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Structural analysis of Iron Doped bismuth borate glasses/glass ceramics

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Abstract
All glasses found to share two common characteristics. No glass has a long range, periodic atomic arrangement. Crystalline nature of CFLBB1, CFLBB2 and CFLBB3 is due to presence of iron ions. Diffraction peaks originate from Fe_3O_4 at 2θ =35.915 35.394, 35.366 are observed in the XRD pattern. Fe^{4+} serves as a network modifier and Fe_2O_3 dominates over CoO in the present compositions. It is observed that intensity of all peaks, especially corresponding to (311) increases as the concentration of iron increases. CFLBB 1 represents sample with 0% cobalt content which increases by 5% cobalt at every step. So CFLBB5 represents sample with 20% cobalt content.

Keywords: Structural analysis, Iron Doped, bismuth borate, glass ceramics

Introduction
All glasses found to share two common characteristics. No glass has a long range, periodic atomic arrangement. Even more importantly, every glass exhibits time dependent glass transformation behavior. This behavior occurs over a temperature range known as the glass transformation region [1]. A glass can thus be defined as "an amorphous solid completely lacking in long range, periodic atomic structure, and exhibiting a region of glass transformation behavior." Any material inorganic, organic or metallic, formed by any technique and exhibits glass transformation behavior is glass [1].

Constituents of Glasses
1) Glass former
2) Property modifier
3) Colorant
4) Fining agent.

The primary glass formers in commercial oxide glasses are silica (SiO_4), boric oxide (B_2O_3) and phosphoric oxide (P_2O_5) which all readily form single component glasses. A large number of other compounds may act as glass formers under certain circumstances, including GeO, Bi_2O_3, As_2O_3, Sb_2O_3, TeO_2, Al_2O_3, Ga_2O_3, and V_2O_5.

Adding certain other materials can do the alteration in the properties of glass forming materials which are known as property modifier such as alkaline earth and Transitional metal oxide, and most importantly Alumina oxide. Colorants are used to control the color of the final glass. In most cases, colorants are oxides of either the 3d transition metals or the 4f rare earths elements. Uranium oxides were once used as colorants, but their radioactivity obviously reduces their desirability for most applications. Gold and silver are also used to produce colors by formation of colloids in glasses. Colorants are only used if control of the color of the glass is desired, and are usually present in small quantities finally fining agents are added to glass forming batches to promote the removal of bubbles from the melt. Fining agents include the arsenic and antimony oxides, potassium and sodium nitrates, NaCl, fluorides such as CaF_2, NaF, and Na_3AlF_6, and a number of sulfates.

The borate glasses are the category of glasses in which the major constituent is theB_2O_3 up to 70-80%. Bismuth borate glass is of great interest optoelectronic devices due to its low melting temperature (600-800 °C), extensive glass formation range, high refractive index ranging from 1.9 to 2.3, high physical and chemical stability, and nonlinear optical property.

Borate glasses containing a large amount of Bi_2O_3 possess a high refractive index & large polarizability, high optical basicity, small metallization and large optical susceptibility [2]. Borate glasses are suitable optical materials because of high transparency, low melting point, high thermal stability & good solubility. Borate glasses containing a large amount of Bi_2O_3 possess a high refractive index &large polarizability, high optical basicity, small metallization and large optical susceptibility [2]. Borate glasses are suitable optical materials because of high transparency, low melting point, high thermal stability & good solubility

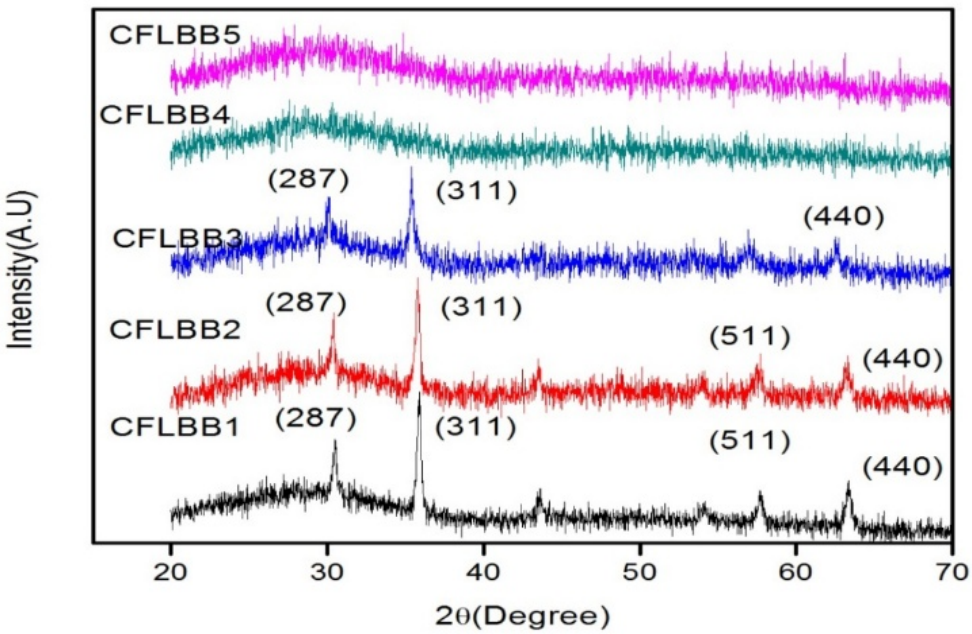
Sample Preparation

The sample was prepared using Melt Quench Technique. Sample codes of the samples having composition xCoO· (20-x)Fe_2O_3·10Li_2O_3·40B_2O_3·10Bi_2O_3, where x=0, 5, 10, 15 and 20.

