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Spectroscopic Investigation of Laser Treated Nano Material Lead Oxide

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Abstract-The study of nanoparticles and its influence with laser plays a major role in material characterization. Particularly laser heat treatment on metal oxides give appreciable results in semi conducting materials. Semiconducting materials are low cost and have significant properties in laser material processing. Now in this study, we present the synthesis and influence of He-Ne laser and diode laser treated nanoparticle PbO. Particle size, structure, peak value comparison, inter atomic spacing of samples with and without laser treatment are studied using XRD analysis. The results of UV and FTIR are also discussed. From the studies of UV the calculated band energy values for PbO is 5.3 to 6.3eV. FTIR study also confirms the presence of PbO nanoparticles.

Keywords: Lead Oxide, laser irradiaton, UV-Spectroscopy, FTIR, and XRD.

1.0 INTRODUCTION

In recent years, the synthesis and characterization of nanomaterials play an important role in material research as well as in different areas such as scientific and industrial applications [1].Also tremendous amount of work is going on in the preparation of nanoparticles towards nano technology with the use of laser heat treatment. The properties of various materials have been improved using low power lasers with different processing conditions. Lead oxide (PbO) nano particles have potential application in many fields such as lead acid or Li-based battery manufacturing industries [2].PbO particles have unique properties because of their application in luminescent materials, gas sensors, storage devices, UV blockers as well as modifiers in oxide glasses. A wide variety of physio- chemical properties including thermal decomposition, laser irradiation on lead nano particles have been used to produce nanometer sized lead oxides[3].In this work, lead oxide nano particles were synthesized through laser irradiation for different time exposures, the laser treated PbO particles were characterized by UV, FTIR Spectroscopy and X-ray diffraction studies. The band gap energy calculation for laser treated PbO samples were analyzed and investigated as well as compared their results with and without laser irradiated PbO nanoparticles [4].

2.0 EXPERIMENTAL PROCEDURE

Commercially available PbO powder (Qualigens, 95% purity) is used for investigation (composition given in table 1). Laser treatments are carried out by using 5.0mW, He – Ne low power gas laser with red light of wavelength 633nm and diode laser with green light of 5mW power with wavelength 532nm. The structural analysis of with and without laser irradiated samples are analyzed using X – Ray diffractometer(P Analytical X – Ray diffractometer) with copper Kα radiation of wavelength λ as 1.5060A and 1.54443A.This spectrum recorded the intensity as a function of Bragg's Angle. While the average crystalline size of the particle can be estimated using the full width at half maximum (FWHM) value of the X – Ray diffraction peaks [5].The optical and spectroscopic investigation of the samples such as UV and FTIR studies using Perkin Elmer FT – IR spectrometer [6].The laser processing parameters used for laser investigation of samples are given in table 2 and the properties of sample used is given in table 3.

Table 1 Chemical composition of sample PbO.

Element	Content
Lead	92.83
Oxygen	7.16

Table 2 Laser processing parameters of samples

Sample	He – Ne Laser irradiation	Green diode laser irradiation
1	Without laser	Without laser
2	15 minutes	-
3	30 minutes	-
4	-	15 minutes
5	-	30 minutes

Table 3 properties of PbO

Properties	Characteristics
Density	8.3 g cm^{-3}
Molar Mass	685.596 g/mol
Magnetic Susceptibility	42.0 x $10^{-6}cm^3$/mol

3.0 RESULTS AND DISCUSSION

3.1 UV – Visible spectral studies

The absorptions studies of UV radiation on the nano powder PbO sample with and without laser irradiation shows appreciable results. From the available data, the calculated band gap energy for the laser treated samples (both He – Ne gas laser and Diode laser) varies from 5.3 – 6.3 eV [7]. The band gap energy for the sample without radiation is 5.3eV.This results conforms the influence of laser on the nano particles PbO towards band gap energy for longer interaction time for both He –Ne and diode lasers. Table 4 shows the band gap energy values for different laser interaction with two different time exposures. Figure 1a – 1e shows the UV visible spectrum of with and without irradiated samples.

