Non Linear optical properties of silver nanoparticles doped polyvinyl alcohol

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ABSTRACT:

In the present work, synthesis silver nanoparticle by laser ablation by using (Q - switched Nd:YAG) pulse duration(E=80mJ, λ=532nm) of silver metal target in ethanol,Z-scan technique was used to study the nonlinear optical properties, represented by the nonlinear refractive index and nonlinear absorption coefficients of Ag NPs/PVA.In this technique, used CW diode laser (λ= 650nm,p=50mw).The results show that the nonlinear refractive indexnegative (self-defocusing) and nonlinear absorption coefficients two photonabsorption (TPA).

KEYWORDS:silver nanoparticle,Polyvinyl Alcohol, Z-scan, nonlinear refractive index, nonlinear absorption coefficients.

1- INTRODUCTION

Nonlinear optical materials are required in a wide range of important applications, such as optical limiting, optical computing, and optical communication[1].Metal nanoparticles and nanocomposites have, in recent years, received significant attention owing to their unique nonlinear optical (NLO) properties, such as two-photon absorption (TPA), saturable absorption (SA), reverse saturable absorption (RSA), and self-focusing/defocusing arising from nonlinear refraction[2,3].The Z-scan method, was applied for the first time more than ten years ago , This method is based on the investigation of changes in Gaussian beam intensity profile in the far field during the moving of the sample through the focal plane [4,5].The surface plasma resonance (SPR), which results from collective electronic excitation at the interface between metal nanoparticles and dielectric matrix, not only is responsible for the linear optical properties but also governs nonlinear optical phenomena [6].Studies of doping transition metal halides into Polyvinyl Alcohol (PVA) are important for determining and controlling the operational characteristic of the differentPVA composites [7]

In this paper we prepared the Ag NPs by laser ablation in a liquid medium used ethanol and doped PVA, then by the technique Z-scan to study the nonlinear optical properties of the nonlinear refractive index and the nonlinear absorption coefficient.

2-EXPERIMENTAL

2-1 MATERIALS AND METHODS

In this case laser ablation of Ag plate has been done using of Nd-YAG pulsed laser (532nm) with energy value (80mJ) in ethanol and pulses(100,200,300), pulse width 10ns and 6Hz repetition rate.PVA films were prepared by dissolving 0.5g of PVA powder in 10ml of DDDW at 50˚.themixture was stirred for two hours continuously to form viscous solution. After completing desolation, 8mL of silver nanoparticles suspension was added to the 20mL aqueous PVA solution, and finally samples were left to dry on a plane surface for one week at room temperature, then use Z-scan experimental, the excitation source was a continuous wave (CW) of 650 nm diode laser with a beam power of 50 mw for Ag NPs/PVA films

2-2 Nonlinear properties of AgNPs/PVA

Using Z-scan technique, the magnitude of nonlinear absorption and the sign and magnitude of nonlinear refraction can be determined simultaneously. When a high intensity laser beam propagates through a material, induced refractive index changes leads to self-focusing or defocusing of the laser beam[8].Fig (1)The Z-scan experiment can be given as follows starting the scan from a distance far away from the focus (-z), the beam irradiance is low and negligible nonlinear refraction occurs leading to linear transmittance. As the sample is brought closer to the focus, the beam irradiance increases leading to self-lensing in the sample [1,9]

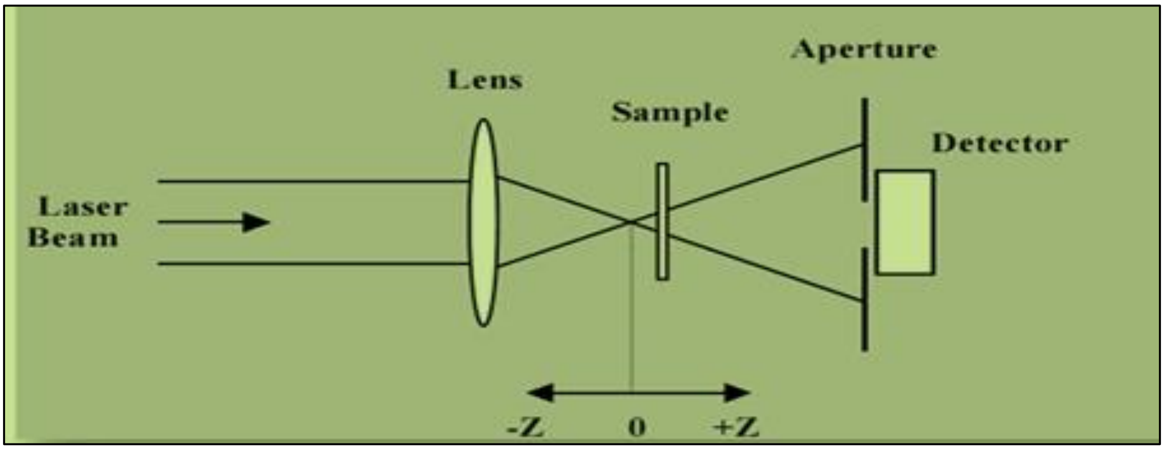

Figure (1): Z-Scan set up

The nonlinear refractive index is calculated from the peak to valley difference of the transmittance by the following formula [10].

