Tikrit Journal of Pure Science 23 (7) 2018
ISSN: 1813 – 1662 (Print)
E-ISSN: 2415 – 1726 (On Line)

TJPS

TIKRIT JOURNAL OF PURE SCIENCE

Journal Homepage: http://main.tu-jo.com/ojs/index.php/TJPS/index

Effect of laser energy on grain size of cadmium oxide nanoparticles in ethanol by PLD method

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ARTICLE INFO.

Article history:
-Received: 10 / 2 / 2018
-Accepted: 29 / 4 / 2018
-Available online: / / 2018

Keywords: Cadmium oxide nanoparticles, Pulse laser deposition technique , The grain size.

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Abstract

The Pulse laser deposition technique was used in the preparation of nanoparticle solutions (CdO) using Nd:YAG laser and five deposition energies (400, 500, 600, 700 and 800 mJ) with fixed pulses (300 pulse and 6 Hz) was used .
(CdO) nanoparticles were deposited on glass substrate at (300C°) to study structure properties and formed thin films of thickness (200 nm). The grain size of cadmium oxide nanoparticles in ethanol have been found to be affected by the laser energy , The results of the AFM tests showed that the higher the deposition energies, the greater the higher the grain size.

Introduction

Due to the increasing complexity of TCO-based devices, it is essential to enhance the electrical and optical properties of transparent conductive oxide thin films. Thus, deposition techniques play an important role in improving thin film properties. These techniques include chemical and physical vapor deposition, thermal decomposition and pulse laser deposition. The similarity in the calculation of reactants makes the progress in pulse laser deposition suitable for the deposition of complex oxides. In laser pulse deposition technology, high-energy laser pulses are used to evaporate the material from the surface of the target because of the very low ambient pressure mixture in the sediment chamber and the high energy of the emission beam. The atoms, ions and electrons are naturally expelled to the surface of the target [1,2].

The Nd:YAG laser is one of the solid state lasers used in deposition technology [3]. The Nd:YAG laser generates high-energy laser pulses which is caused by the chronological age of electrons in the volatile energy level. The active medium, here, is a great reservoir of energy [4]. In order for the laser to have an effect on the material, there must be an absorption of the laser beam. This absorption is highly important for the interaction between the laser and the material. The absorption process is an essential source of energy within the material. This source shows that the laser beam emitted determines the material Laser irradiation. The falling pulse of the laser quickly heats the target material, causing a phase shift and, thus, generates waves of stress in the irradiated target. The useful range of the wavelengths in the laser deposition technique is (200-1100) nm [5,6].

Materials and methods

Cadmium oxide nanoparticles were synthesized by pulsed laser deposition of cadmium oxide target in ethanol. The cadmium oxide target (purity of 99.95%) was fixed at bottom of glass vessel containing of 4 ml of ethanol , the level of the ethanol up to the target surface is 5 mm, the high of laser source is 17 cm, The deposition was achieved using focused output of pulsed Nd:YAG laser operating with a repetition rate of 6Hz. Deposition is carried out with laser operating at 1064 nm wavelengths with (400,500,600,700,and 800) mJ by (300) pulses. (CdO) nanoparticles were deposited on glass substrate at (300C°) to study structure properties and formed thin films of thickness (200 nm). The grain size of cadmium oxide nanoparticles measured by Atomic force microscope (AFM) .

Results and discussion

Figures (1a), (2a), (3a), (4a), (5a) show 2D images of CdO samples showing roughness average, Root mean square and the diameter average of grain size. The comparison of energy deposition of each form shows that by increasing the deposition energy the roughness average is and the root mean square decreased and grain diameter are increased due to perpendicular crystalline surface growth [7]. While figures (1b), (2b), (3b), (4b), (5b) are 3D images of CdO samples representing the topography of all sample surfaces. They also show the appearance of grain formation which is formed on the surfaces. The Z axis represents surface thickness which means the highest peak of crystalline crystals on the surface. By comparing the three-dimensional images of the CdO samples according to the different deposition energies, it is proved that the higher the deposition energy is the less the thickness, which ensures the regularity and crystalline growth in addition to the even spread of grains, thus reducing the defects in the sample[8]. The values of grain particle size and distribution of grain aggregates obtained by surface growth are illustrated in Figures (1c), (2c), (3c), (4c), (5c) The diagram shows percentage of grain particle size distributions on the surface of the samples. These values prove that the more the sample's energy deposition is the more the regularity of distribution. This in turn is attributed to the increase of atoms' growth rate and grain size partials rate. Thus, it leads to less crystalline defects and improves the crystalline formation of the sample [9]. For the ease of comparison between the results obtained for each sample and the effect of each deposition energy on the structural characteristics resulting from this test, these values are shown in Table (1).