Table 4-Bandgap energy values

Sample number	Time duration of laser irradiation (sec)	Band gap energy (eV)
1	Without laser irradiation	5.3
2	15 minutes (with He-Ne laser irradiation)	6.3
3	30 minutes (with He-Ne laser irradiation)	6.3
4	15 minutes (with Green Diode laser irradiation)	5.5
5	30 minutes (with Green Diode laser irradiation)	6.1

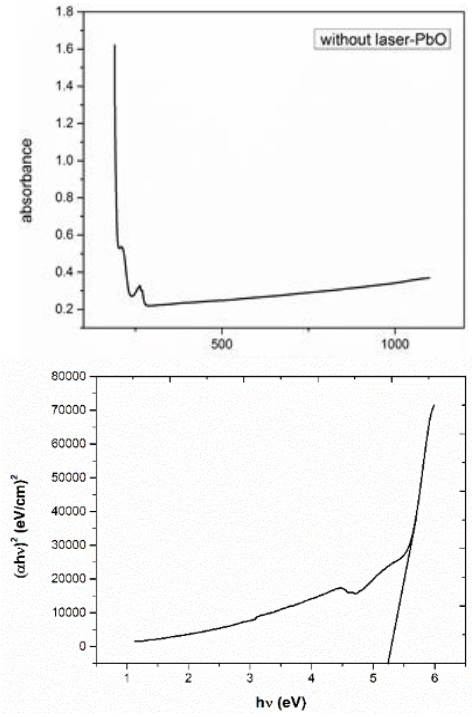

Fig 1(a) UV-Vis Absorption spectra of sample 1

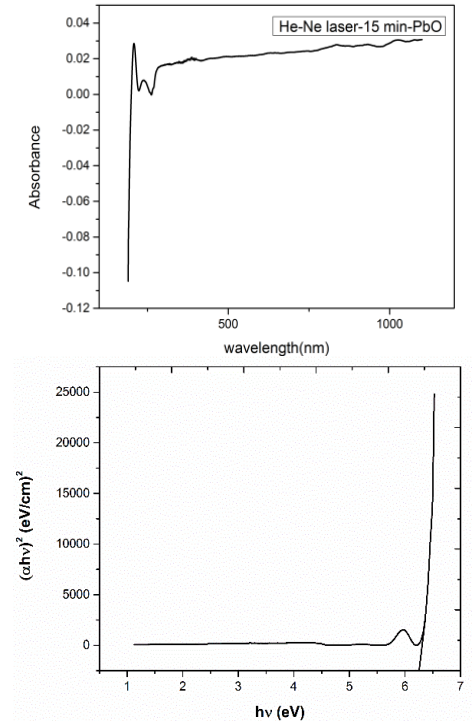

Fig1(b)-UV-Vis Absorption spectra of sample 2

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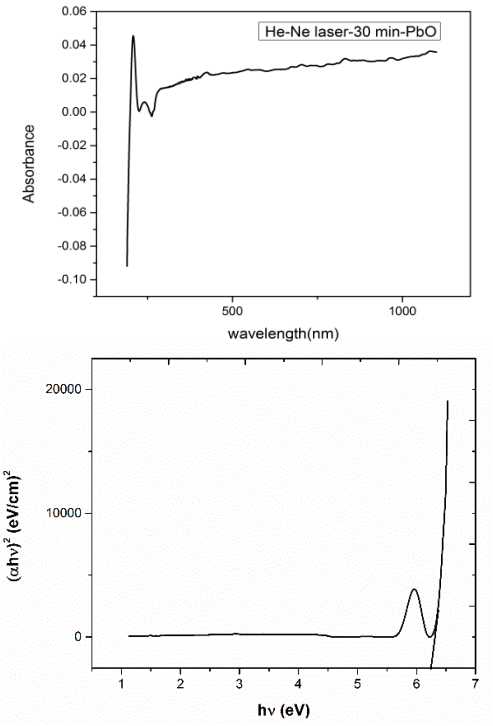

