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Spectroscopic Investigations of Nd³⁺ Doped Heavy Metal Oxide Borophosphate Glasses

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Abstract—Spectroscopic and physical properties of Nd^{3+} doped multi component heavy metal oxide glass systems in varying molar concentrations of Nd^{3+} ion in the glass matrices shown by the composition as $30PbO - 20Bi_2O_3 - 25MgHPO_4 - (25-x) B_2O_3 - xNd_2O_3$ (where x=1.0, 1.5 and 2.0 mol %) have been studied. Optical absorption spectra have been used to determine the Judd-Ofelt intensity parameters (Ω_2 , Ω_4 and Ω_6) have been computed from the intensities of the energy levels. The radiative lifetimes (τ_R), branching ratios (β) and absorption cross sections (σ_a) have been evaluated for the lasing levels ${}^2H_{11/2}$, ${}^4F_{9/2}$, ${}^4F_{7/2}$, ${}^4F_{5/2}$, and ${}^4F_{3/2}$. The emission cross sections (σ_e) for the significant lasing transitions ${}^4F_{3/2} \rightarrow {}^4I_{9/2}$, ${}^4I_{13/2}$ evaluated from the photoluminescence spectra are reported. The lasing potencies estimated for all the glasses under study indicate their good lasing potencies.

Keywords— Judd-Ofelt parameters, hypersensitive transition, Oscillator strengths, Lifetimes, Absorption cross sections, Emission cross sections

1. INTRODUCTION

Heavy metal oxide glasses are very attractive hosts for the RE ions [1-4]. Optical Kerr shutter switching and degenerated four wave mixing experiments have been performed on bismuth borate glasses using femto second pulse lasers [5-7]. In view of these characteristics, Bi_2O_3 based glasses have potential applications in optoelectronic circuits as ultra fast switches, infrared windows, optical isolators [6, 7]. The nonconventional glass forming oxide Bi₂O₃, participates in the glass structure with two possible co-ordinations [BiO₃] pyramidal and [BiO₆] octahedral units [6-8]. Further, bismuth ion was found to be an efficient luminescent activator with applications in lasers as a sensitizer for some rare earth ions [9]. The modifier oxide, PbO, when added to bismuth borate glasses, the glasses are expected to become highly stable against devitrification and chemically inert [10]. Structural studies of borophosphate glasses [11, 12, 13–15] confirm that boron atoms are incorporated as either trigonal, B (3), or tetrahedral, B (4), sites within the borophosphate network, depending on composition. In the phosphate-rich range of the composition, boron atoms are mostly B (4), while in the borate-rich range, B (3) dominates. This difference in the coordination number will affect the properties of the glasses.

Rare earth (RE) doped materials is widely studied due to their important applications. Particularly, RE containing glasses are known to be good candidate materials for devices such as optical amplifiers, up conversion lasers and glass lasers [16–21]. Since, a maximum laser output requires an optimum concentration of Nd³⁺ it becomes

important to study the spectroscopic properties as a function of concentration of rare earth ions. Both higher and lower concentrations lead to lower laser efficiencies. The lower efficiencies at higher concentrations are due to non-radiative self-quenching process. Neodymium doped glasses have attracted attention as they act as key element for optical amplifier around 1.3 μ m and for higher power laser applications around 1.05 μ m [22]. The outer shell configuration of neodymium is 4f¹² 5s² 5p⁶ 6s². The transition probability between 4f states, however are sensitive to the ions surrounding the rare earth ions.

The present study a varied concentration of Nd_2O_3 has been investigated in these glasses for their possible application as efficient 1.06 nm laser material and also aimed at studying the radiative properties of Nd^{3+} doped in lead bismuthate magnesium borophosphate glasses by variation of concentration of Nd^{3+} .

