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Received on: 28/09/2016
Accepted on: 29/12/2016

Production Micro and Nano magnesium powder by Pulsed Laser Ablation

Abstract- *In this work, magnesium oxide micro/nano particles were prepared using laser ablation in deionized water. This is technique very simple, cheap and a single step method. In the present work, at which ablation of pure Mg metal target in deionized water was accomplished using 9nsec Q-switched Nd:YAG laser at 1064 nm laser wavelength, the effect of laser energy on particle size material and the effect of number of laser pulses on optical properties and surface morphology have been studied. UV-visible measurement showed that a red shift in the absorption spectra of MgO NPs is obtained with increasing number of laser pulses. X-ray Florence's (XRF) investigation showed the Mg metal powder percentage purities. Particle size analysis (PZA) investigation showed the particle size distribution of magnesium in deionized water after laser ablation. Atomic force microscope (AFM) investigation showed that magnesium oxide nanoparticles have root mean square of surface roughness 0.954 nm and particle size distribution of magnesium was (15-155)nm after laser ablation.*

Keywords- *Nd:YAG laser, magnesium micro/nano particles, deionized water.*

How to cite this article: Z.A. Khaleefah, A.Z. Mohammed and M.S. Hamza, "Production Micro and Nano magnesium powder by Pulsed Laser Ablation," *Engineering and Technology Journal*, Vol. 35, Part A. No. 7, pp. 772-775, 2017.

1. Introduction

The micro/nano materials is a major theme of all nanotechnological programs. Micro/Nanoscale means manipulation of material with new optical, electrical, physical and chemical properties from it bulk equivalent [1,2]. Changes in materials characteristics obtains due to large surface area obtained at nanoscale of 1 to 100 nm and microscale of 0.1 to 100 μm [3]. Magnesium oxide is one of the candidate materials. The features of magnesium oxide semiconductors is high optical absorption and nontoxic and low cost fabrication.

Laser ablation refers to removing material with a pulsed laser. At low laser flux, the material is heated by the absorbed laser energy and evaporates or sublimates. At high laser flux, the material is typically converted to a plasma. Pulsed Laser Ablation in Liquids technique was used effectively to synthesize M/NPs due to its simplicity and low cost maintenance. Ablation parameters, materials optical properties, laser wavelength and pulse length can be controlled to ensure a specific size M/NPs [4].

The advantage from liquid layer allow collecting micro/nano particulate matter and improving the quality of micro/nanomachining [5]. The final structure and morphology of the particles are dependent on the surfactant concentration in solution or on the competition between aqueous oxidation of metals particles and surfactant protection [6,7].

2. Experiment work

The setup for this work consisted of f Nd:YAG laser, magnesium target, deionized water, and test vessel. High purity magnesium powders with particle size of less 44 μm was pressed with 20 Ton by using hydraulic press to form pellet with diameter of 16mm. The magnesium pellet was ablated by pulsed laser ablation using Q-switching Nd-YAG laser (1064nm). The target is fixed at the bottom of a quartz container.

In synthesis of micro particles, the number of laser shots applied for the metal target 300 pulse and the repetition rate for the metal target 6Hz. The laser irradiated was focused on the targets by a lens (focal length 80 mm). The laser energy applied for the metal target 200mJ and 500mJ. The magnesium micro particles was measured by PZA device.

In synthesis of nanoparticles maximum pulse energy used for the metal target 100mJ, and the number of laser shots applied for the metal target 150 pulse. The laser irradiated was focused on the target by a lens (focal length 80 mm). The repetition rate applied for the metal targets 6 Hz. Absorption spectra of the Nanoparticles solution were measured by UV-VIS double beam spectrophotometer.

https://doi.org/10.30684/etj.35.7A.14
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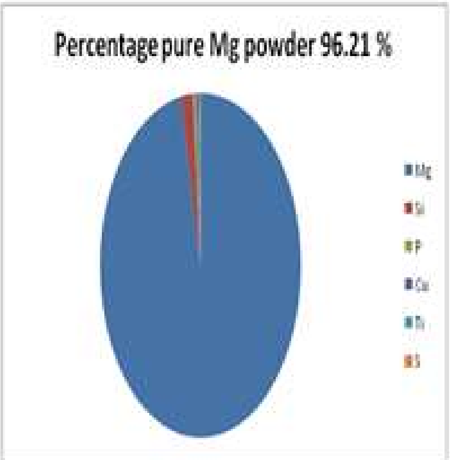
The magnesium nanoparticles was characterized by atomic force microscopy (AFM) is carry out on AA 3000 Scanning probe microscope Angstrom Advanced.