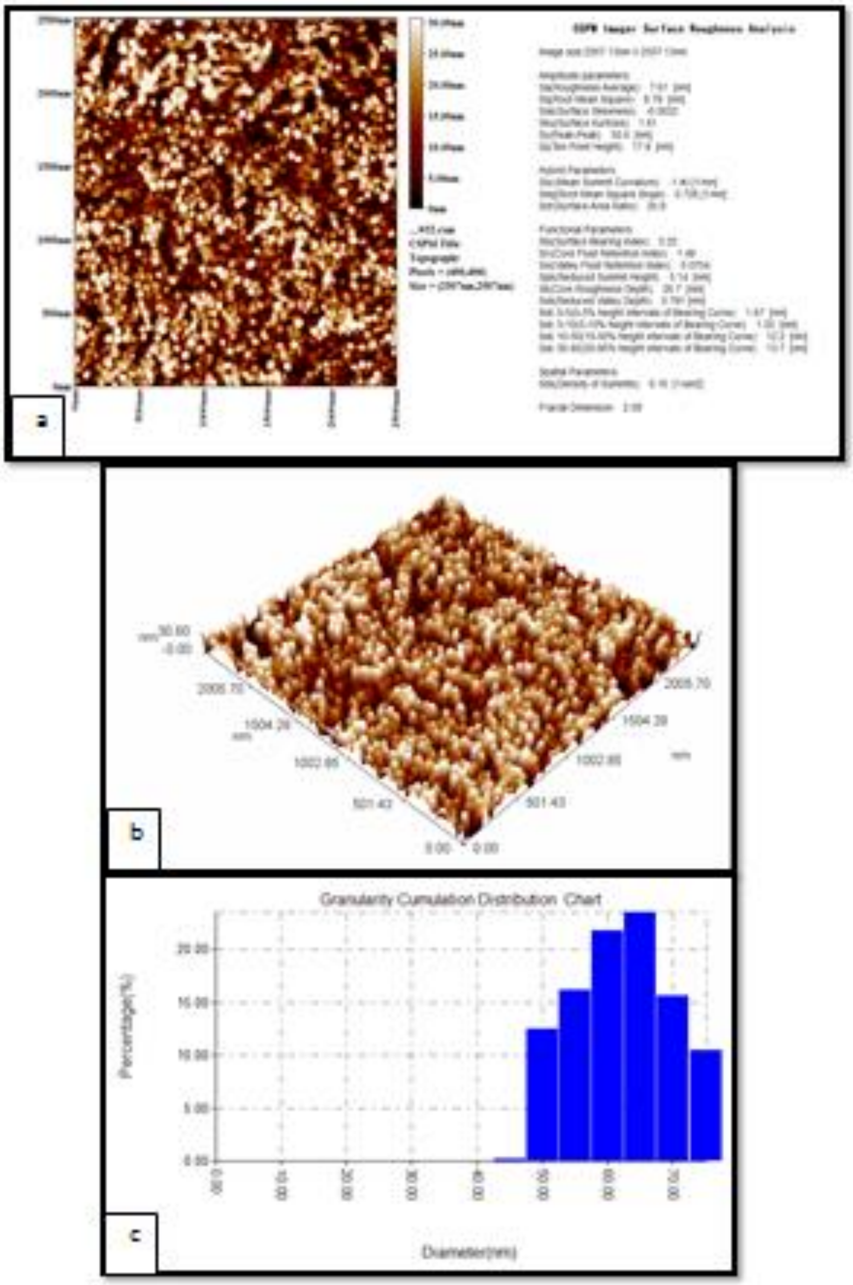

Fig.1: AFM images of Prepared CdO with (400) mJ a-2D images b-3D images c- grain size distributions