2. EXPERIMENTAL

The Lead bismuth magnesium borophosphate (LBMBPN) glasses doped with Nd³⁺used in the present work is prepared with the following composition in mol%: $30Bi_2O_3-20PbO - 25MgHPO_4 - (25-x) B_2O_3 - xNd_2O_3$ (where x=1, 1.5 and 2 mol %) by conventional melt quenching technique. These glass samples are labeled as LBMBPN1, LBMBPN1.5 and LBMBPN2.0. Ingredients are weighed for each sample as 10g for each batch. They are mixed thoroughly in an agatre mortar then melted at $1050^{\circ}C$ for 1 h in a porcelain crucible in a temperature controlled muffle furnace. The melts were poured on a preheated brass plate and then annealed at $350^{\circ}C$. The obtained glasses were cut and polished well for measuring their optical properties. Absorption spectra of these glass

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samples were obtained in the 200-2200 nm region by using a JASCO UV-vis-NIR V-670 spectrophotometer with resolution of 0.5 nm. Density was measured by Archimedes' principle using O-xylene as an immersion liquid. The refractive indices (n) of these samples were determined using conventional methods [23]. The Photoluminescence spectrum for emission in the wave length range of 700-1600 nm was recorded using Dongwoo Optron spectrophotometer at excitation wave length of 532 nm.

3. RESULTS AND DISCUSSION

3.1 Physical Properties

Physical properties such as Neodymium ion concentration (N), inter ionic distance (r_i) , polaron radius (r_p) field strength (F), molar refractivity (R_M), electronic polarizability (α) and optical basicity are evaluated using relevant expressions [24,25, 26] for Nd³⁺ doped LBMBPN1, LBMBPN1.5 and LBMBPN2 glasses and are presented in Table 1. The number of luminescent centers is found to be densely distributed because of the fact that the glass density (d) and refractive index (n) values are higher. The polaron radius (r_p) is smaller than inter ionic distance (r_i) and hence such a smaller r_p value has resulted in a higher field strength (F) shown in Table.1. Polaron radius and inter ionic distances are low for LBMBPN1 and high for LBMBPN1.5. The polaron radius, inter ionic distance, electronic polarizability and molar refractivity are observed to be high for LBMBPN1.5. But the field strength is low for LBMBPN1.5.

3.2 Absorption Spectra

The observed energy levels (Fig 3.2) of LBMBPN1,1.5,2 glasses at 513 nm, 525 nm, 583 nm, 627 nm, 683 nm, 747 nm, 803 nm and 875 nm were assigned to ${}^{4}I_{9/2} \rightarrow {}^{4}G_{9/2}$, ${}^{4}G_{7/2} + {}^{2}K_{13/2}$, ${}^{4}G_{5/2} + {}^{2}G_{7/2}$, ${}^{2}H_{11/2}$, ${}^{4}F_{9/2}$, ${}^{4}F_{7/2} + {}^{4}S_{3/2}$, ${}^{4}F_{5/2} + {}^{2}H_{9/2}$ and ${}^{4}F_{3/2}$ transitions [27] respectively. The energy levels lying below 450 nm could not be observed in the present glass system due to intrinsic inter band absorption of the host matrices.



Fig. 1: Vis absorption spectrum of Nd³⁺ions doped LBMBPN1.0, 1.5 and 2.0 glasses.

3.2.1 Optical Band Gap

To understand optically induced transitions and optical band gaps of materials, the study of optical absorption edge gives more important information. The principle of the technique is that a photon with energy greater than the band gap energy will be absorbed. There are two kinds of optical transitions at the fundamental absorption edge: direct and indirect transitions, both of which involve the interaction of an electromagnetic wave with an electron in the valence band. The optical band gaps (E_{opt}) for both indirect and direct transitions of prsent glasses are measured [28] given in Fig. 2a and 2b. The indirect and direct mobility gap both show a maximum for 1.5 mol% and a minimum for 2mol% concentration of Nd₂O₃. The variations of cut-off wavelength agree with the trend followed by direct and indirect mobility gap. As the content of Nd³⁺ ions increases in the borate network BO₃ units with non-bridging oxygen (NBOs) atoms are increased, except for 1.5 mol% of Nd³⁺. Since NBOs are more excited than bridging oxygens (BOs), the band gap decreased as shown in Table 2. At 1.0 and 2.0 mol% concentration of Nd^{3+} in glass matrices the E_g is lower and increases at 1.5 mol% concentrations suggesting that lower concentration of Nd^{3+} , favors Bi^{3+} ions to exist in BiO_6 octahedral symmetry. Interestingly, at 1.5 mol% concentration of Nd³⁺ the band gap again increased may be due to conversion of BiO₆ octahedral to BiO₃ pyramidal.