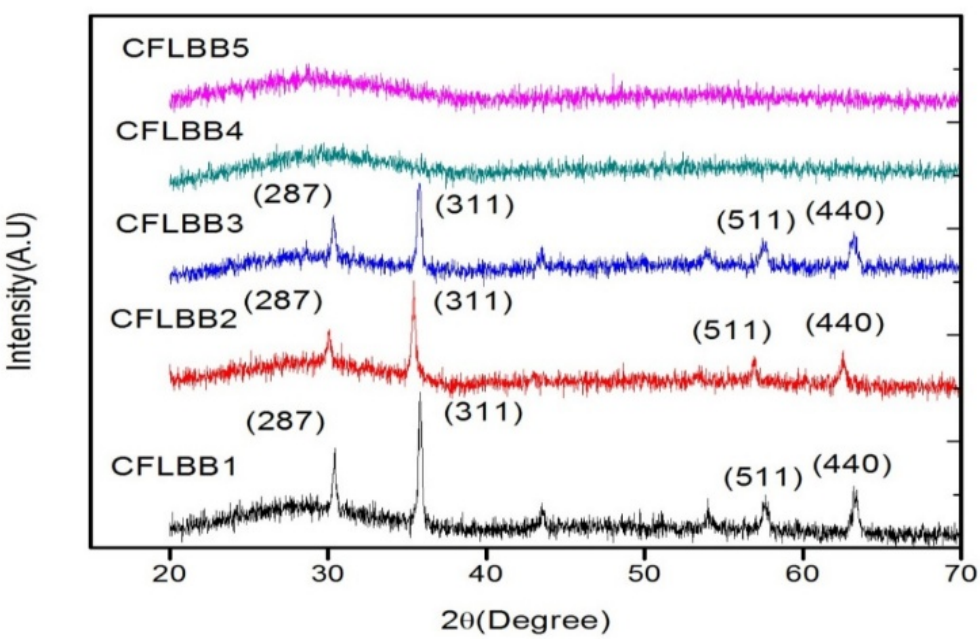
XRD Analysis

The value of crystallite size (D) of samples prepared through different techniques calculated using Debye Scherer equation where K (Debye Scherer constant) = 0.89, β is full width at half maximum(FWHM in radians) and θ is Bragg's angle. The prepared samples were studied by XRD as follows:

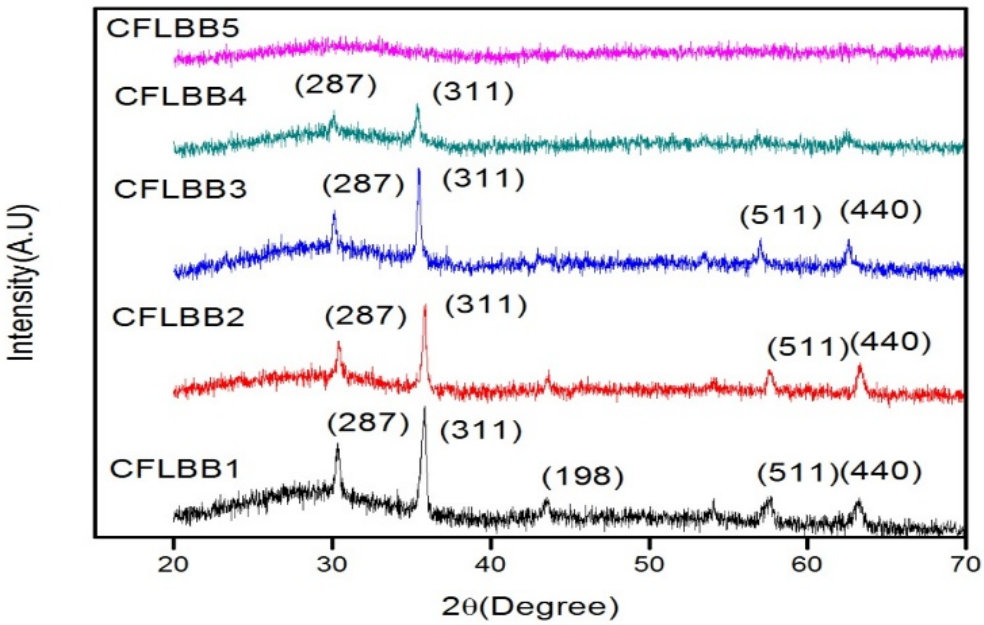
1. As-prepared samples
2. On annealing at 400^0 C for 4 hours.
3. On annealing at 400^0 C for 6 hours**.**



