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Enhancement of the linear, nonlinear and optical limiting properties of epoxy resin decorated by zinc oxide nanoparticles

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Abstract

Epoxy resin decorated by zinc oxide (ZnO) nanoparticles film was successfully prepared onto a glass substrate. Field-emission scanning electron microscopy was used to examine the surface morphology of the prepared film. It is clearly observed that these nanoparticles are adhered onto the surface of the epoxy resin and cover its entire area. The UV–vis measurements of the as-prepared ZnO/epoxy resin microstructures displayed the outstanding enhancement in the photocatalytic properties. The optical band gap of the obtained film shows a significant increase up to 3.7 eV due to the non-stoichiometric distribution of zinc and oxygen atoms in the obtained structure. The nonlinear optical properties of the film were investigated using the Z-scan technique. Large and negative nonlinear refractive index of the sample is determined. The optical limiting property of the film is reported, and the optical limiting mechanism is originated from the thermal effect and the nonlinear scattering. The obtained materials along with the high nonlinearities demonstrates the possibly of incorporating this material in many functions related to photonic applications.

Keywords: ZnO nanoparticles, epoxy resin, surface morphology, Z-scan technique, optical limiting

(Some figures may appear in colour only in the online journal)

1. Introduction

Materials with high optical nonlinearities have attracted substantial amount of curiosity and have established themselves as the suitable building bulk for several photonic applications related to optical signal processing, optical limiting, optical switching, etc [1–20]. The search for new materials possesses high nonlinear optical properties have continued until today for the sake of finding appropriate materials that included these properties, such as semiconductors, inorganic and organic materials. Among these materials, semiconductors have attracted considerable attention due to their electrical and optical properties which made them as promising candidates for the use in many photonic applications [21–24]. Among various known materials, zinc oxide (ZnO) has a large exciton binding energy of 60 meV along with a direct wide band gap of 3.37 eV in ambient condition which qualifies its applications in many areas related to energy storage super capacitors [25], UV and gas sensors [26–30], optoelectronic devices [31, 32], antireflection coatings [33], biosensors and photocatalyst [34, 35] etc. Diversity of researches have been directed to study the ZnO nanoparticles in different shapes and goals such as photo luminescent ZnO nanoparticles for biological applications [36], ZnO nanoparticles modified carbon paste electrode for cyclic voltammetric study for drug analysis [37], for using in co-precipitation method in determining synthesis and characterization of Fe doped ZnO nanoparticles [38], influence of Ga doping on crystal structure and polarimetric pattern of SHG in ZnO nano films [39], in imaging of ZnO nanoparticles penetration in human skin *in vitro* and *in vivo* [40] to name a few. Several investigations were conducted to study

