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Effect of current intensity on structural properties of cupper iodine nanoparticles produced by exploding Cu wire

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Abstract

Exploding wire Technique is a way for production metal and its compound nanoparticle that is capable of production of bulk amount at low cost semiconductor. In this work a copper iodine nanoparticles were fabricate by exploding copper wires with different currents in iodine solution. The produced samples were examined by XRD, FTIR, SEM and TEM to characterize their properties. The XRD proved the Nano-size for producer. The crystalline size increases with increasing current. FTIR measurements show a peaks located at 638.92 for Cu-I stretch bond indicate on formation of copper iodide compound and the peaks intensities increase with increasing current. The SEM and TEM measurements show that the thin films have nanostructures.

Key words
Exploding wire, copper iodide, SEM, TEM.

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تأثير شدة التيار على الخواص التركيبية CuI النانوي المحضر بطريقة انفجار سلك النحاس

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الخلاصة

أن طريقة انفجار السلك من الطرق البسيطة لانتاج المعادن والمركبات والتي لها امكانية في انتاج كميات كبيرة بكلفة قليلة، في هذا العمل تم انتاج وتصنيع جسيمات يوديد النحاس بطريقة تفجير السلك باستخدام تيارات مختلفة في محلول اليود واجريت فحوصات XRD, FTIR, SEM, TEM لنماذج المحضرة واثبتت فحوصات XRD أن العينات المحضرة لها خصائص نانوية وان الحجم البلوري يزداد بزيادة التيار واوضحت FTIR أن القمم تقع عند المدى $638.92\ cm^{-1}$ وهي تخص اصرة Cu-I وان شدة هذه القمة تزداد بزيادة التيار. بينت فحوصات SEM, TEM ان الاغشية تمتلك تراكيب نانوية.

Introduction

A nano size CuI is being pursued with great interest because of several possible technical applications in catalysis, drug delivery systems, separation techniques, photonics as well as piezoelectric and other dielectric devices [1].

Explosion wire technique is a simplest technique to produce nanoparticles, which has interested in recent researches [2]. The size and shape of nanoparticles produced by this technique depend on several parameters, such as current pulse, material type and wire diameter [3], and the surrounded medium [4]. Control the size of produced nanoparticle is very important object which altered their electrical and optical properties [5].

Copper iodide is a promising materials in many applications [6]. It is exists in three crystalline forms: zinc blende and rock salt structures depending on temperature [7]. γ- CuI has the most attention due to it is wide bad gap, p- type semiconductor with special optical and electrical properties [8].

Experimental set up

Iodine powder (Purity: 99.99%; Alfa Asser) with concentration 5 mg/ml were used to form iodine solution by dissolving in de-ionized water by magnetic stirrer for 35 hour parted in five days at fixed temperature (333 K) to help the material to be dissolved.

Copper wires with 0.24 mm diameters and 20 mm long were exploded using high currents power supply with DC voltage and variable current (100 and 160 A, at 20 V), with energy higher than the Cu evaporation energy in 100 ml iodine solution to produce CuI nanoparticles. The schematic for used circuit to explode the copper wires to produce nanoparticle is shown in Fig. 1.

The wire was replaced after each of 15 contacts times between the wire and copper plate. Many parameters can influence the particles produced by electro exploding wire technique. In this work, we examined the effects of used current.