3. Result and Discussion

The magnesium powder percentage purities was test by XRF which is an analytical method to determine the chemical composition of all kinds of materials accorded to the results magnesium metal powder was equal 96.21% see in Figure 1.
Figure 2 Magnesium metal powder pure percentage (96.21%) with mesh 325 (particle size less 44 µm) was pressed with 20 Tons by using hydraulic press to form pellet with diameter of 16 mm , weight 2g and thickness 5 mm. The thickness depend on the density of the magnesium equal 1.738 g/cm^2.



No.	Element	Percentage %
1	Mg	96.21
2	Si	1.86
3	P	0.49
4	Cu	0.35
5	Ti	0.32
6	S	0.08

Figure 1: Percentage pure magnesium metal powder

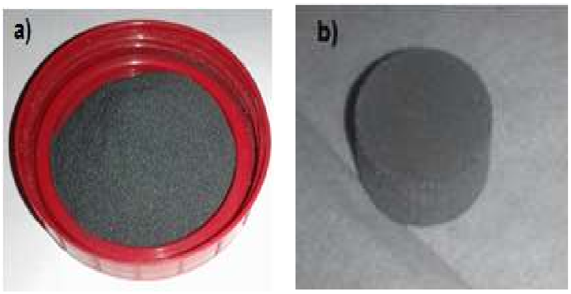


Figure 2: a) Magnesium metal powder b) Magnesium powder after pressed with 20 Tons by using hydraulic press

MgO micro & nano particles is prepared by the reaction of deionized water with magnesium suspended.

$$H_2O + Mg \rightarrow MgO + H_2$$

Particle Size Analyzer distributions of magnesium oxide micro particles, produced by laser ablation of metal pellet immersed in deionized water; the laser wavelength is 1064 nm. In Figure 4 shows The micro particles range diameters of (329.3nm - 341.3nm) and mean diameter 335.2nm at the laser energy 200 mJ and repetition rate 6 Hz. In Figure 5 Shows, the micro particles range diameters of (125.76nm-3773.1nm) and mean diameter 1899.3nm at the laser energy 500mJ repetition rate 6 Hz.

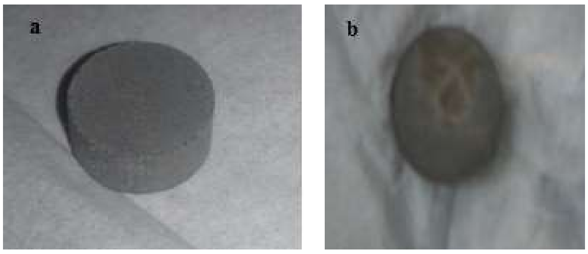
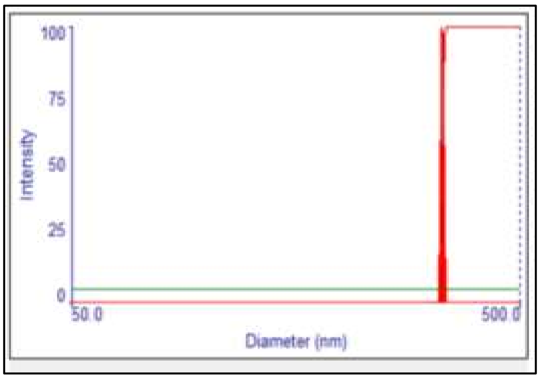
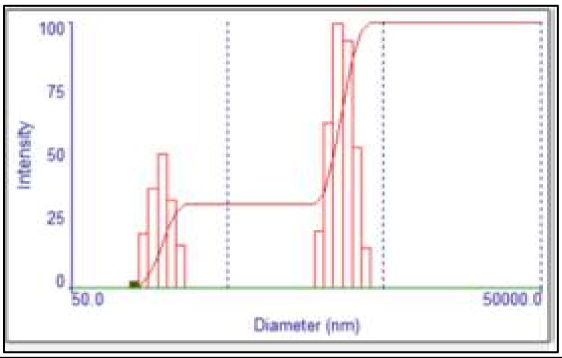