Fig1(c)-UV-Vis Absorption spectra of sample 3

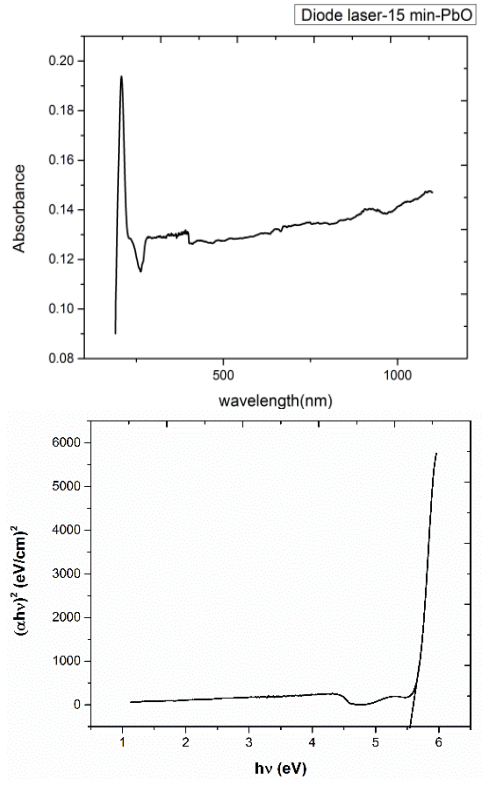

Fig1(d)-UV-Vis Absorption spectra of sample 4

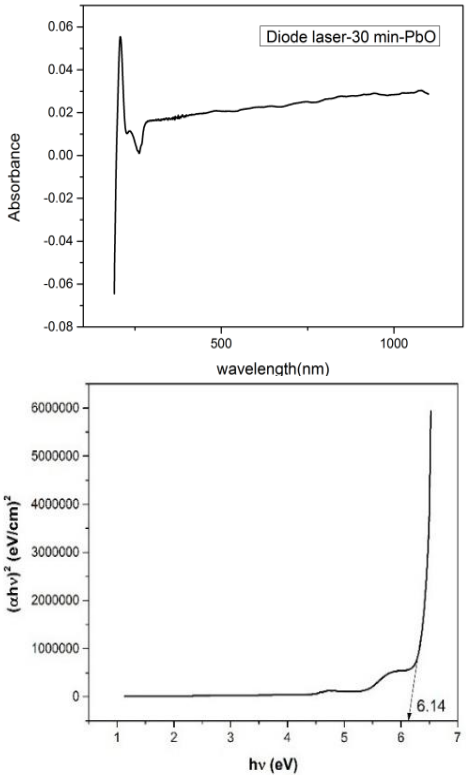

Fig1(e)-UV-Vis Absorption spectra of sample 5

3.2 FTIR SPECTRAL STUDIES

The FTI R Spectrum of PbO particles are given in 2(a) – 2(e). The function analysis [8] from the FTIR data is given in 5.1 – 5.5.

Table 5.1 FTIR Analysis (without laser PbO)

Group	Frequency	Vibrations	Intensity
O-H (H-bonded)	3424.65	Broad Stretching	Strong
CH Alkanes	2935.90	Stretching	Strong
NH_2Amines	1570.50	Scissoring bending	Medium-strong
CH_2 Alkanes	1419.41	Deformation bending	Medium
S-S Disulphide	456.31	Symmetry stretching	Weak

Table 5.2FTIR Analysis (He-Ne laser-15 min PbO)

Group	Frequency	Vibrations	Intensity
N-H	3433.59	Stretching	Strong
N-H Amines	1567.95	Stretching	Strong
C-H	1417.13	Symmetry stretching	Strong
C-X (iodo alkanes)	528.68	Asymmetric stretching	Medium-strong
CH_2 rocking	455.03	Bending	Weak

Table 5.3 FTIR Analysis (He-Ne laser-30 min PbO)

Group	Frequency	Vibrations	Intensity
N-H	3436.93	Stretching	Strong
N-HAmines	1567.95	Stretching	Strong
C-H	1417.60	Symmetry stretching	Strong
C-X (iodo alkanes)	528.63	Asymmetric stretching	Medium-strong
CH_2 rocking	454.65	Bending	Weak

Table 5.4 FTIR Analysis (Diode laser-15 min PbO)

Group	Frequency	Vibrations	Intensity
N-H (2 bonds)	3427.07	Stretching	Strong
NH_2 Amines	1570.07	Scissoring bending	Medium-strong
α- CH_2 (ketones)	1417.02	Bending	Strong
C-X (bromo alkanes)	528.66	Stretching	Medium-strong
CH_2	454.49	Bending	Weak

Table 5.5 FTIR Analysis (diode laser-30 min-PbO)

Group	Frequency	Vibrations	Intensity
N-H (2 bonds)	3433.79	Stretching	Strong
NH_2 Amines	1567.63	Scissoring bending	Medium-strong
S=0 (sulfoxide)	1416..58	Stretching	Strong
C-X (bromo alkanes)	528.64	Stretching	Medium-strong
CH_2	454.67	Bending	Weak

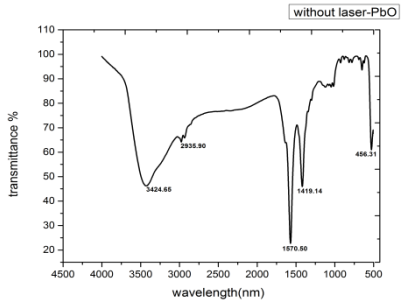

Fig2(a) FTIR spectra (Sample 1)

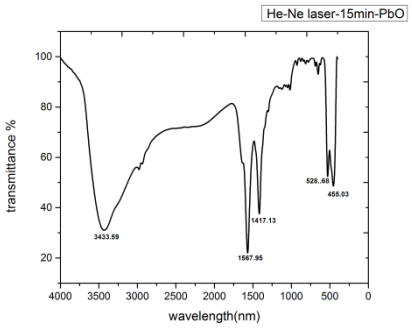

Fig2(b) FTIR spectra (Sample 2)

