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Research Article

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Spectroscopic properties of lead borax glasses doped with ytterbium

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ABSTRACT

A new lead borax glasses ($PbO\text{-}Na_2B_4O_7.10H_2O$) doped with Yb(III) is presented for the study of emission, absorption and other optical properties of borax glasses. Samples with different concentrations of Yb(III) were produced had their emission cross-sections, fluorescence lifetimes and minimum pump intensities determined. Changes in the position and the intensity parameters of the transitions are closely related to structural changes in the glass network. Specimen have high refractive index of 2.1 and a density of 4.2 g/cm^3 for a doping level of 0.5%, the fluorescence lifetime after excitation at 930nm is 0.92ms this is comparable to Yb: telluride laser glass. So it is a possibility to explore a laser material for lasing purpose.

Keywords: Ytterbium, Fluorescence, Borax.

INTRODUCTION

In recent years considerable attention has been devoted to the search for new materials to be used as hosts for rare-earth ion impurities. These ions can be incorporated easily into several glass matrices; which can make them suitable to achieve laser radiation due the appearance of sharp and unambiguous absorption bands in their optical absorption spectra. The procedure used to evaluate the intensities of the transitions for rare earth ions is based on the Judd-Ofelt theory (1, 2) However the increasing importance of glasses doped with rare earth ions as possible lasing materials has created considerable interest in the study of their optical properties materials doped with Yb(III) ions exhibits highly efficient emission using InGaAs laser diodes as pump source. As their two manifolds in the Yb(III) energy level scheme the $^2F_{7/2}$ ground state and $^2F_{5/2}$ excitation state. There is lack of intermediate levels and the large separation between the excited state and the ground state manifolds reduces non-radiative decay. It is known that knowledge of the spectroscopic properties of Yb(III) ions is of fundamental importance for laser action. Thse properties include emission cross-section and fluorescence lifetime these properties are calculated by using intensity parameters based on the judd-Ofelt theory. Since there is only the $^2F_{5/2} \rightarrow {}^2F_{7/2}$ transition for Yb(III). It is impossible to calculate directly the Judd-Ofelt parameters (3). In this paper, we present optical and physical properties of a new lead borax glasses doped with Yb(III) ions with different concentrations. The optical and physical properties were determined by means of absorption study and its associated lifetime, refractive index and density measurements calculation of spontaneous emission probability and emission cross-section were performed.

EXPERIMENTAL SECTION

The glasses presented in this work are prepared with 99.99% pure (AnalR of Merck) elements. Different concentrations of Yb_2O_3 (0.5 wt% to 4 wt%) were added to the glass matrix. These samples were melted in muffle

furnace at 700- 750 ^{o}C for approximately 1 hour using borocil glass crucible, next the melt was poured into borocil glass plate and this melt pressed by another borocil glass plate for a quite solidification disk and finally yellow colored, transparent and homogeneous samples were obtained. Glass samples with two faces and 3.2 mm thickness are used for measurement of refracted index, absorption, emission and other radiative properties. The refractive index was 2.4 determined. The absorption spectra were draw using a Perkin elmer Lambda 3B spectro photometer in the range of 920- 1160 nm at room temperature. The density of samples was 4.2 g/cm3 measured using Archimedes principle.