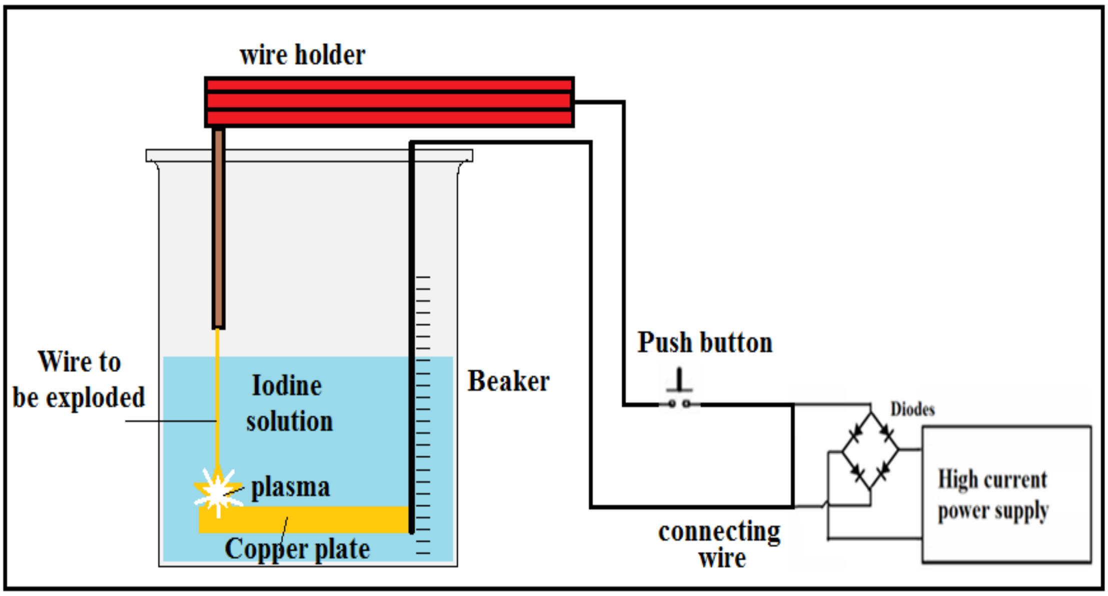

Fig. 1: Schematic for exploding wire.

Drop casting technique was used to deposit the produced nanoparticles on glass slides by put some colloidal drops on cleaned horizontal glass substrates and take the solution to vaporize at room temperature. The structure of the CuI thin films has been examined by X-ray diffraction (XRD), Fourier Transform Infrared Spectroscopy (FTIR), Scanning Electron Microscopy (SEM) and Transmitted Electron Microscopy (TEM).

Results and discussion

Fig. 2 shows the XRD patterns for CuI thin film, produced by exploding Cu thin wire in iodine solution using variable dc current ranging from 100 to 160 A, dropped on glass substrate and dried at room temperature. The results show that all CuI thin films have poly-crystalline structure identical with standard card No. 96-900-8845 for cubic-CuI crystals with peaks located at 25.4974°, 29.4634°, 42.1990°, 49.9411° and 52.3495° along (111), (200), (220) and (311) directions respectively. One can observed that the increasing of current causes to decrease of the peaks intensities and increase the full width at half maximum (FWHM). These behaviors may be due to the decreasing of crystalline size with increasing of current.