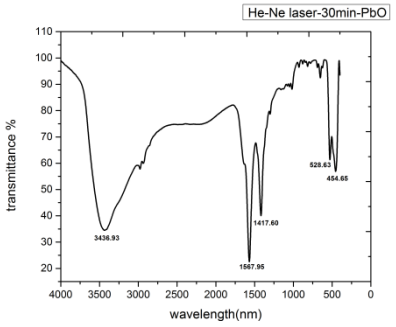

Fig 2(c) FTIR spectra (Sample 3)

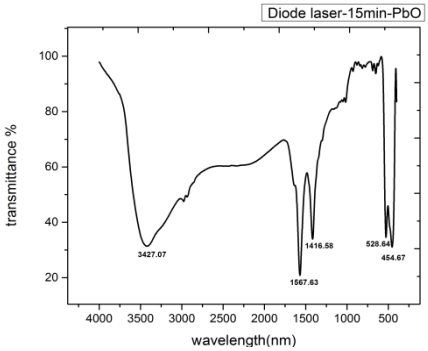

Fig 2(d) FTIR spectra (Sample 4)

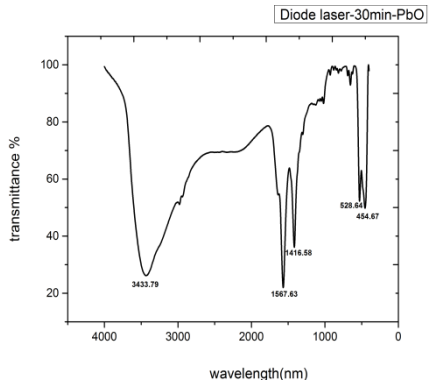

Fig 2(e) FTIR spectra (Sample 5)

3.3 X- RAY Diffraction Studies

The X – ray diffraction patterns of all the samples are given in fig 3a – 3c. From the X – ray diffraction studies, we infer that the structure of the PbO nanoparticle is triplumbic Tetragonal [9].The average crystallite grain size evaluated from the Scherrer formula [10] is given in table 6.

Table 6 crystalline grain size of PbO

S.No	Samples	Grain size(nm)
1	Without laser-PbO	4.56
2	He-Ne laser-15min-PbO	4.8
3	He-Ne laser-30min-PbO	5.0
4	Diode laser-15min-PbO	4.5
5	Diode laser-30min-PbO	4.6

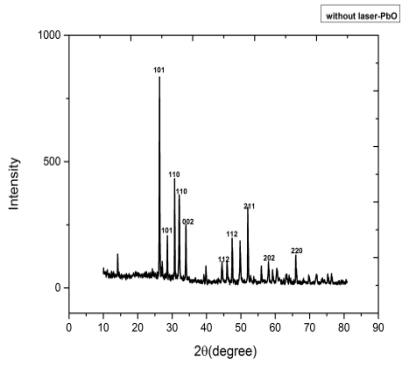

Fig 3(a) XRD Spectrum (Sample 1)

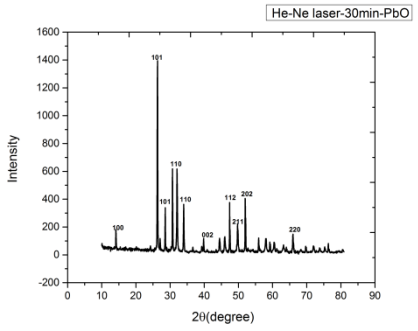

Fig 3(b) XRD Spectrum (Sample 3)

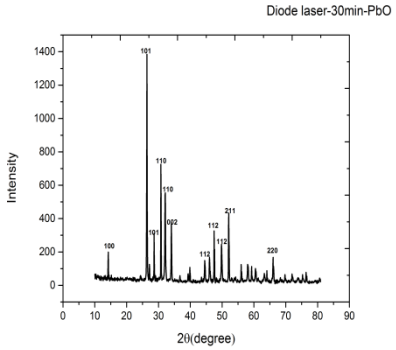

Fig 3(c) XRD Spectrum (Sample 5)

From table 6 it is seen that the calculated grain size for sample 3 is 5.0nm which is slightly higher than the other samples.

4.0 Conclusion

In this we investigated the effect of laser (He – Ne, Diode) induced nano particles PbO. The results observed are given below.

a. From the UV Spectrum studies the absorbed band gap energy for various laser treated Samples were calculated. (Values vary from 5.3 - 6.3eV)

b. The functional groups for different peaks absorbed for FTIR spectrum were analyzed.

c. From the X – ray diffraction studies we observed the structure of PbO nano particle is triplumbic tetragonal.

d. The crystallite gain size of the samples calculated are 4.5nm (sample1), 5.0nm (sample3) and 4.6nm (sample5) were observed from the X – ray diffraction studies.

e. In general, when the laser power with increased time exposure gives improved result in band gap energy and grain size structure.

3.5 REFERENCES

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