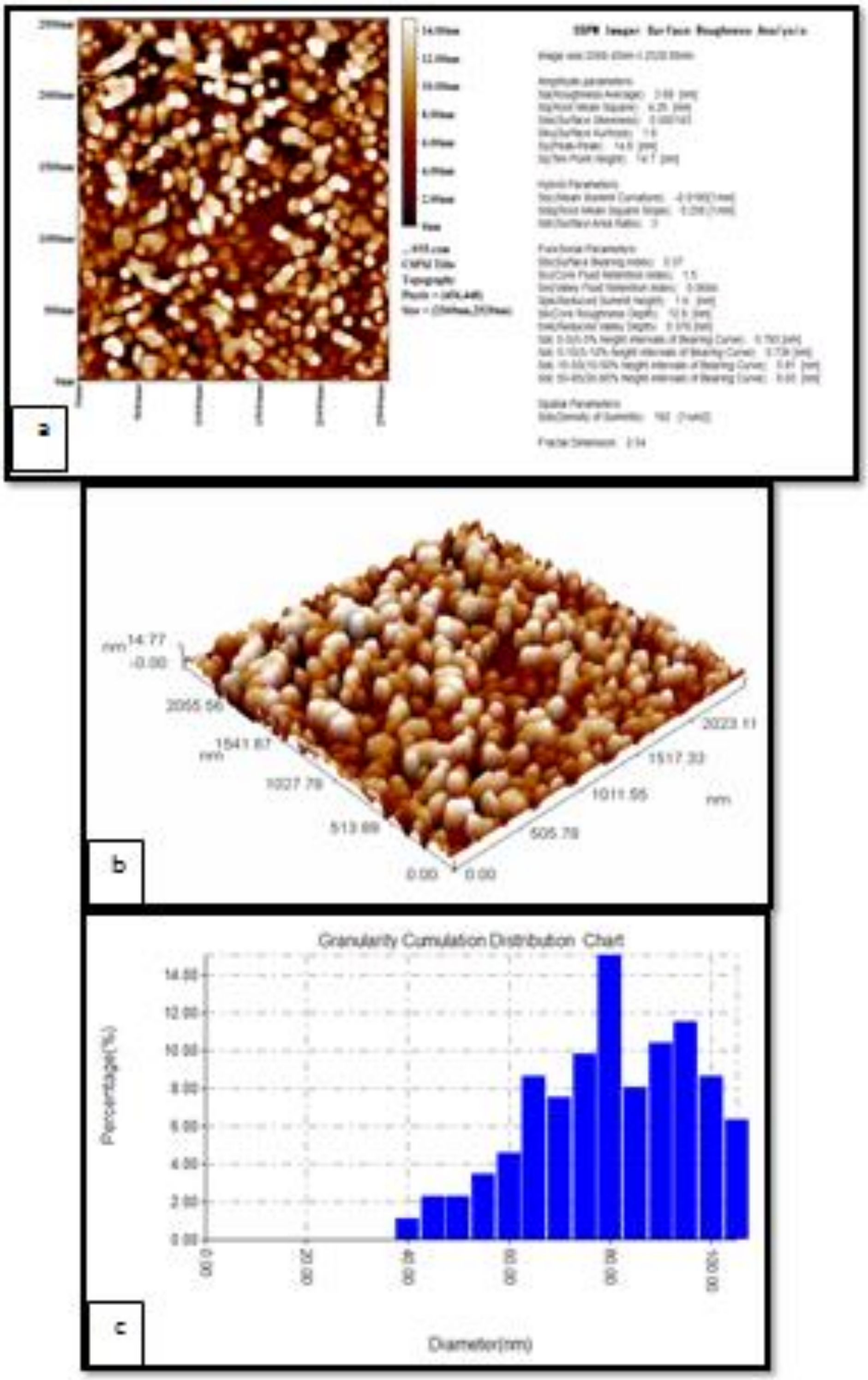

Fig.2: AFM images of Prepared CdO with (500) mJ a-2D images b-3D images c- grain size distributions

