www.sphinxsai.com

ChemTech

International Journal of ChemTech Research
CODEN (USA): IJCRGG ISSN : 0974-4290
Vol.6, No.3, pp 1705-1707, May-June 2014

ICMCT-2014 [10th – 12th March 2014]
International Conference on Materials and Characterization Techniques

Radiative properties and energy transfer mechanism of Sm^{3+} ion in zinc-alumino-sodium-phosphate (ZANP) glasses

K. Brahmachary, D. Rajesh, A. Balakrishna and Y.C. Ratnakaram*

Department of Physics, Sri Venkateswara University, Tirupati-517502, India

***Corres.author: ratnakaramsvu@gmail.com**

Abstract: The fluorescence properties of different concentrations of Sm^{3+} doped Zinc-Alumino-Sodium-Phosphate (ZANP) glasses were studied by the XRD, optical absorption, and photoluminescence. X-ray diffraction profiles confirmed the amorphous nature of the glass samples. Judd-Ofelt (J-O) theory was applied to the experimental oscillator strengths to evaluate three phenomenological J-O intensity parameters, Ω_λ (λ=2, 4 and 6). Using J-O intensity parameters and emission spectra, various radiative parameters such as radiative transition probabilities (A_R), radiative lifetimes (τ_R), calculated and measured branching ratios (β_R & β_m), effective bandwidths ($\Delta\lambda_{eff}$) and stimulated emission cross-sections (σ_P) were calculated for observed emission transitions. The intensity of emission transitions with the variation of Sm^{3+} ion concentration was studied.
Keywords: Judd-Ofelt Parameters; Emission cross-section; Branching ratio.

1. Introduction and Experimental

Rare earth ions doped glasses are important materials for bulk lasers, optical fibers, optical amplifiers and wave guide lasers [1-3]. The interest in selection of phosphate glass as a host for rare earth ions is owing to their transparency in a wide spectral range (from ultraviolet to infrared), which makes them suitable for fabrication of optical fibers, low melting point, thermal stability and high gain density.

Among various lanthanide ions, Sm^{3+} ion is one of the most interesting ions, because of its increasing demand in various fluorescent devices, high-density optical storage, under sea- communication and color displays. Its emitting $^4G_{5/2}$ level exhibits relatively high quantum efficiency and also shows different quenching emission channels [4,5].In the present paper, the authors report the results obtained on the and spectroscopic properties of different concentrations of Sm^{3+} doped zinc-aluminium-sodium-phosphate (ZANP) glass matrix. The Judd-Ofelt (J-O) theory has been applied to explore the f↔f transition of rare earth ion to evaluate Ω_λ (λ=2, 4 and 6) parameters and radiative properties of the excited states.

The glass samples synthesized in the present work have the compositions (50-x) P_2O_5-20Na_2HPO_4-10ZnO-10AlF_3-10NaF-xSm_2O_3 (where x= 0.1, 0.5, 1.0, 1.5 and 2.0 mol%). These glass samples here after are represented as ZANPSm01, ZANPSm05, ZANPSm10, ZANPSm15 and ZANPSm20 for 0.1, 0.5, 1.0, 1.5 and 2.0 mol% concentrations respectively. These glass samples were prepared by the standard melt quenching technique and the samples were annealed at 400°C for 4 h in order to remove mechanical stress.

2. Results and Discussion

The X-ray diffraction profiles of different concentrations of Sm^{3+} doped zinc-alumino-sodium-phosphate (ZANP) glass matrix shown in Fig.1 confirm the amorphous in nature of the glass samples. Optical absorption (UV-Vis-NIR) spectra for the investigated glass samples consist of sixteen peaks and the ground state for them is $^6H_{5/2}$.

The Judd-Ofelt parameters along with the parameters reported for other glass matrices and quality factors are reported in Table 1. In the present work, Ω_2 parameter is lower at 1.5 and 2.0 mol% and higher at 0.5 mol% of Sm^{3+} doped glasses indicating lower and higher covalencies of Sm-O bond in these glass matrices. Ω_4 and Ω_6 parameters indicate rigidity of the medium.