3.2.2 Spectral Intensities

The experimental oscillator strengths (f_{exp}) of all the absorption bands have been measured using the area method from the equation 1. The f_{cal} values for all those bands are evaluated using Judd-Ofelt theory [29, 30] from the literature [28]. The experimental (f_{exp}) and calculated (f_{cal}) spectral intensities of obtained energy levels of Nd³⁺ are presented in Table 3.4. The rms deviation between f_{exp} and f_{cal} is very low, confirming the validity of Judd-Ofelt theory [31].

$$f = 4.32 \times \int \varepsilon(v) dv \tag{1}$$

Where ε is the molar extinction coefficient which can be calculated using the Beer–Lambert law at energy $\upsilon \text{ cm}^{-1} \int \varepsilon(\upsilon) d\upsilon$ was evaluated by measuring the area under the curve shown in Fig.1

3.2.3 Hypersensitive Transition

The hypersensitive transition ${}^{4}I_{9/2} \rightarrow {}^{4}G_{5/2} + {}^{2}G_{7/2}$ of Nd³⁺ ions, obeys the selection rules $\Delta J \leq 2$, $\Delta L \leq 2$ and $\Delta S = 0$. The intensity of hypersensitive transition in all the glass hosts of present study is given in Table 4. These transitions are found to be very sensitive to the environment of the rare earth ion. As observed from Table.1, the intensity of hypersensitive transition shows a maximum for 2 mol% and a minimum for glass containing 1.5 mol % of Nd₂O₃ due to concentration quenching. This indicates that the non-symmetric component of electric field acting on Nd³⁺ ion is low for glass containing 1.5 mol % and high for 2 mol % of Nd₂O₃. The possible reason could be the formation of NBO's around 2 mol% concentration of Nd₂O₃ as discussed in explaining the density of the present glass system. The creation of non-bridging oxygen from bridging oxygen increases the asymmetry of the bond to the neighboring network cation [32]. A decrease in intensity of hypersensitive transition for 1.5 mol% Nd₂O₃ glass can be because of clustering of rare earth ions for higher concentrations ie., concentration quenching. The values of Ω_2 are found to be proportional to the intensities of the hypersensitive transition, in accordance with the theory [33].

3.2.4 Intensity Parameters

Judd–Ofelt analysis [29, 30] has been performed on these eight well resolved observed absorption bands of Nd³⁺ to estimate the three phenomenological intensity parameters ($\Omega_{2,4,6}$) through least square fitting of their experimental line strengths. The Judd-Ofelt intensity parameters Ω_{λ} are evaluated using the formula:

$$\Omega_{\lambda}\left(cm^{2}\right) = \left(\frac{3h}{8\pi mc}\right) \left(\frac{9n}{(n^{2}+2)^{2}}\right) (2J+1)T_{\lambda}$$
⁽²⁾

The J-O parameters derived from absorption spectral data are shown in Table.4. The J-O parameters for LBMBPN1, LBMBPN 1.5 and LBMBPN 2.0 glass systems in the present investigation are similar to the values reported for other glass systems in the literature [34]. J-O parameter Ω_2 is most sensitive to local structure and host glass composition and its value is indicative of asymmetry of the rare earth ion site and covalency [35]. The values of J-O parameters are found to be in the following order for Nd³⁺ ions: $\Omega_6 > \Omega_2 > \Omega_4$ presented in Table 4. The molar concentration variation trend for Nd³⁺ in the glass system LBMBPN1, LBMBPN1.5 and LBMBPN2 exhibits the following tendency in the magnitude of Ω_2 parameter. LBMBPN1>LBMBPN2>LBMBPN 1.5

The Luminescence Intensity of Nd3⁺ Ions Increases with the Increase of Nd3⁺ Concentration, Reaches a Maximum Value at 1.0 Mol % and Then Decreases Due to the Concentration Quenching Phenomenon in Rare Earth Ions, When the Concentration of Nd3⁺ is More Than 1.0 Mol %. Ω_2 Parameter Which Indicates Covalency, Increases with the Increase of Intensity of the Hypersensitive Transition [37]. The Ω 2 Intensity Parameters are Related to Asymmetry of the Ligands Around the Nd3⁺ and Thus Covalency of Nd-O Bonding. The Larger Value of Ω 2 Parameter in Present Glasses is Due to the Relatively More Asymmetric Crystal Field Around Dopant Ions Compared to the Other Hosts [34]. Ideally, the Intensity Parameters Do Not Show Any