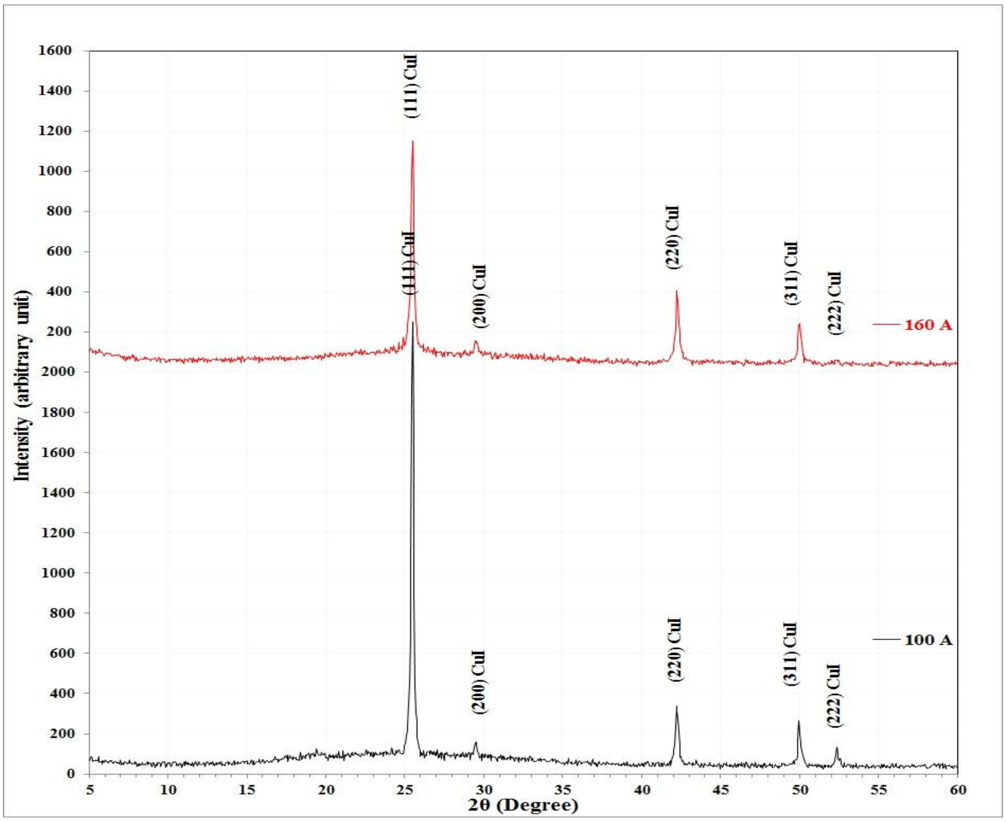

Fig. 2: X-ray diffraction patterns for produced CuI nanoparticles using different current.

Table 1 shows the X-ray diffraction parameters which contain Bragg angle (2θ), miller indices (hkl), experimental and standard inter molecular planer distance (d_{hkl}), FWHM and crystalline size (C.S) for produced CuI nanoparticles using 0.24 mm Cu wire diameter at 100 A and 160 A currents. Also this table shows the average crystalline size for produced CuI decrease with increasing current. These results agree with Reference [2].

Table 1: XRD parameters for produced CuI nanoparticles using 0.24 mm Cu wire diameter with different currents (100 and 160 A).

I(A)	2θ (Deg.)	FWHM (Deg.)	d_{hkl} Exp.(Å)	G.S (nm)	d_{hkl} Std.(Å)	hkl	card No.
100	25.4974	0.1832	3.4906	44.5	3.4888	(111)	96-900-8845
	29.4634	0.1767	3.0292	46.5	3.0213	(200)	96-900-8845
	42.1990	0.2618	2.1398	32.5	2.1364	(220)	96-900-8845
	49.9411	0.1833	1.8247	47.8	1.8219	(311)	96-900-8845
	52.3495	0.1178	1.7463	75.1	1.7444	(222)	96-900-8845
160	25.4994	0.2152	3.4904	37.8	3.4888	(111)	96-900-8845
	29.4968	0.2460	3.0258	33.4	3.0213	(200)	96-900-8845
	42.2065	0.2255	2.1394	37.8	2.1364	(220)	96-900-8845
	49.9963	0.2665	1.8228	32.9	1.8219	(311)	96-900-8845

Fig.3 shows the FTIR measurements for CuI nanoparticles produced by exploding wire technique using 100 and 160 A current. The 100 A current pattern shows two peaks located at 497.18 and 772.55 cm^{-1} corresponding to Cu-I stretch bond indicate on formation of copper iodide compound, and additional bonds located at 1064.12, 1416.42, 1631.05, 2364.00, 2343.76, 2849.94, 2922.83, 2963.33, 3437.12 cm^{-1} corresponding to adsorbed atmospheric gasses in sample [9, 10] as shown in Table 2. With increasing current leads variation in Cu-I bond energy which located at 602.47 cm^{-1} as a result of decreasing particle size which leads to increasing lattice backing.