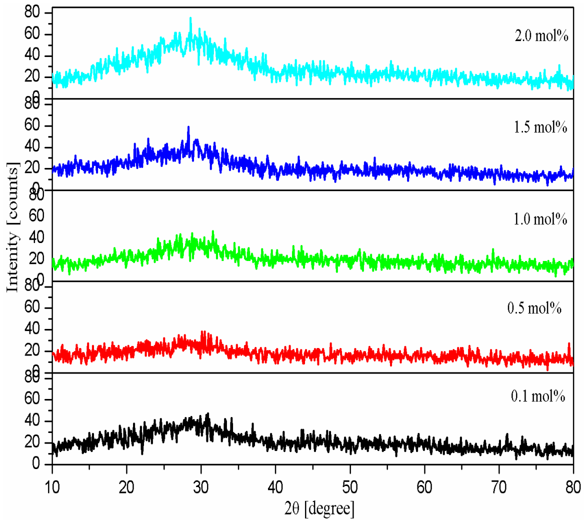

Fig. 1 X-ray diffraction patterns of Sm^{3+} doped ZANP glass matrix (for diffrent concentrations).

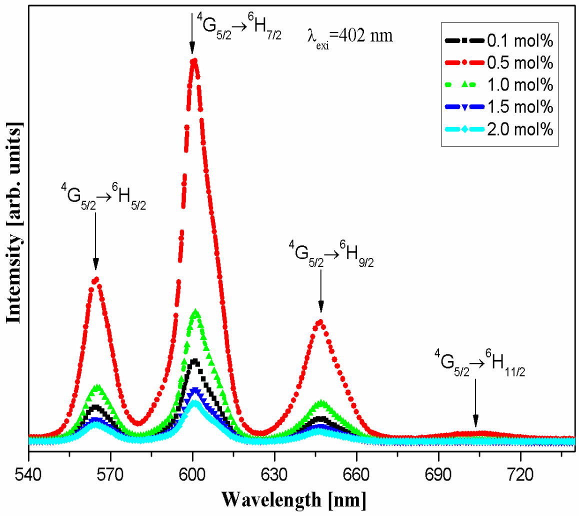

Fig. 2 Emission spectra of Sm^{3+} doped zinc-alumino-sodium-phosphate glass matrix (for different concentrations).

Emission spectra of different concentrations of Sm^{3+} doped ZANP glass matrix in the spectral region 540-750 nm is shown in Fig. 2 As seen from the fig., four emission peaks nearly at 564, 600, 647 and 703 nm, which are due to transitions from excited level $^4G_{5/2}$ to its lower lying levels, $^6H_{5/2}$, $^6H_{7/2}$, $^6H_{9/2}$ and $^6H_{11/2}$ respectively are observed. Among these four transitions, $^4G_{5/2}\rightarrow{}^6H_{7/2}$ (600 nm) transition exhibits high intensity and its full-width at half maximum

Table 1 Judd-Ofelt intensity parameters, Ω_λ (λ=2, 4 and 6) ($\times 10^{-20}$ cm^2) of Sm^{3+} doped zinc- alumino-sodium-phosphate glass matrix (for different concentrations).

S. No	Glass matrix	Ω_2	Ω_4	Ω_6	Trend
1	ZANPSm01	0.55	6.98	4.19	$\Omega_4>\Omega_6>\Omega_2$
2	ZANPSm05	0.63	5.84	4.56	$\Omega_4>\Omega_6>\Omega_2$
3	ZANPSm10	0.48	6.21	5.03	$\Omega_4>\Omega_6>\Omega_2$
4	ZANPSm15	0.36	6.50	5.40	$\Omega_4>\Omega_6>\Omega_2$
5	ZANPSm20	0.36	5.81	4.08	$\Omega_4>\Omega_6>\Omega_2$

Table2 Emission band positions (λ_p, nm),), radiative transition probability (A_{rad}), branching ratios (β_{exp}) and peak stimulated emission cross-sections (σ_p x 10^{20} cm^2) of Sm^{3+} doped Zinc- alumino – sodium- phosphate glass (for different concentrations).