Variation with the Concentration in Same Host Matrix Owing to the Occupation of Similar Dopant Sites. With Increasing Concentration Giving Rise to the Variations in Local Crystal Field as Well as Asymmetry Around Dopant Ions. So, some Deviation is Observed in Judd-Ofelt Intensity Parameters in Present Glasses Due to the Tendency of Clustering of Dopants Ions as Well as Site-To-Site Variation [36]. Ω_4 and Ω_6 Values Depend on Bulk Properties such as Viscosity and Dielectric of the Media and are Also Affected by the Vibronic Transitions of the Rare Earth Ions Bound to the Ligand Atoms [28]. The Rigidity and Dielectric Indicative $\Omega 4$ and $\Omega 6$ Parameters Obtained in the Present Study for LBMBPN1, 1.5, 2 Glass Systems Show Lower and Higher Respectively in their Magnitudes Compared to $\Omega 2$ Parameter Suggesting the Favorable Spectroscopic Quality of the Glass Hosts Under Study. The Values of $\Omega 4$ and $\Omega 6$ are Strongly Influenced by the Vibrational Levels Associated with the Central Nd3⁺ Ions Bound to the ligand atoms.

3.3.5 Radiative Properties

J-O parameters Ω_4 and Ω_6 play crucial role in defining the radiative properties like transition probability, branching ratio and emission cross-section of active ions. The values of spectroscopic quality factors in present glasses have been tabulated in the Table.5, which is observed to be decreasing with the increase in dopant concentration suggesting enhanced intensity for ${}^{4}F_{3/2} \rightarrow {}^{4}I_{11/2}$ transition at higher Nd³⁺ concentrations. Using Judd–Ofelt intensity parameters, Ω_k (k = 2, 4 and 6) obtained from the measured spectral intensities of the absorption bands and using the formulae given in the theory, the total radiative transition probabilities (A_T) and radiative lifetimes (τ_R) of the excited states ${}^{4}G_{9/2}$, ${}^{4}G_{7/2}$, ${}^{4}G_{5/2}$, ${}^{2}H_{11/2}$, ${}^{4}F_{9/2}$, ${}^{4}F_{5/2}$ and ⁴F_{3/2} of Nd³⁺ion in LBMBPN1, 1.5, 2 glasses have been calculated. It is observed from the table that the total spontaneous transition probabilities of all the excited states of Nd³⁺ increases with increasing covalency of the rare earth site which is indicated by Ω_2 value. The calculated radiative lifetimes of all the above-excited states are presented in Table.5 and it is observed to be more for LBMBPN1.5 glass. The above parameters can be evaluated from the literature [32]. Radiative transition probabilities (A_{rad}), radiative life times (τ_R), branching ratios (β) and absorption cross-sections (σ_a) for the exited states ${}^{4}G_{9/2}$, ${}^{4}G_{7/2}$, ${}^{4}G_{5/2}$, ${}^{2}H_{11/2}$, ${}^{4}F_{9/2}$, ${}^{4}F_{5/2}$ and ${}^{4}F_{3/2}$ of Nd³⁺ion in LBMBPN1, 1.5, 2 hosts are calculated and presented in Table.4. The above parameters can be evaluated from the literature [28].

3.4 Fluorescence Properties

From the recorded emission spectra of the glass, the emission level peak wavelengths (λ_p nm), effective band width (FWHM) ($\Delta\lambda_p$ nm) and stimulated emission crosssections (σ_E) were measured [28] and reported in Table 6. The Judd–Ofelt intensity parameters Ω_2 , Ω_4 and Ω_6 are

Physical parameter	LBMBPN1.0	LBMBPN1.5	LBMBPN2.0
Average molecular weight	221.9	223.3	224.6
Density	4.995	4.737	4.83
Refractive index 'n'	2.105	2.107	2.108
Concentration $N(\times 10^{-22})$	1.36	1.28	1.29
Polaron radius $R_p(\times 10^{-8})$	3.62	3.7	3.68
Inter ionic distance $r_i (\times 10^{-8})$	4.19	4.28	4.26
Field strength 'F' ($\times 10^{+15}$)	2.28	2.20	2.22
Molar refraction 'R _M '	23.7	25.2	24.8
Electrical polarizability ' α ' (× 10 ⁻²⁴)	9.51	9.39	1.05
Molar volume 'Vm'	44.4	47.1	46.5
Dielectric constant ' ϵ '	3.43	3.44	3.44

Table 1: Physical properties of Nd³⁺:LBMBPN1.0, 1.5 and 2.0 glasses.