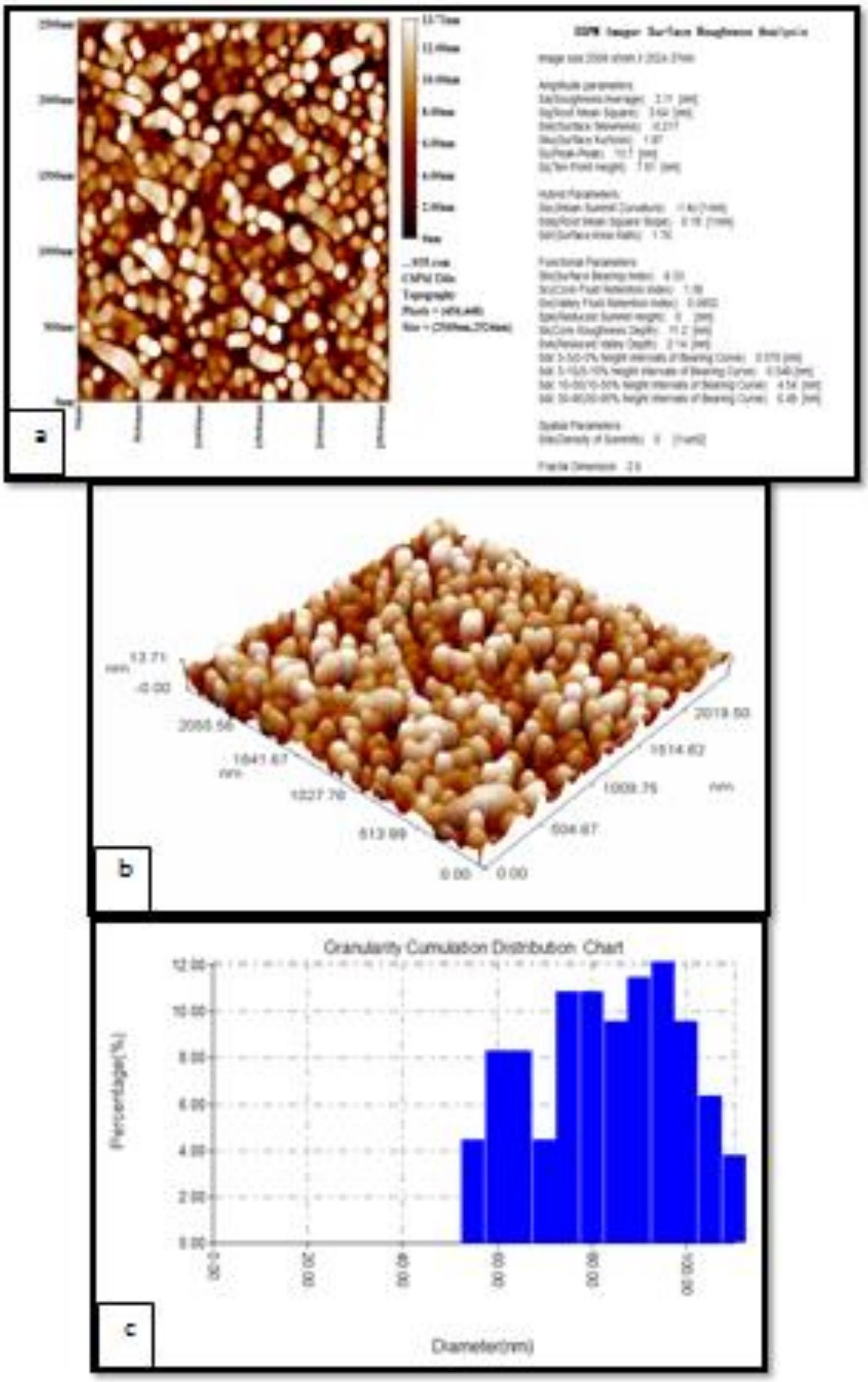

Fig.3: AFM images of Prepared CdO with (600) mJ a-2D images b-3D images c- grain size distributions

