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Study of Spectroscopic Properties of Pure and Nd Doped $Ca_3La_2(BO_3)_4$ Glasses

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Abstract

In this paper, we report pure and 5 mol% Nd doped Ca_3La_2 $(BO_3)_4$ glasses and their spectroscopic properties. A ternary system La_2O-3CaO-$4H_3BO_3$ was adopted and glasses were prepared by using a conventional melt quenching technique. The amorphous nature of the glasses has been confirmed by powder X-ray diffraction analysis. In order to study the spectroscopic properties of fabricated glasses, ultraviolet-visible transmission and absorption spectroscopy has been performed. The absorption spectrum of Nd doped glass shows that the transition $^4I_{9/2} \rightarrow {}^4G_{5/2} + {}^2G_{7/2}$ is more intense as compared to the other transitions. Optical band gap energies of both glasses have been determined and found decreased for Nd doped glass as compare to pure glass.

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Keywords: Borate glass, Quenching technique, z- scan measurement, Energy band gap;

1. Introduction

Borate glasses have received much attention of scientific community in last several years due to their good optical properties. In borate glasses, B_2O_3 is one of the best glasses former that can provide glasses at low melting temperature having high optical transparency over wide spectral range high thermal stability and good rare-earth ion accommodation capability [1, 2, 3]. It has been shown that borate glasses are very attractive host matrices for rare earth ions because of their high refractive index and low transition temperature. The rare earth ions are of great

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scientific and technological interest because of their emission properties which arise from the 4f–4f transitions in the electronic configurations of these ions [4]. The rare earth ions doped borate crystals and glasses are mostly used as promising materials in display devices, sensors, short wavelength lasers and hole burning high-density memories due to their attractive spectroscopic, luminescent and laser properties [5, 6]. Recently, a new disordered borate family with the general chemical formula $M_3R_2(BO_3)_4$ (M=Ca, Sr, Ba; R=Y, La, Gd) have attracted a great attention. The member crystals belong to the orthorhombic system with space group Pnma. These new laser host disordered crystals are mechanically hard, have good chemical stability and are nonhygroscopic in nature. The crystals of Nd^{3+}-doped $Ca_3R_2(BO_3)_4$ have been grown by the Czochralski method and the spectroscopic study confirm the absorption and emission bands are strongly in homogeneously broadened due to their disordered structure [6]. The broadening of absorption and emission bands facilitates efficient pumping and production of ultra-short pulses. Similar study has been reported by many researchers on Nd^{3+}, Yb^{3+}, Er^{3+} doped calcium lanthanum borate ($Ca_3La_2(BO_3)_4$, CLB) disordered crystals [8-11]. In the CLB crystal, Ca^{2+} and La^{3+} ions are statistically situated in three different sites in crystal structure, produces a disordered structure that results in large inhomogeneous broadening of the peaks [12]. Although crystals of pure and various rare earth ions doped LCB have been grown but there is no report on the preparation of CLB glass and study on its properties.

In this paper, we report a fabrication of pure and Nd doped CLB glasses. The powder X-ray diffraction (XRD) and ultraviolet-visible (UV-vis) transmission and absorption studies have been presented. The direct band gaps have also been estimated from UV-vis transmission data.

2. Experimental

2.1. Glass preparation

The synthesis of pure and Nd doped CLB polycrystalline powder samples was carried out using starting materials- Neodymium oxide (Nd_2O_3), lanthanum oxide (La_2O_3), calcium carbonate ($CaCO_3$) and boric acid (H_3BO_3) and used as they received without further purification. Nd_2O_3, La_2O_3, $CaCO_3$ and H_3BO_3 of 99.9% purity were procured from SD-fine chemicals, Mumbai. Appropriate quantities of starting materials were weighed and thoroughly mixed by grinding. Each composition was taken in an open silica crucible and kept in a muffle furnace for heat treatment to get pure and 5 mol% Nd doped CLB polycrystalline powder samples. Initially, the mixed materials were kept at a 500 ^oC temperature for 12 h to evaporate the moisture and decompose carbonate present in the materials. After cooling, the materials were remove from the crucible and once again grounded and sintered at 900 ^oC for next 18 h. The pure and 5 mol% Nd-doped CLB glasses were obtained from corresponding polycrystalline compounds according to standard glass technology. Appropriate quantities of polycrystalline powders were taken in an open silica crucible and kept in a muffle furnace. The temperature was raised upto 1050 ^oC to melt compounds and maintained the temperature for 1–2 h for homogenisation. The pure and 5 mol% Nd doped CLB glasses were obtained by quenching the corresponding melt. The prepared glasses were cut into proper shape and polished (Fig. 1) to use in further studies.

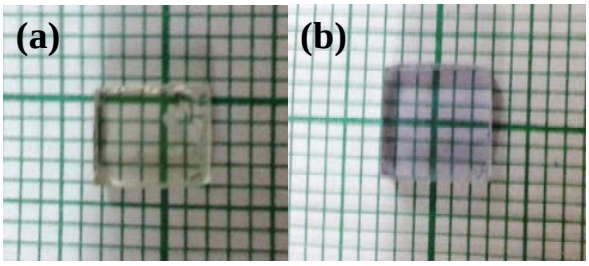

Fig. 1 Photographs of (a) pure and (b) 5 mol% Nd doped CLB glass.