Table 2: Optical band gaps for Nd³⁺:LBMBPN1.0, 1.5 and 2.0 glasses.

Energy gap	LBMBPN1.0	LBMBPN1.5	LBMBPN2.0
Indirect mobility gap (eV)	3.166	3.176	3.153
Direct mobility gap (eV)	3.172	3.184	3.167

 Table 3: Measured and calculated Oscillator strengths (f ×10⁻⁶) of observed absorption bands of Nd³⁺: LBMBPN1.0, 1.5 and 2.0 glasses.

Transition ${}^{4}I_{9/2} \rightarrow$	LBM	BPN1	LBM	BPN2	LBMBPN3		
	f_{exp}	f_{cal}	f_{exp}	f_{cal}	f_{exp}	f_{cal}	
${}^{4}F_{3/2}$	2.459	3.12	2.58	2.36	1.76	2.36	
${}^{4}F_{5/2} + {}^{2}H_{9/2}$	9.658	8.99	9.03	9.32	9.14	9.32	
${}^{4}F_{7/2} + {}^{4}S_{3/2}$	8.562	8.92	8.69	10.6	10.5	10.6	
${}^{4}F_{9/2}$	0.484	0.71	0.478	0.79	0.68	0.79	
$^{2}H_{11/2}$	0.207	0.197	0.227	0.217	0.22	2.17	
${}^{4}G_{5/2} + {}^{2}G_{7/2}$	25.8	25.8	25.7	25.6	27.8	27.9	
${}^{4}G_{7/2} + {}^{2}K_{13/2}$	4.303	5.48	7.94	5.17	8.31	5.17	
${}^{4}G_{9/2}$	2.955	1.96	0.347	1.75	0.43	1.75	
rms dev.	± 0.045		±0.101		±0.107		

Table 4: Comparison of Judd–Ofelt intensity parameters ($\Omega_k \times 10^{-20}$) (k= 2, 4, 6) (cm²) of Nd³⁺ ions in various glass environments.

Glass	$arOmega_2$	$arOmega_4$	$arOmega_6$	Ω_4 / Ω_6	A_{em}/A_{ESA}
LBMBPN1.0	5.55	2.78	6.28	0.44	1.68
LBMBPN1.5	3.77	4.08	3.92	1.04	1.23
LBMBPN2.0	5.12	2.65	4.79	0.55	1.38
N10[35]	2.45	3.67	3.45	1.06	1.45
N15[35]	2.55	3.44	3.44	1.00	1.45

considered equally important in defining the luminescence characteristics of the glass doped with the RE ions. In the case of the 1Nd glass, the radiative properties of the fluorescent. levels have their characteristics defined by Ω_4 and Ω_6 only. Thus, the fluorescence levels of 1Nd glass are independent of the Ω_2 value. In case of Nd³⁺, Ω_4 parameter favors an intense ${}^{4}F_{3/2} \rightarrow {}^{4}I_{9/2}$ transition; whereas, Ω_6 is responsible for ${}^{4}F_{3/2}$

 $\rightarrow^{4}I_{11/2}$ transition. The ratio Ω_{4}/Ω_{6} , termed as spectroscopic quality factor (χ) is useful in the estimation of relative weight factors for intrinsic intensities of ${}^{4}F_{3/2} \rightarrow {}^{4}I_{9/2}$ and ${}^{4}F_{3/2} \rightarrow {}^{4}I_{11/2}$ transitions respectively [38]. For the relationship between the variation of spectroscopic quality factor and the NIR transitions ${}^{4}F_{3/2} \rightarrow {}^{4}I_{11/2} {}^{4}{}^{2}g_{9/2}$, it is reported that in case of $\Omega_{4} \ge \Omega_{6}$, the efficiency of the ${}^{4}F_{3/2} \rightarrow {}^{4}I_{11/2}$ transition is reduced and, on

Glass λ	${}^{4}F_{3/2} \rightarrow {}^{4}I_{9/2}$			${}^{4}F_{3/2} \rightarrow {}^{4}I_{11/2}$			${}^{4}F_{3/2} \rightarrow {}^{4}I_{13/2}$					
	λ_p	A_{rad}	Δλ	σ_{E}	λp	A_{rad}	Δλ	σ_{E}	λ_p	A_{rad}	Δλ	σ_{E}
LBMBPN1.0	902	2542	52	0.968	1062	4414	24.4	6.88	1335	955	42.2	2.15
LBMBPN1.5	904	3146	51	1.227	1062	3475	30.0	4.40	1334	647	45.8	1.33
LBMBPN2.0	906	2386	52	0.92	1062	3728	30.0	4.72	1334	794	43.0	1.74
BBSN1[32]	905	980	-	1.67	1075	1130	-	2.20	-	-	-	-
BBSN2[32]	905	854	-	2.03	1075	1023	-	2.03	-	-	-	-