$n_2 = \Delta\Phi_o / I_o L_{eff}\, k$... (1)

Where $\Delta\Phi_o$: - nonlinear phase shift, $k = 2\pi/\lambda$, λ: - is the wavelength of the beam.

$\Delta\Phi_o = \Delta T/0.406$ … (2)

I_o is the intensity at the focal spot given by

$I_o = 2P_{peak}/\pi\omega^2_o$… (3)

Where, ω_o: - the beam radius at the focal point, P: - the peak power of laser beam.

$L_{eff} = (1-e^{-\alpha oL})/\alpha_o$... (4)

Where, L:the sample length, αo: - linear absorption coefficient.

The absorption of the material (α) is intensity dependent given by[11]:-

$\alpha = \alpha_o + \beta I$ … (5)

Where, β: the nonlinear absorption coefficient related to the intensity, α_o: linear absorption coefficient.

3- RESULT AND DISCUSSION

3-1 X-ray diffraction of polymer films

Fig(2) The X-ray diffraction peaks of polymer films doped with silver NPs occur at 2θ values of (19.9°, 38. 34°) and(19.6°,44°) in which it observed and compared with the standards powder diffraction card of (JCPDS), Ag file number (04–0783). The average particle size was measured by Debye-Sheerer equation

$$D= (0.89\ \lambda)/ (\beta^* \mathrm{Cos}\ (\theta)) \quad ...\ (6)$$

Where D is grin size, β=FWHM, θ is Diffraction angle [12]. The grain size of PVA doped Ag NPs thin film is shown inTable (1).

Table (1): Size of PVA & Ag NPs/PVA as a function of laser pulses

sample	2θ°	Full width at half maximum(FWHM)	NPs size(nm)	(h k l)
PVA	40.5	1.73E-03	89.1	111
AgNPs/PVA	38.34	5.28E-03	26.01	111

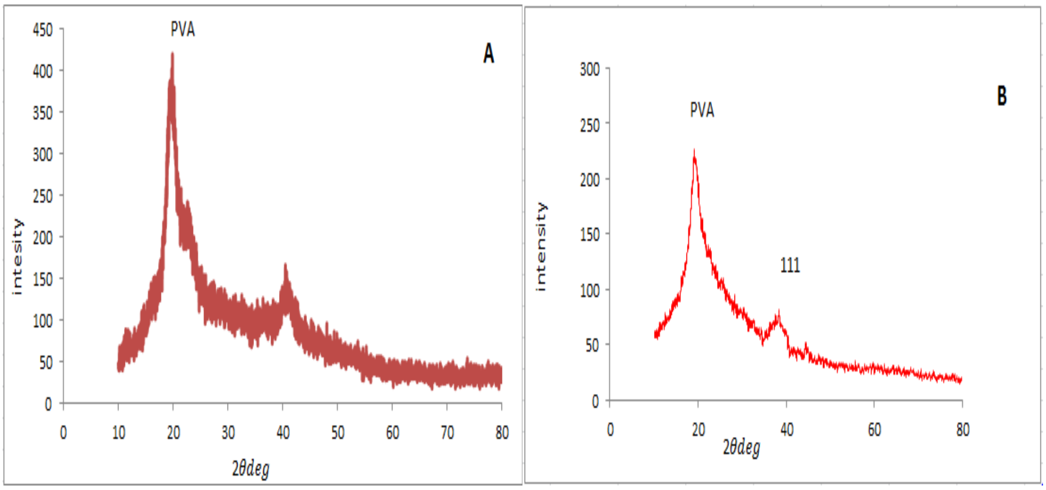

Figure (2) X-ray diffraction pattern (A) PVA (B) Ag NPs / PVA in ethanol at 100 pulses

3-2 nonlinear refractive and nonlinear absorption coefficient

Fig (3a)(3b)(3c)The results show that the nonlinear refractive index negative (self-defocusing: that mean the peak followed by avalley) ,and thenonlinear absorption coefficient two photon absorption then the values of nonlinear refractive and nonlinear absorption coefficient indices are found as summarized in Table (2).