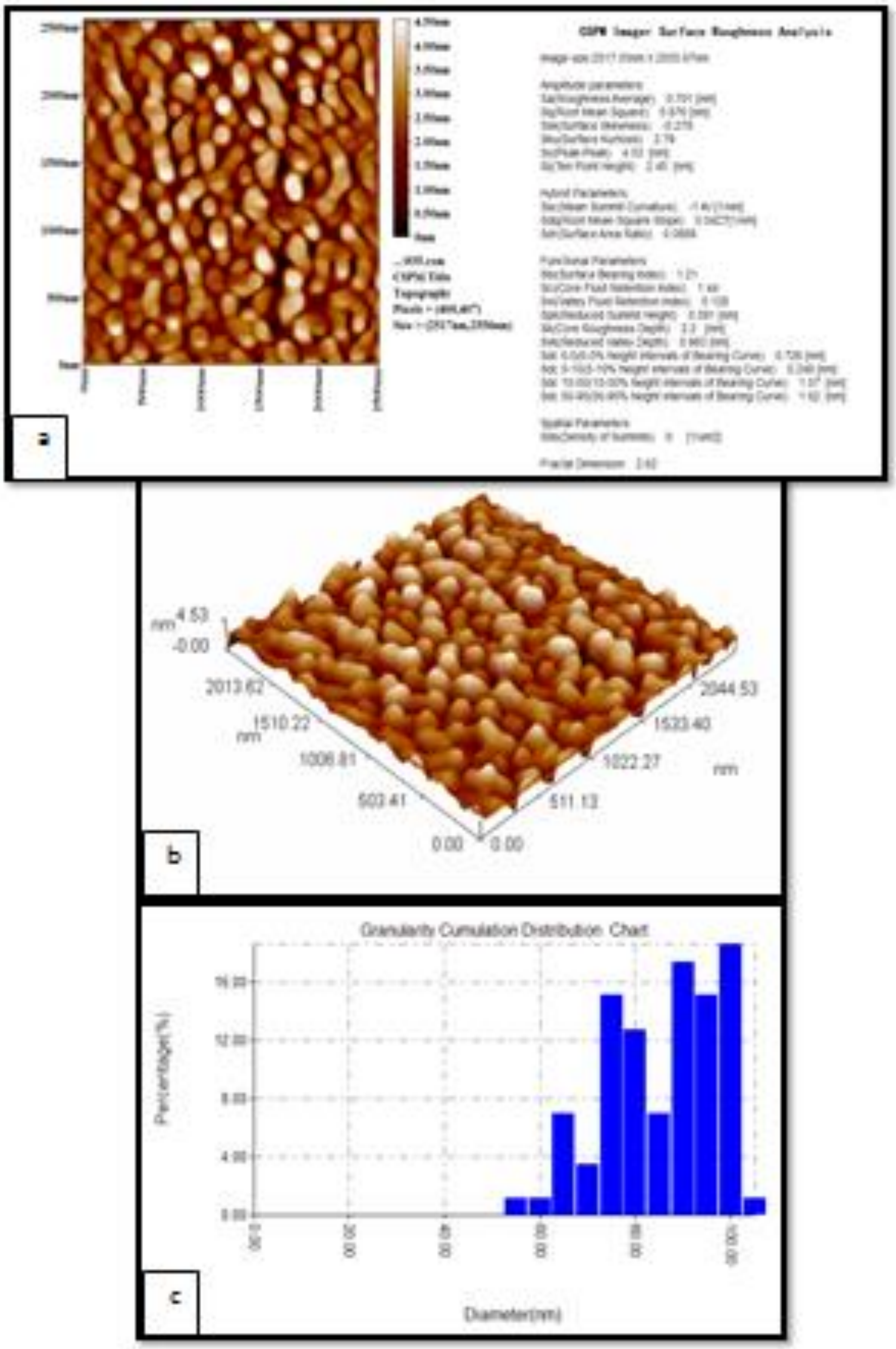

Fig.4: AFM images of Prepared CdO with (700) mJ a-2D images b-3D images c- grain size distributions