Table 5: Peak wavelength λ_p (nm), effective line width $\Delta\lambda$ (nm), spontaneous emission probability A_{rad} and stimulated emission cross section σ_e (10⁻²⁰ cm²) for laser transitions of Nd³⁺:LBMBPN1.0, 1.5 and 2.0 glasses.

the other hand, that of the ${}^{4}F_{3/2} \rightarrow {}^{4}I_{9/2}$ transition are enhanced [20, 39]. In fact, the present glass satisfies, $\Omega_{6} \gg \Omega_{4}$, which means that this glass system is favorable for lasing in the NIR (${}^{4}F_{3/2} \rightarrow {}^{4}I_{11/2}$) at 1.06 mm, as shown in Fig. 3. For ${}^{4}F_{3/2} \rightarrow {}^{4}I_{9/2}$ transition the emission crosssection is high for LBMBPN1.5 and least for LBMBPN2.0. For ${}^{4}F_{3/2} \rightarrow {}^{4}I_{11/2}$ and ${}^{4}F_{3/2} \rightarrow {}^{4}I_{13/2}$, σ_{E} is least for LBMBPN1.5 due to concentration quenching and more for LBMBPN1.0.



Fig. 3: Emission spectra of Nd³⁺ions doped LBMBPN1.0, 1.5 and 2.0 glasses.

3.5 FT-IR Analysis

FT-IR spectroscopy has been utilized to study the structural changes produced by the variation of the PbO and Bi2O3 contents in 30PbO-20Bi2O3-25MgHPO4-(25x) B₂O₃-xNd₂O₃ (x=1.0, 1.5 and 2.0 mol %) glasses. Three major broad bands in the wave number ranges of 450-650cm⁻¹, 650-1150 cm⁻¹, and 1150-1500 cm⁻¹are observed in the LBMBPN1-4 glass systems. These bands are characteristic of bond vibrations of the phosphateoxygen and boron-oxygen networks. The infrared absorption spectra of the glasses shown in Figure.4, exhibit bands with maxima are attributed to different ligands are shown in Table 7. The band which appears in the region of $450-550 \text{ cm}^{-1}$ is assigned to the deformation vibrations of the phosphate groups [40]. The frequency of PO_4^{-3} and (P–O–P) symmetric groups are 552 cm⁻¹ and 714 cm⁻¹ respectively [47]

4. CONCLUSIONS

The laser spectroscopic properties of newly developed Lead bismuth magnesium borophosphate (LBMBPN) glasses doped with Nd³⁺ have been systematically

investigated in three different concentrations. The Judd-Ofelt analysis indicated an enhancement in the Nd-O bond covalency and asymmetry around the active ions on increase in dopant concentration from 1.0 to 1.5 mol%. This has caused an inhomogeneous broadening of emission profile at these concentrations. At 1.5 mol% concentration of Nd³⁺ the band gap is increased due to conversion of BiO₆ octahedral to BiO₃ pyramidal. Due to concentration quenching a decrease in intensity of hypersensitive transition for 1.5 mol% Nd₂O₃ glass occurs because of clustering of rare earth ions for higher concentrations. The molar concentration variation trend for Nd^{3+} in the glass systems exhibits the following tendency in the magnitude of Ω_2 parameter. LBMBPN1.0 > LBMBPN2.0 > LBMBPN1.5. From the emission spectra it is conformed that for ${}^{4}F_{3/2} \rightarrow {}^{4}I_{11/2}$ and ${}^{4}F_{3/2} \rightarrow {}^{4}I_{13/2}$ transitions, σ_{E} is least for LBMBPN1.5 more for LBMBPN1.0. Substantial emission cross-sections suggests the potential of present Nd3+ doped Lead bismuth magnesium borophosphate (LBMBPN) glasses for efficient infrared laser applications. From the all observations LBMBPN glasses are showing their good candidature for lasers because of their higher emission cross-sections.

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