Table (2)Values of nonlinear parameters for prepared Ag NPs /PVA.

pulses	$\Delta\Phi_o$ (rad)	n_2*10^{-8} (cm^2/W)	$\beta*10^{-3}$ (cm/W)
100	0.78	1.02	2.49
200	0.56	2.53	2.02
300	0.14	3.98	1.63

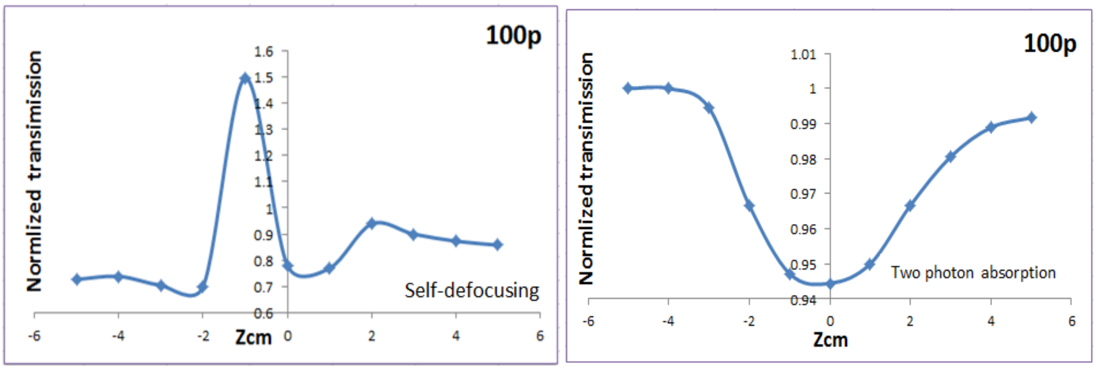

Figure (3a)Z-scan experimental data excitation Close aperture &Open aperture curve, for AgNps /PVA

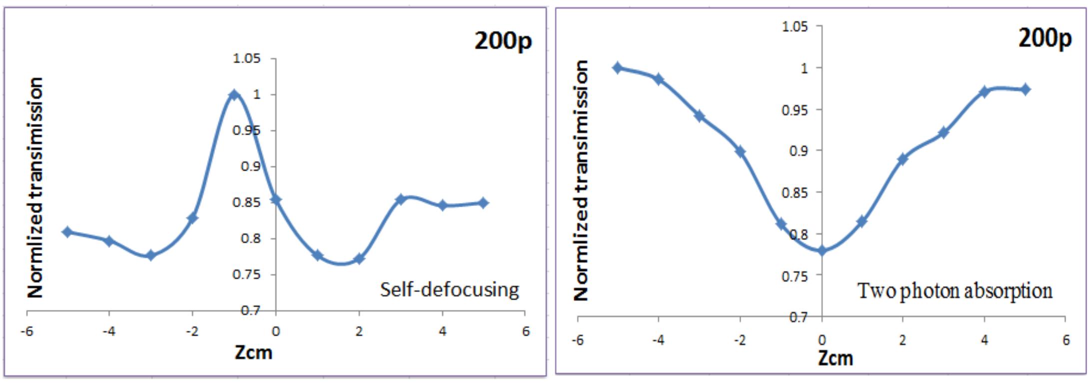

Figure (3b) Z-scan experimental data excitation Close aperture &Open aperture curve, for AgNps /PVA

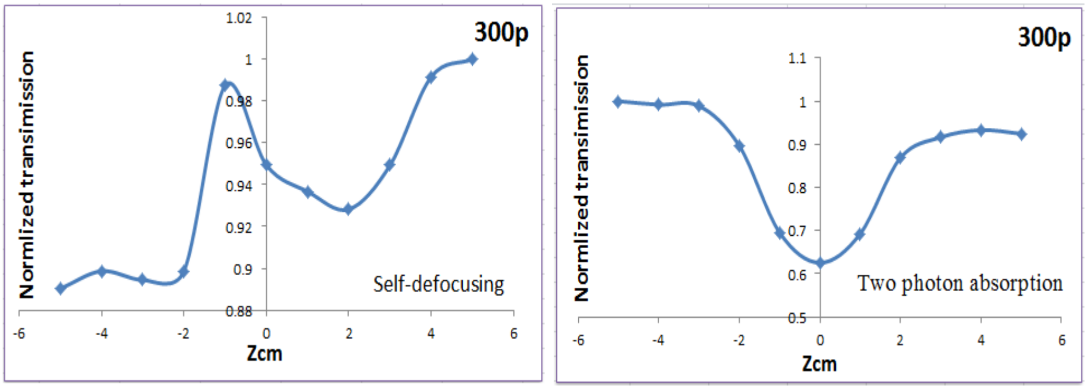

Fig (3c) Z-scan experimental data excitation Close aperture &Open aperture curve, for AgNps /PVA

4-Conclusion

Nonlinear refraction of different composites containing AgNPs/PVA was studied employing, Z-scan technique, the nonlinear refractive index and nonlinear absorption were measured and the sign of nonlinear refractive index was found to be negative. The nonlinear refractive index increase from -1.02×10^{-8} cm^2W^{-1} to 3.98×10^{-8} cm^2W^{-1}.From the experimental conditions and theory fit results, we attribute the nonlinear absorption to TPA effect at 650 nm.

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