Figure 3: a) Magnesium target before ablation, b) magnesium target after ablation



d(nm)	G(d)	C(d)	d(nm)	G(d)	C(d)	d(nm)	G(d)	C(d)
311.0	0	0	336.4	98	79	364.0	0	100
313.2	0	0	338.9	57	95	366.6	0	100
315.5	0	0	341.3	16	100	369.2	0	100
317.7	0	0	343.7	0	100	371.9	0	100
320.0	0	0	346.2	0	100	374.6	0	100
322.3	0	0	348.7	0	100	377.3	0	100
324.6	0	0	351.2	0	100	380.0	0	100
326.9	0	0	353.7	0	100	382.7	0	100
329.3	17	5	356.3	0	100	385.4	0	100
331.7	59	22	358.8	0	100	388.2	0	100
334.0	100	51	361.4	0	100	391.0	0	100

Figure 4: Particle size analyzer distributions of magnesium oxide nano & micro particles laser energy 200mJ.



d(nm)	G(d)	C(d)	d(nm)	G(d)	C(d)	d(nm)	G(d)	C(d)
83.6	0	0	373.4	0	32	1667.9	0	32
95.8	0	0	427.9	0	32	1911.0	21	36
109.8	0	0	490.2	0	32	2189.5	62	48
125.8	2	0	561.7	0	32	2508.7	100	68
144.1	20	4	643.5	0	32	2874.3	93	86
165.1	37	12	737.3	0	32	3293.2	53	97
189.1	50	22	844.8	0	32	3773.1	15	100
216.7	33	28	967.9	0	32	4323.0	0	100
248.3	16	32	1109.0	0	32	4953.1	0	100
284.5	0	32	1270.6	0	32	5675.0	0	100
325.9	0	32	1455.8	0	32	6502.1	0	100

Figure 5: Particle size analyzer distributions of magnesium oxide nano & micro particles laser energy 500mJ

From test the material magnesium oxide micro particles by particle size analyzer I observed the particle size diameter increase with increase laser energy see in Table 1 and Figure 6.

Table 1: Represent the mean diameter and range diameter with laser energy 200mJ and 500mJ to magnesium target in DDW, repetition rate 6 Hz and laser shots 300 pulse

Material	Laser energy (mJ)	Mean diameter (nm)	Range diameter (nm)
Magnesium	200	335.2	329.3-341.3
	500	1899.3	125.7 - 3773.1

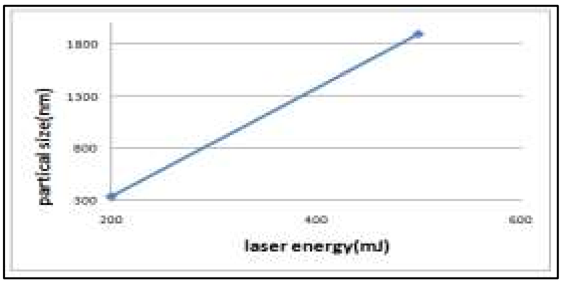
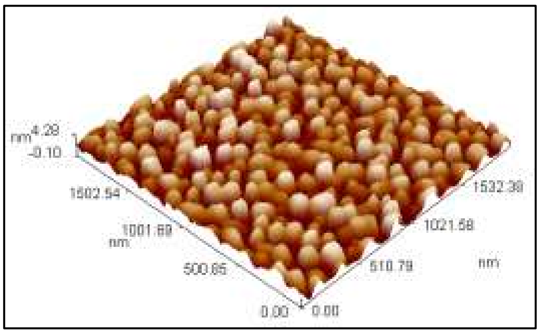
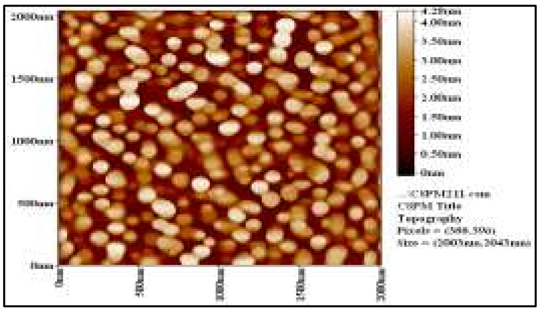


