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Short Communication

Synthesis and optical properties of borate glass of system $3Li_2O$-$2K_2O$-$5B_2O_3$

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Abstract

A glass of system $3Li_2O$-$2K_2O$-$5B_2O_3$ has been prepared by melt quenching technique. The glass sample was characterized by powder X-ray diffraction (XRD) to confirm an amorphous nature of glass. Obtained glass was characterized using ultraviolet-visible-near infrared (UV-vis-NIR) spectroscopy, which was used to determine percent transmission of the glass. The optical band gap of the grown glass has also been reported.

Keywords: Borate glass, Powder XRD, UV-vis-NIR spectroscopy.

Introduction

In past few years, borate-based glasses have attracted much attention due to their potential applications in electronic, electrochemical, electro-optic devices and optical applications[1]. The glasses are featured by the absence of long range order in their structure. The category of solid materials is commonly termed amorphous in compare with the crystalline materials[2,3]. Nowadays, borate is one of the most important glass formers and has been fitted into several kinds of glass systems to achieve the desired chemical and physical properties[2,4]. The important attractive properties of non-crystalline borate glass such as high transparency, low melting point, large values of refractive index, radiation and thermal stability, non-radiative relaxation states and good optical properties[5-10]. As per the literature survey, borate-based glasses such as potassium lithium borate[2], lithium-potassium borate[11] lead sodium borate[12], alkali bismuth borate[13], calcium bismuth borate[6], bismuth borate[14], lead borate[15] and Bi_2O_3–Li_2O–B_2O_3 glasses system[7] have been found studied thoroughly for different applications purpose.

In the present work, we have synthesized a glass of system $3Li_2CO_3$-$2K_2CO_3$-$5B_2O_3$ (LKB) by the melt quenching method and characterized it for optical properties. The sample was characterized by powder X-ray diffraction (XRD) and ultraviolet-visible-near infrared (UV-vis-NIR) transmission spectroscopy. The optical energy band gap of the material determined by using transmission spectrum is reported.

Materials and methods

Materials and synthesis: High purity analytical reagent grade chemicals- lithium carbonate (Li_2CO_3) purchased from LOBA Chemi, India, potassium carbonate (K_2CO_3) purchased from Fisher scientific, India and Boron trioxide (B_2O_3) was purchased from sd Fine chemicals, India., India were used as starting materials for the preparation of glass.

Appropriate amounts of the raw materials were taken and crushed to make the homogeneous mixture. The mixture was calcinated at 300°C for 3 hour to remove moisture. The mixture was removed from the crucible and once again crushed and heated at 500°C for 1 hour to receive a polycrystalline powder of LKB compound. Then powder sample was melted in a platinum crucible in an electric furnace for 15 minutes at 1000°C. The obtained melt was poured on a stainless steel plate and immediately pressed with second one for immediate quenching to form amorphous phased solid. The formed glass sample was allowed to cool gradually to room temperature. The obtained glass was cut into rectangular slabs of dimensions 6x4x2 mm^3 and polished to use for further characterization.

Powder XRD patterns of powder glass sample was recorded on a X-ray diffractometer (Rigaku, Miniflex-II, Japan) using Cu-Kα (λ=1.504 Å) radiation to check the amorphous state of the prepared glass sample at the scanning rate of 8 deg/min and 2θ varied from 10–80°. UV-vis-NIR transmission and optical band gap study have been performed using Black-CSR-50 StellarNet UV-vis spectrophotometer.

Results and discussion

Powder XRD analysis: Figure-1 shows recorded powder XRD pattern of glass sample LKB. This figure doesn't exhibit any sharp peak that represents the sample is of amorphous nature.

UV-vis-NIR spectroscopic study: Figure-2 shows the optical transmission spectra recorded in the wavelength range 190-1083 nm and a plot of variation of $(\alpha h\nu)^2$ versus hν (eV) from which a band gap of LKB glass has been determined. It can be observed that the lower cutoff wavelength for the grown glass is lying in

UV range at around 200 nm. The glass has shown the optical transparency above 75% in the UV and visible regions. The optical absorption coefficient (α) was evaluated using the relation (1);

$$\alpha = (2.303/d)\log(1/T) \quad (1)$$

Where: 'd' is the thickness of the glass and 'T' is the transmittance.

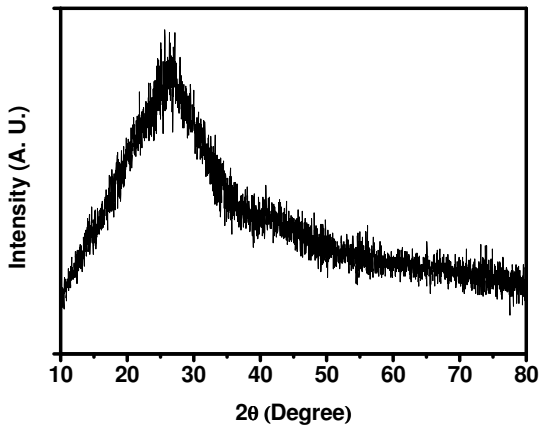

Figure-1: Powder XRD Patterns of LKB Glass.

The direct band gap of the glass can be determined with the help of a relation (2);

$$(\alpha h\nu)^2 = A(E_g - h\nu) \quad (2)$$

Where: 'A' is a constant.

Plotting a graph between $(\alpha h\nu)^2$ and $h\nu$[10], as shown the Figure-2 (b), and drawing tangent to straight portion intercepting energy axis gives energy band gap and it was found to be nearly 6.3 eV.

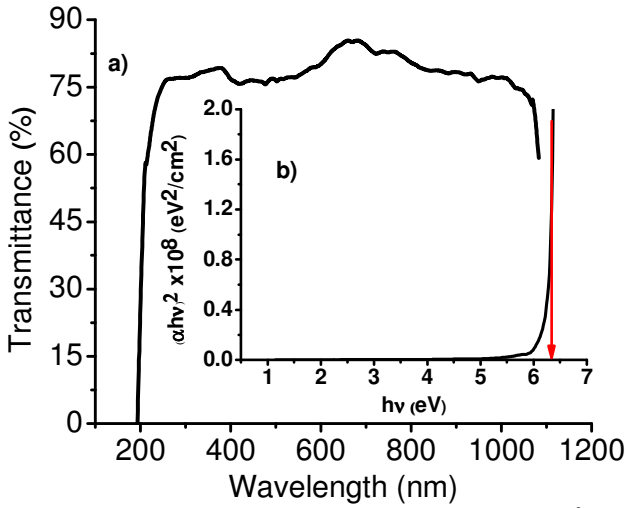

Figure-2: a) UV-Vis spectrum and b) a graph of $(\alpha h\nu)^2$ versus hν (eV) for LKB glass.

Conclusion

In the present report, a glass of system LKB was successfully grown. A simple melt quenching technique was used to prepare glass of large size with good optical transparency. The amorphous nature of the glass has been confirmed from powder XRD pattern. The optical transparency of the present crystal was more than 75 percent and envisages good optical quality. The band gap energy of the grown glass was found to be 6.3 eV and shows lower cutoff at 200 nm.

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