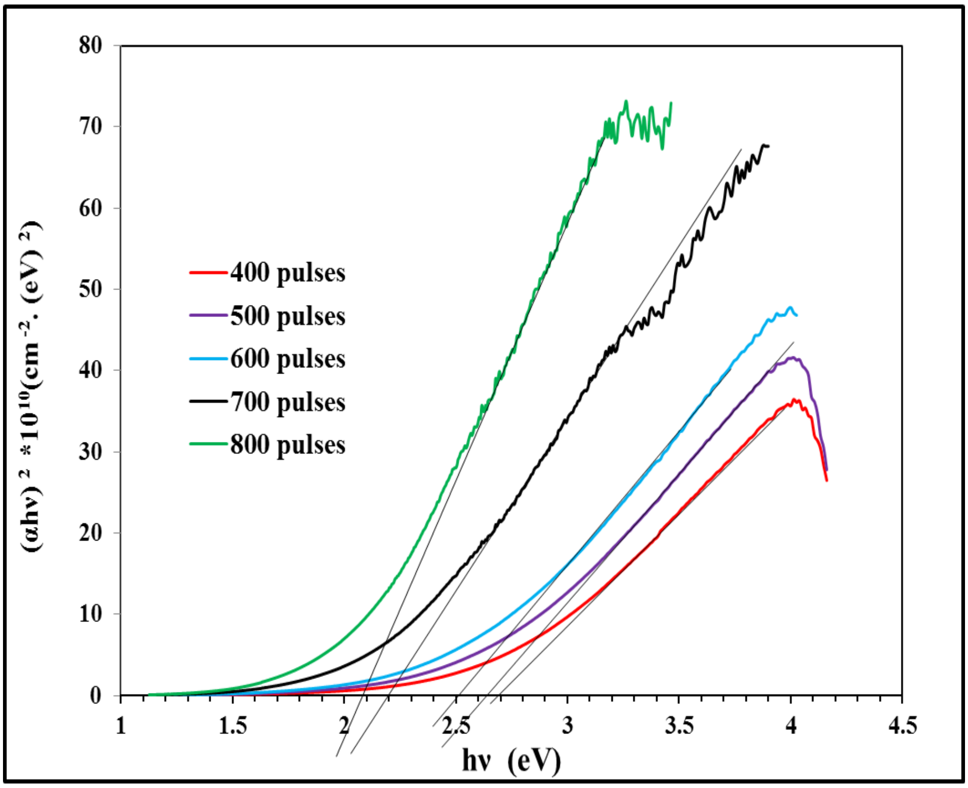

Fig. 5: Variation of $(\alpha h\nu)^{1/2}$ with photon energy (hν) of $CuO_{0.9}Sn_{0.1}$ thin films as a function of number of laser pulses.