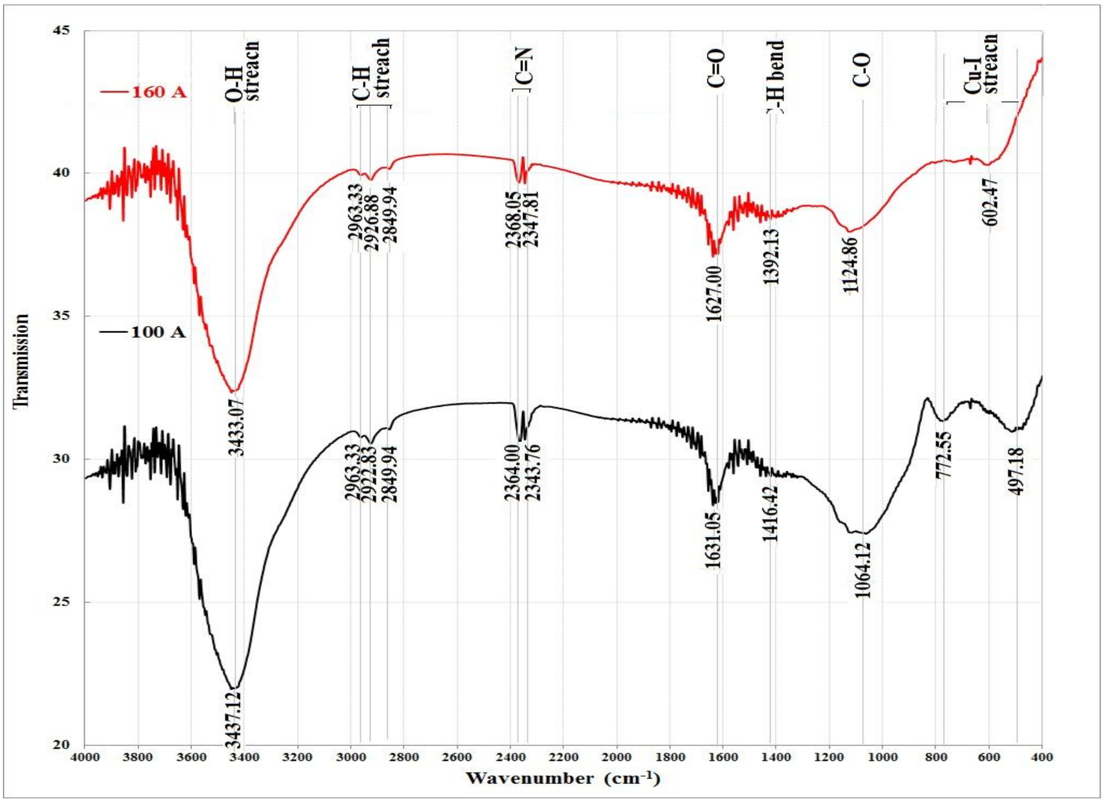

Fig. 3: FTIR for produced CuI nanoparticles using 100 and 160 A current.

Table 2: FTIR bonds of CuI nanoparticles produced by two different currents

	100 A	**160 A**
Cu-I stretching	497.18, 772.55	602.47
C-O	1064.12	1124.86
C-H bend	1416.42	1392.13
C=O	1631.05	1627.00
C=N	2343.76, 2364.00	2347.81, 2368.05
C-H stretch	2849.94, 2922.83, 2963.33	2849.94, 2926.88, 2963.33
O-H stretching	3437.12	3433.07

Fig. 4 shows the SEM image in ×10k magnification power of CuI prepared with different currents (10 and 160) A. This figure illustrates CuI nanoparticles as crystals with pyramids shape mixed with foam like shape.