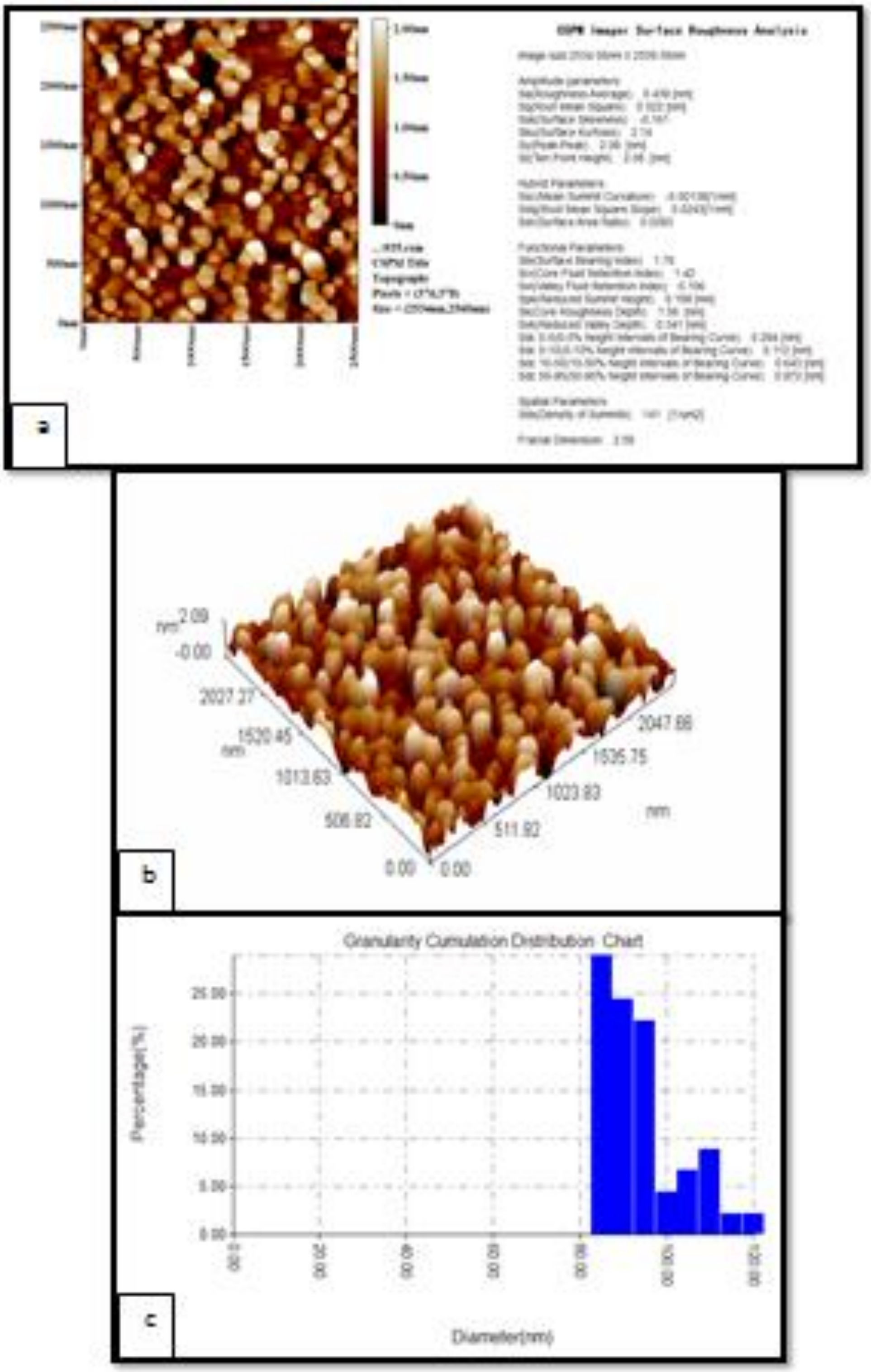

Fig.5: AFM images of Prepared CdO with (800) mJ a-2D images b-3D images c- grain size distributions

Table 1: result of AFM test to CdO Samples

Surface Thickness (nm)	Roughness Average (nm)	Root Mean Square (nm)	Average Grain (Size nm|)	(Laser Energy mJ)
30.60	7.61	8.79	59.67	400
14.77	3.69	4.26	77.67	500
13.71	3.11	3.64	80.54	600
4.53	0.701	0.867	83.32	700
2.09	0.439	0.522	91.26	800

ISSN: 1813 – 1662 (Print)
E-ISSN: 2415 – 1726 (On Line)

Conclusion

The preparation method of CdO nanoparticles via using (1064 nm) Nd-YAG pulse laser has been successfully developed. The possibility of controlling the properties of cadmium oxide nanoparticles is gained by changing the laser deposition energies. Grain size changes as the deposition energy changes.

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تأثير طاقة الليزر على الحجم الحبيبي لجسيمات (CdO) النانوية في الإيثانول بطريقة الترسيب بالليزر النبضي

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الملخص

استعملت تقنية الترسيب بالليزر النبضي في تحضير محاليل جسيمات (CdO) النانوية حيث استعمل ليزر النديميوم ياك ، واستعملت خمس طاقات للترسيب mJ (800، 700، 600، 500، 400) وبعدد نبضات ثابت (300) نبضة وبتردد Hz(6) وبطول موجي nm(1064).

رُسبت محاليل جسيمات (CdO) النانوية على أرضيات زجاجية بدرجة حرارة ($300C^{\circ}$) لمدة ساعة لدراسة الخصائص التركيبية وتكونت أغشية بسمك nm(200) . وجد أن الحجم الحبيبي لجسيمات أوكسيد الكادميوم (CdO) النانوية المحضرة في الإيثانول يتأثر بتغيير طاقة الليزر، إذ بينت نتائج فحوصات(AFM) بأنه كلما زادت طاقة الترسيب كلما ازداد معدل الحجم الحبيبي.