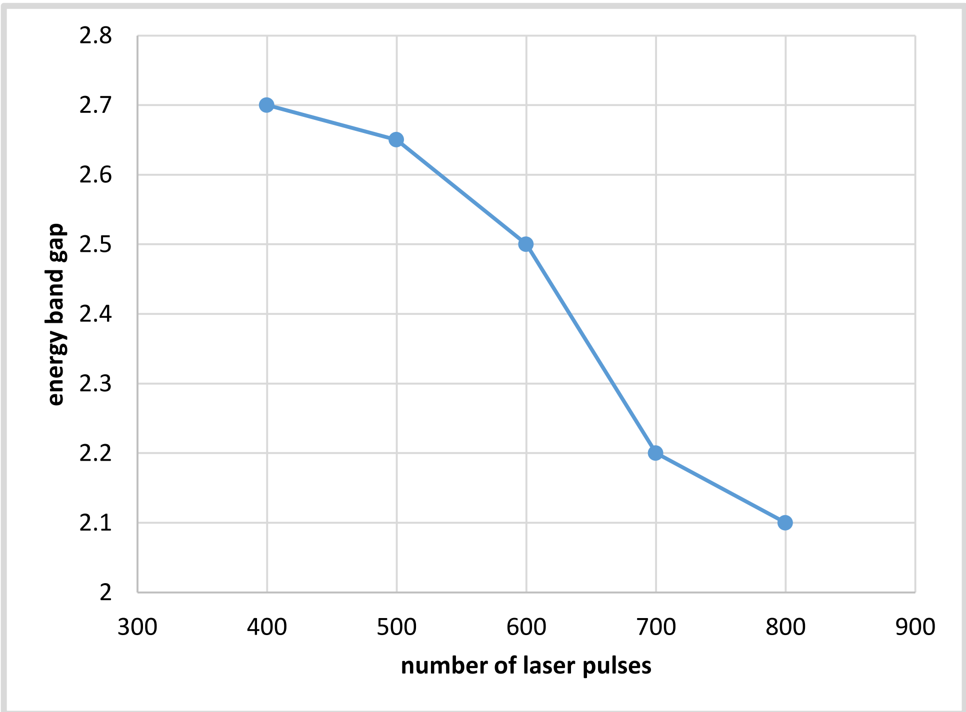

Fig.6: Band gap energy as a function of number of laser pulses.

Extinction coefficient of ($CuO_{0.9}Sn_{0.1}$) films prepared to 673K were studied as a function of Wavelength is shown in the Fig.7. It can be observed from this figure that the extinction, in general, increase with increasing a number of laser pulses.

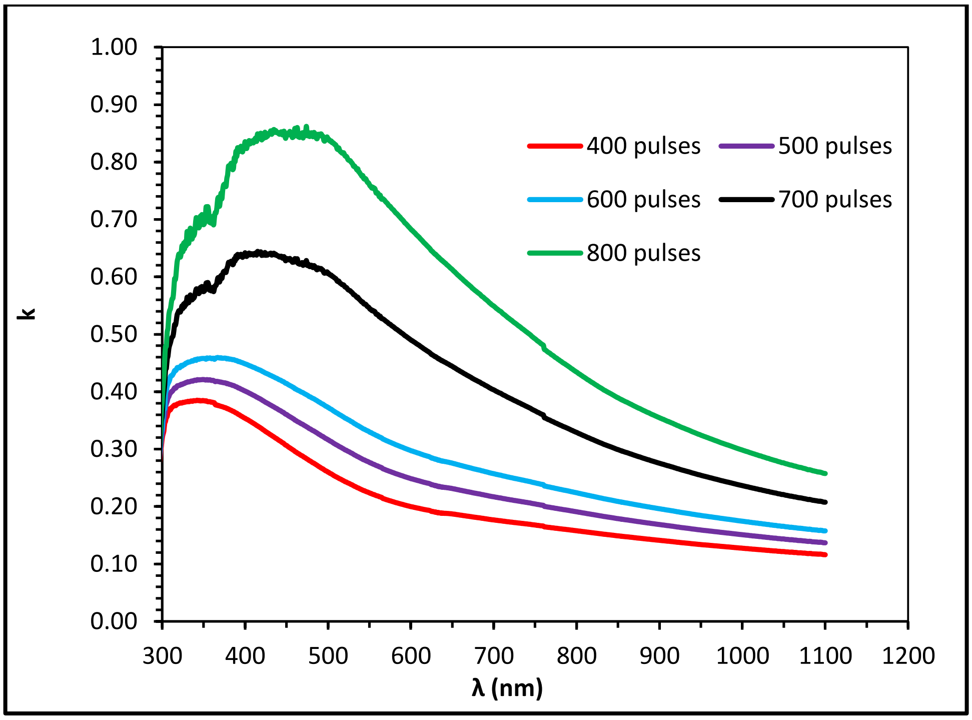

Fig.7: The Extinction coefficient of $CuO_{0.9}Sn_{0.1}$ at the different number of laser pulses by using Nd:YAG laser wavelength 1046nm,laser pulse energy 700nm, and annealing temperature 673K.

Conclusions

The structural and optical properties of $CuO_{0.9}$ $Sn_{0.1}$ prepared by pulsed laser deposition depends strongly on the number of laser pulses. The films deposited at 673K. The XRD analysis shows that the $CuO_{0.9}$ $Sn_{0.1}$ films were a monoclinic structure. The optical properties of the $CuO_{0.9}$ $Sn_{0.1}$ films were investigated. The transmittance, refractive index and energy band gap were increased with the increasing of the number of laser pulses. The absorption coefficient and extinction coefficient increase with the increasing of number of laser pulses.

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