Transition	Parameter	0.1 mol%	0.5 mol%	1.0 mol%	1.5 mol%	2.0mol%
$^4G_{5/2}\rightarrow{}^6H_{5/2}$	λ_P	564.3	564.6	564.7	564.8	564.9
	β_{exp}	0.21	0.19	0.20	0.20	0.21
	σ_P	4.95	5.09	4.97	5.03	4.55
$^4G_{5/2}\rightarrow{}^6H_{7/2}$	λ_P	600.6	600.7	600.8	600.9	601.0
	β_{exp}	0.60	0.60	176.6	0.62	0.60
	σ_P	8.16	8.33	8.20	8.18	7.76
$^4G_{5/2}\rightarrow{}^6H_{9/2}$	λ_P	646.5	646.6	646.7	648.8	646.9
	β_{exp}	0.19	0.20	0.19	0.17	0.19
	σ_P	4.80	5.06	4.99	4.98	4.22
$^4G_{5/2}\rightarrow{}^6H_{11/2}$	λ_P	703.1	703.5	703.6	703.7	703.8
	β_{exp}	0.01	0.01	0.01	0.01	0.01
	σ_P	5.45	5.66	5.41	5.50	5.13

(FWHM) is 15 nm. It is observed that the intensity of all the emission peaks increases up to 0.5 mol% of Sm^{3+} ion concentration and then decreases for remaining concentrations. This phenomenon is called as concentration quenching in rare earth ions. Table 2. presents radiative properties of four emission transitions in all concentrations of Sm^{3+} doped glasses. It is observed that out of four emission transitions, $^4G_{5/2}\rightarrow{}^6H_{7/2}$ shows the highest radiative transition rate. As seen from the table, the transition $^4G_{5/2}\rightarrow{}^6H_{7/2}$ has higher branching ratio values among all the transitions. Good laser transition shows large stimulated emission cross-sections(σ_p). From table 5, it is observed that the stimulated emission cross-section is higher for $^4G_{5/2}\rightarrow{}^6H_{7/2}$ transition among the four transitions and it shows maximum at 0.5 mol% of Sm^{3+} doped glass matrix. Therefore, based on above emission properties, Sm^{3+} doped with 0.5 mol% glass shows higher emission parameters values for the emission transition, $^4G_{5/2}\rightarrow{}^6H_{7/2}$ suggesting its suitability for reddish-orange laser emission applications.

3. Conclusions

Optical absorption and fluorescence spectra of Sm^{3+} ion doped zinc-alumino –sodium-phosphate glasses for different glass concentrations have been recorded at room temperature. Intensity of all the emission peaks increases upto 0.5 mol% of Sm^{3+} ion concentration and then decrease for remaining concentrations. This is mainly due to Sm3+-Sm3+ interactions at higher concentrations. The stimulated emission cross-section is higher for $^4G_{5/2}\rightarrow{}^6H_{7/2}$ transition among the four transitions and it shows maximum at 0.5 mol% of Sm3+ doped glass matrix.

Acknowledgements

One of the author KBA expresses his sincere thanks to University grants Commission-South Eastern Regional Office (UGC-SERO), Hyderabad for providing financial assistance under Faculty Development Programme (FDP).

References

1. Chen B.J., Pun E.Y.B., Lin H., J. Alloys Compd., 479, 2009, 352.
2. Lai B., Wang J., Su Q., Appl. Phys., B 98, 2010, 41.
3. Som T., Karmakar B., J. Phys. Condens. Mater., 22, 2010, 035603.
4. Tripathi G, Rai V.K., Rai S.B., Appl. Phys., B, 84 , 2006, 459.
5. Huang L., Jha A., Shen S., Opt. Commun., 281, 2008, 4370.

*****