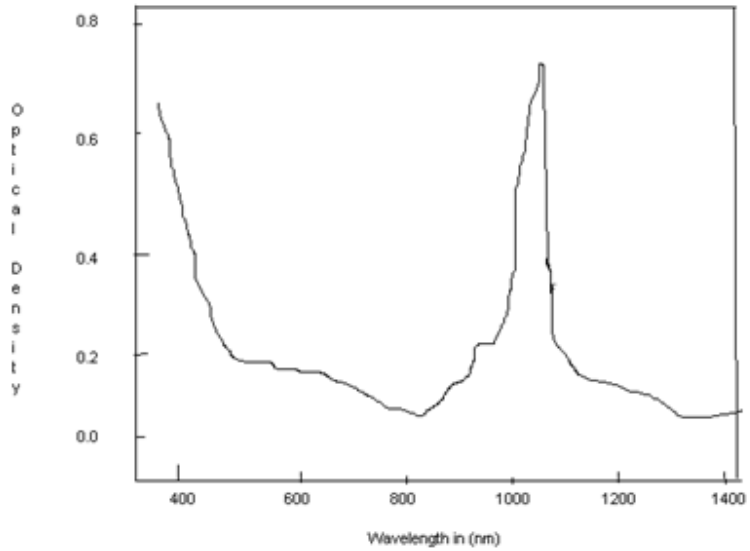

Fig-(1) Absorption spectrum for borax glass doped with 0.5 wt% of Yb(III) ion

RESULTS AND DISCUSSION

Fig (1) presents the absorption spectrum for the sample doped with 0.5 wt% of Yb(III) ion, with 3.2 mm thickness, in order to show the optical transparency. The fluorescence lifetime measured (δ_f) are shown in table (1).

Table (1)- Some spectroscopic properties of Yb (III) doped samples of different concentrations.

SN	Concentration (Wt%)	$\sigma_{em}(10^{-20}$ cm$^2)$	A_R (S^{-1})	δ_f (ms)	$\Delta\lambda_{eff}$	σ_{em} ,$\Delta\lambda_{eff}$
1.	0.5	1.09	3891.2	0.92	67.10	61.73
2.	1.0	0.95	2915.7	0.82	76.13	62.42
3.	2.0	0.81	2430.8	0.72	83.31	59.98
4.	3.0	0.75	2415.7	0.61	85.42	52.10
5.	5.0	0.69	2319.1	0.54	86.44	46.67

The highest value is 0.92ms for the sample doped with 0.5 wt% of yb(III) ions and as the concentration increases the lifetimes shortens gradually. The spontaneous emission probability A_R and emission cross section σ_{em} presented in table (1) are calculated using equation (2) that follows.

$$A_R = \frac{8\pi Cn^2(2J'+1)}{\lambda^4_P(2J+1)\delta}\int K(\lambda)\,d\lambda \qquad (1)$$

$$\sigma_{em} = \frac{\lambda^4 A_R\, g(\lambda)}{8\pi Cn^2} \qquad (2)$$

Where C is represents the velocity of light, n is the refractive index, λ_p is the absorption peak wavelength, δ is the concentration of yb(III) ions, K(λ) is the absorption coefficient, J and J' is the total momentum for the lower and upper levels and g(λ) is the normalized line shape function of the fluorescence transition of yb(III) ions. Based on

the above considerations, I come to the conclusion, that the samples with the best spectroscopic properties for an optical laser material is the one with 0.5 wt% of yb(III) in table (1). The above calculated spectroscopic data are comparable to some yb(III) doped laser glasses: Yb:YTG glasses has a fluorescence lifetime of 0.9 ms (4).Yb: PNK glass has an emission cross-section of 1.08 cm^2(5).

CONCLUSION

A new borax glasses doped with different concentrations of Yb(III) are presented. All the samples obtained exhibits good thermal stability against devitrification ($\Delta T \geq 70^oC$). The yb(III) doped lead borax glasses present a wide range of transmission, which provides the observation of several absorption lines associated to the trivalent rare earth ion Yb(III). The one of the best spectroscopic properties of sample doped with 0.5 wt% of Yb(III) ion has fluorescence lifetime of 0.92ms; emission cross section of 1.09×10^{-20} cm^2 at 998 nm; fluorescence effective line width of 67 nm. This new glass has very similar to properties when compared to other known glasses which are also used as other active laser glass media. These features make it for possibility to explore good candidate for laser action.

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REFERENCES

[1] B. R. Judd, optical absorption intensities of rare earth ions phy.Rev. 127 (**1962**)750-765.
[2] G.S. Ofelt Intensities of Crystal spectra of rare earth ions, J. chem.. Phys. 37 (**1962**) 511-520.
[3] X. Zon, H Toratam, "Evaluation of Spectroscopic properties of yb (III) doped glasses", phys Rev. B-52, 15889-15897 (**1995**).
[4] C Jiany, F. Gan, J. Zhang. "Yb telluride lasser glasses with high emission cross section", Materials letter 41, 205-214 (**1999**).
[5] C. Jiang, H. Liu "Yb:Phosphate lasert glass with high emission cross section " J. chem. And phys. Of solids 61, 1217-1223 (**2000**).