Figure 6: Represented the relation between laser energy (mJ) and mean diameter (nm) to magnesium oxide micro particles with repetition rate 6 Hz and laser shots 300 pulse

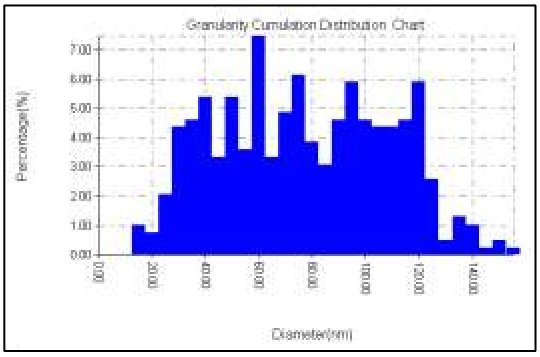
In Figure 7 shows AFM for MgO with size area=2003nmX2043nmand ability analytical (pixels=388, 396). Figure 7a explains AFM picture in (3D) with structural rod shape for grains, Figure 7 b explain AFM picture in (2D). Average Roughness was found 0.829nm and RMS(Root mean square) was 0.954nm and Figure 7 c represents particles distribution, where grains number was 390. Figure 8 illustrates the absorption spectra of MgO nanoparticales suspended in deionized water prepared at different number of laser pulses. The absorption spectra of magnesium oxide nanoparticales colloidal exhibits broad bands and possess highest peak absorption at around 350 nm. The absorption spectra of magnesium oxide nanoparticles colloidal showed a shift in absorption peak as the number of laser pulses vary. The observed absorption peak as the number of laser pulses vary. The observed absorption peaks were located at 350 nm, which corresponded to number of laser pulses 50, 100 and 150.



(a)



(b)



(c)

Figure 7: Atomic force microscope for magnesium oxide

Figure 9 depicts the FTIR spectra of MgO NPs, which are prepared at number of laser pulse 150. In this figure, the absorption peaks can be recognized at (613.38 cm^{-1}, 740.65 cm^{-1}) which corresponding to MgO. The additional peaks were noticed in the region of 1100-1700 cm^{-1} indicating the presence of physisorbed water. The peak at (3998.37 cm^{-1}) belong to O-H bond.

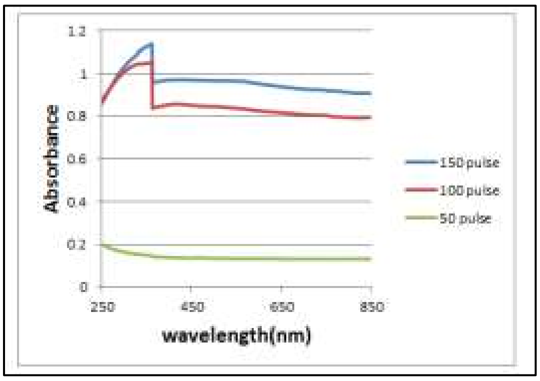


Figure 8: UV-Vis spectra of magnesium oxides nanoparticles colloidal in deionized water synthesized at different pulses of laser (50, 100 and 150) respectively

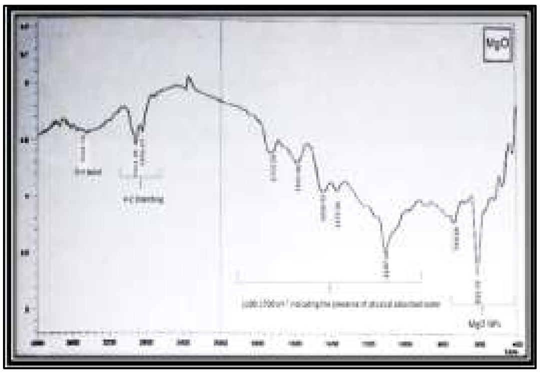


Figure 9: FTIR spectra of the MgO NPs prepared at number laser pulses in deionized water 150 pulse

4. Conclusion

Best Pressed Magnesium metal powder by hydraulic pressure at 20 Tons with diameter of 16 mm to form best pellets. The micro and nano particles size could be controlled by proper selection of the laser parameters. The particles size diameter increase with increase laser energy and laser pulses. Morphological and optical properties are found to be dependent on material Mg.

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