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Linear and nonlinear optical properties of Gd^{3+} doped zinc borotellurite glasses for all-optical switching applications

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ABSTRACT

In this work, linear and nonlinear optical parameters of zinc borotellurite glasses doped with Gd^{3+} have been studied for all-optical switching applications. A series of gadolinium zinc borotellurite glasses were synthesized by using conventional melt quenching technique. Optical absorption spectra were recorded by UV–vis spectroscopy. From the optical absorption spectra, the cut-off wavelength, optical band gap, Urbach energy and refractive index have been determined and are related to the structural changes in the glass systems. The nonlinear optical properties of Gd^{3+} doped glasses are investigated by using Z-scan technique. The values of nonlinear refractive index and absorption coefficient with closed and opened apertures of the Z-scan, respectively, were determined for proper utilization in nonlinear optical devices.

Introduction

Photonics materials with high third nonlinear optical properties have provided important information in the optical field for applications in all-optical switching device in optical telecommunication field. Host glasses such as tellurite glass contain unique properties such as low phonon energy, high refractive index and large third-order nonlinear susceptibility which with the presence of other modified matrices have been established to enhance the electrical conductivity, the relaxation strength and optical properties of the glass systems [1–3]. Optical glasses with large non-resonant nonlinear refractive indices are potential materials for all-optical switching devices and may also be used to enhance the performance of mode-lock solid-state laser [4].

Among all photonics materials, rare earth oxides glasses are found to have better third order nonlinear optical properties due to their fast response times, negligible linear loss and small two-photon absorption (TPA) in the wavelength range of interest [4]. The addition of rare earth oxide such as gadolinium oxide, Gd_2O_3 into glass network will cause enhancement in optical, physical and chemical properties of the glass such as greater hardness, greater thermal and elastic properties, higher chemical durability and show nonlinear optical properties [5]. In addition, Gd_2O_3 is a favorite material used for scintillating glasses to increase density and improve luminescent properties. Previously reported Gd_2O_3 containing glass by Binnemans et al. [6] shows that Gd^{3+} ions has strong emission around 310–312 nm which is very useful for producing narrow band UVB (ultraviolet broadband) light for medical application in treatment of skin diseases. Jimenez [7]. reported that addition of silver oxide to P_2O_5–BaO–Gd_2O_3 enhances the uv emission from Gd^{3+} ions which suggests potential UV type B luminescent materials for phototherapy lamps applications. However, there are very few studies on the linear and nonlinear optical properties of zinc borotellurite glasses doped with Gd_2O_3.

Nonlinear optical properties such as nonlinear refractive index, n_2 and nonlinear absorption coefficient, β can be measured by Z-scan technique, in which a sample is scanned near the focal region of a focused laser beam. When the sample is move along the propagation direction of the laser beam (Z-axis), it consequently experiences a phase and intensity modulation, which can be observed in the transmittance measured as a function of the sample position [8]. Bala et al. [4] shows that addition of Bi_2O_3 to ZnO–SiO_2 glasses caused the glass to have large nonlinear refractive index and comparatively small nonlinear absorption coefficient values which can be used for photonic application such as broadband optical amplifiers. The higher value of nonlinear refractive index obtained gives strong evidence of the contribution of

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