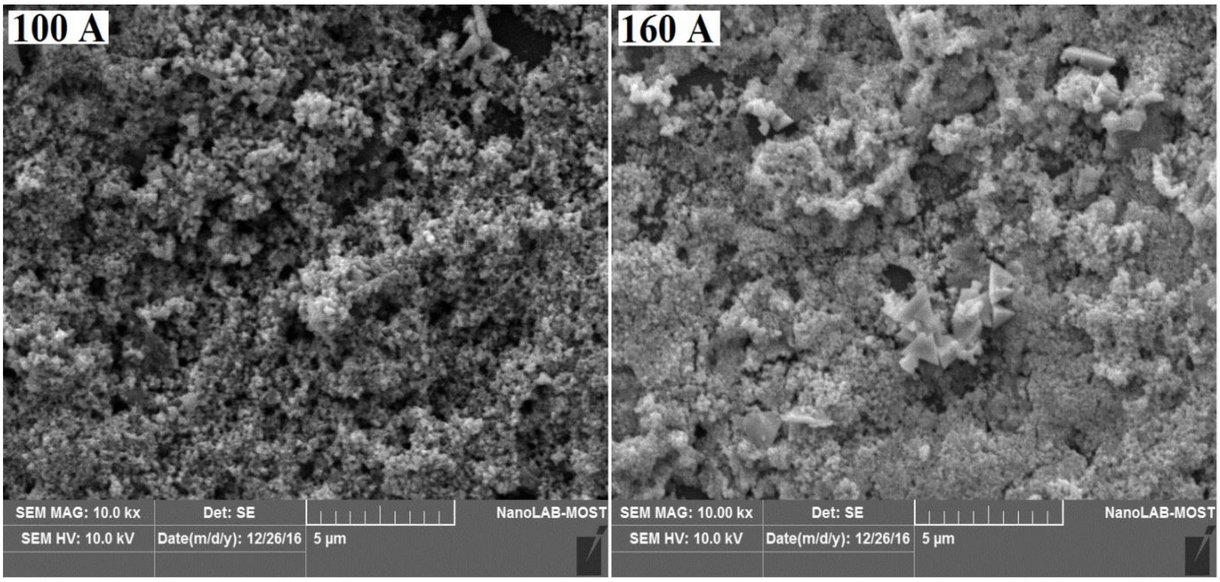

Fig. 4: SEM images for producer using exploding Cu wire in Iodine solution using 100 and 160 A current.

Fig. 5 shows the TEM image with ×92000 magnification power for 100 and 160A samples prepared and the histogram of their granulate accumulation. This figure illustrates CuI nanoparticles with different diameter uniformly distributed around the average size. The average of particle size was decrease from 14.58 to 13.46 nm with increasing current from 100 to 160 A.