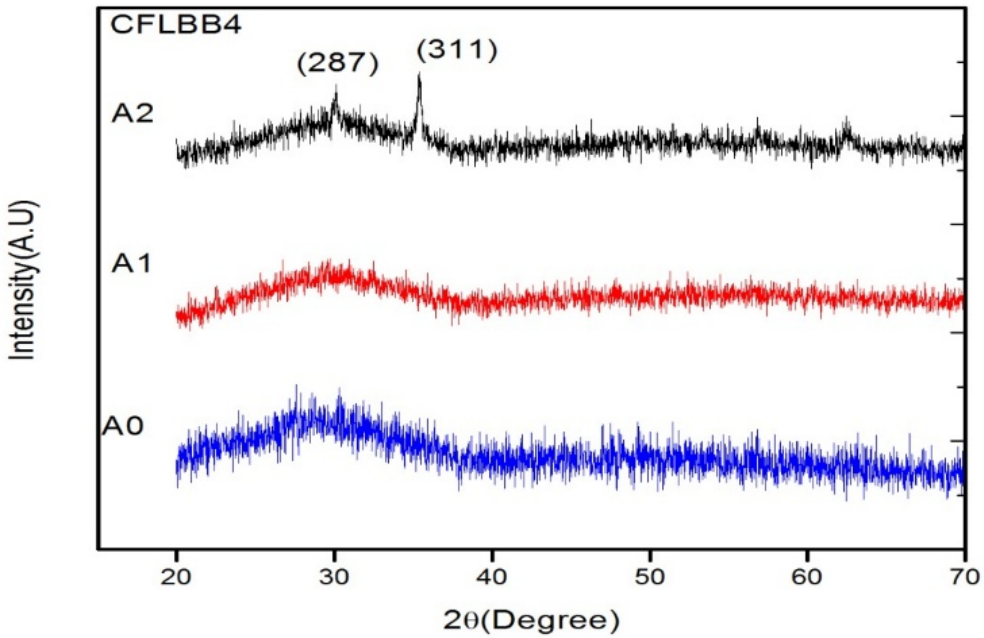
XRD Spectra of as prepared samples



XRD spectra of samples annealed at 400 ^{0}C for 4 hours**.**



XRD spectra of samples annealed at 400 ^{0}C for 6 hours**.**



XRD spectra of CFLBB4 for as-prepared (A0), annealed at 400 ^{0}C for 4h (A1) and for 6h (A2).

Discussion

Crystalline nature of CFLBB1, CFLBB2 and CFLBB3 is due to presence of iron ions [3]. Diffraction peaks originate from Fe_3O_4 at 2θ =35.915 35.394, 35.366 are observed in the XRD pattern [4]. Fe^{4+} serves as a network modifier and Fe_2O_3 dominates over CoO in the present compositions. From Fig.3.2, it is clearly observed that intensity of all peaks, especially corresponding to (311) increases as the concentration of iron increases.

As XRD spectra shows, peaks become sharper on annealing i.e. crystalline nature is improved. The intensity of the XRD peaks was found to increase with increasing heat treatment temperature. This is due to an increase of energy given to samples, which in turn increase the probability and the crystallization will take place [5]. It was found that particle size does not increase or decrease in a regular trend in present investigation of prepared samples. For CFLBB1, particle size (*D*) increases when heat treated for 4 hours at 400 ^{0}C but *D* decreases when sample was heat treated for 6 hours at the same temperature. No significant change in *D* was observed for CFLBB2 (*D* ~34nm), when heat treated at 400 ^{0}C for 4hours and 6 hours. Particle size for as-prepared CFLBB3 is ~36nm. While it becomes ~33nm after heating for 4 hours at 400 ^{0}C and then increases (~42nm) by heating for 6 hours at same temperature. CFLBB4 becomes ceramics on heating for 6 hours. From this we can conclude that on annealing the samples, either agglomeration or nucleation can take place. The crystallite size increases with the heat-

treated temperature and time. It may be due to the energy used to increase the contact between them and increase the surface area and then the increase the particle size. In some times this effect become randomly. It may be due to the found more than one phase and the energy divided be-tween them according the growth of every phase [5].

Generally the XRD lines are broadened due to two reasons: Due to Small crystallites and due to inhomogeneous stress distribution in the crystals. Stresses in glass ceramics are predominantly due to phase transition during cooling or to a mismatch in the thermal expansion coefficients of the glassy matrix and the crystalline inclusions. In the present case phase transitions can be excluded. This type of stresses may give rise to slight shift of the XRD lines; however they may not cause XRD line broadening. Hence small crystallites should be the only reason for XRD-line broadening [6].

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