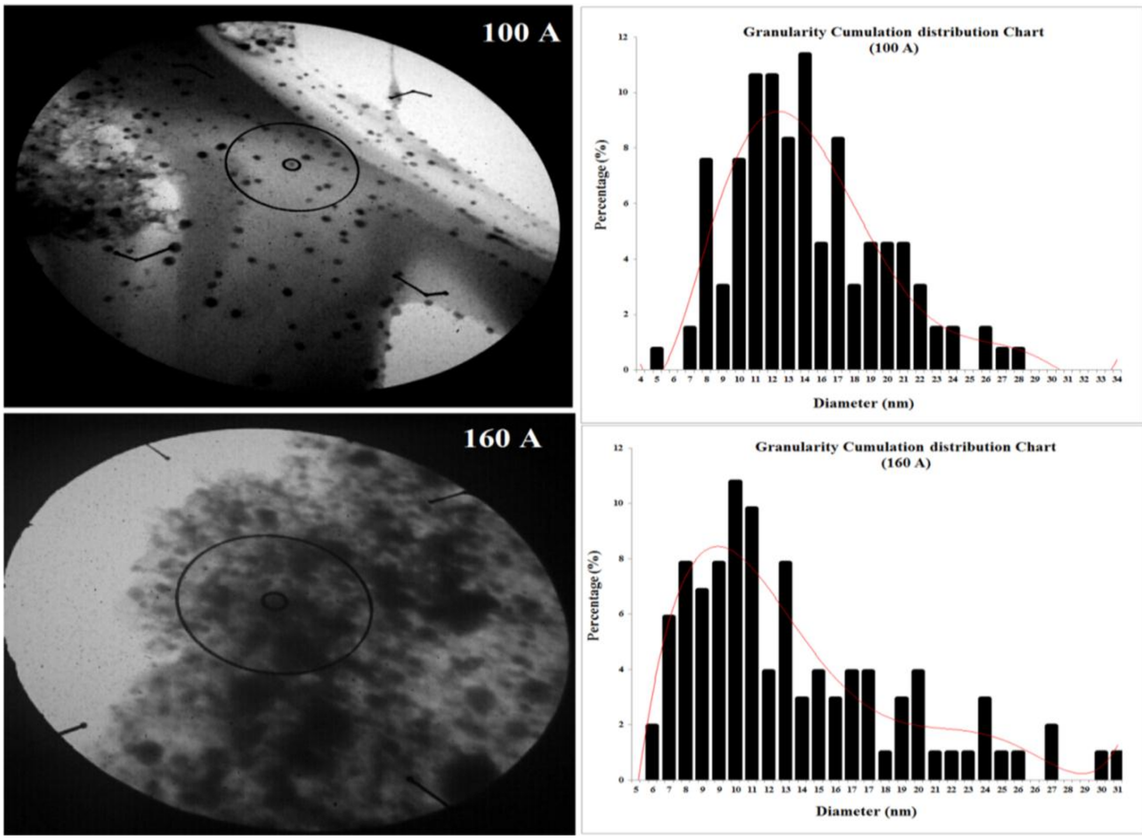

Fig. 5: TEM image and granulate accumulation for CuI nanoparticles prepared using 100 and 160 A current.

Conclusions

The study indicate that the exploding wire Technique is simplest Technique which used in the preparation of copper iodine (CuI) Nano particle with selected size by varying used current. The XRD mesurements, shows a poly-crystalline structure with cubic-CuI crystals, and the crystalline size decrease with increasing current. FTIR measurements shows two peaks located at 497.18 and 772.55 cm^{-1} corresponding to Cu-I bond, increasing current leads to variation in Cu-I bond energy to 602.47 cm^{-1} as a result of decreasing particle size. SEM images show CuI nanoparticles crystals with pyramid shapes mixed with foam like shape. Analyzing of TEM image show decreasing in Nano-size with from 14.58 to 13.46 nm with increasing used current from 100 to 160 A.

References

[1] M. R. Johan, K. Si-wen, N. Hawari, N. Azri, K. Aznan, Int. J. Electrochem. Sci., 7, 6 (2012) 4942-4950.

[2] P. Wankhede, P. K. Sharma, A. K. Jha, J. Eng. Res. Appl., 3, 6 (2013) 1664-1669.

[3] C. C. Koch, Nanostructured Materials Processing, Properties and Potential Edited by. Norwich, New York, U.S.A.: William Andrew Publishing, 2002.

[4] A. Alqudami and S. Annapoorni, J Nanopart Res, 10 (2008) 1027-1036.

[5] R. Rashid, G. Murtaza, A. Zahra, Trop. J. Pharm. Res., 13, July (2014) 1169-1177.

[6] G. Luka, P. Stakhira, V. Cherpak, D. Volynyuk, J. Appl. Phys., 108 (2010) 064518-064522.

[7] A. Holleman and E. Wiberg, Inorganic Chemistry. San Diego: Academic Press, 2001.

[8] Z.Hotra, L.Voznyak, N.Kostiv, D.Volunyuk, G.Pakhomov, G.Luka, B.Witkowski, L.Wachnicki, Lviv-Slavske, Ukr. Lviv, 2012 (2012) 528-529.

[9] Jia Lia and Joanne Macdonald, Biosensors and Bioelectronics, 83, 15 September (2016) 177-192.

[10] Hammad R. Humud and Sawsan Hussein, Iraqi Journal of Physics, 15, 35 (2017) 142-147.