

$^4F_{9/2}$	15325	15334	15325	15365	15325	15324
$^4S_{3/2}$	18433	18433	18348	18349	18399	18399
$^2H_{11/2}$	19175	19175	19175	19176	19175	19175
$^4F_{7/2}$	20512	20506	20576	20550	20492	20492
rms dev	±4.24		±18.3		±0.65	

3.3. Radiative properties:

Radiative transition probabilities (A), branching ratios (β) and radiative lifetimes (τ_R) for stimulated emission for certain excited states $^4G_{11/2}$, $^4F_{5/2}$, $^4F_{7/2}$, $^2H_{11/2}$, $^4S_{3/2}$, $^4F_{9/2}$, $^4I_{9/2}$, $^4I_{11/2}$ and $^4I_{13/2}$ of Er^{3+} doped LMBBPE glasses have been calculated [22]. These results are presented in Table 6 and Table 8. The radiative lifetimes of the excited states $^4F_{5/2}$, $^4F_{7/2}$, $^4S_{3/2}$ and $^4I_{13/2}$ are decreasing with the increment of Er^{3+} in the above glass matrices. It is observed that the magnitudes of lifetimes are slightly higher in the case of LMBBPE1 glass than glasses. It is observed from the table that the branching ratios of the transitions $^4F_{7/2} \rightarrow ^4I_{15/2}$ and $^4S_{3/2} \rightarrow ^4I_{15/2}$ are increasing with Er^{3+} content.

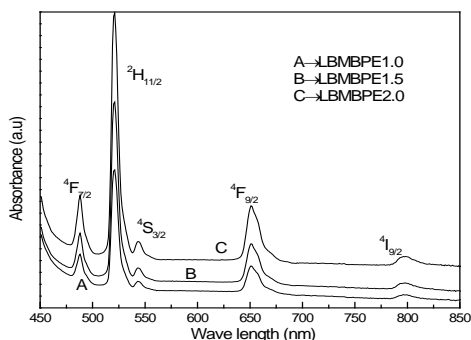


Figure 1 (a): Visible absorption spectrum of LMBBPE1, LMBBPE1.5 and LMBBPE2 glasses.

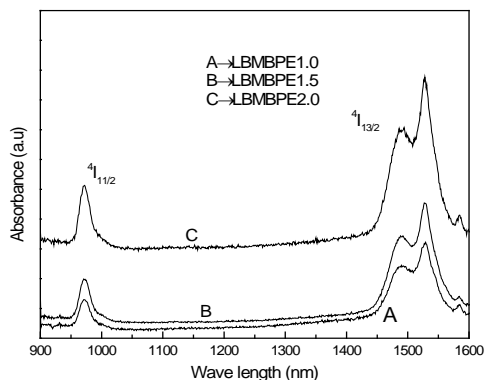


Figure 1 (b): NIR absorption spectrum of LMBBPE1, LMBBPE1.5 and LMBBPE2 glasses.

3.4 Optical band gap

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 present glasses are measured [3] given in Fig. 2a and 2b.

Table 4: Experimental and calculated spectral intensities ($f \times 10^{-6}$) of observed absorption bands of Er^{3+} ions doped with 1.0, 1.5 and 2.0 mol% LMBBPE glass matrices.

level	LMBBPE1.0		LMBBPE1.5		LMBBPE2.0	
	f_{exp}	f_{cal}	f_{exp}	f_{cal}	f_{exp}	f_{cal}
$^4F_{7/2}$	3.56	5.04	3.46	5.59	3.62	5.61
$^2H_{11/2}, ^4G_{11/2}$	17.1	17.1	16.6	16.6	17.5	17.5
$^4S_{3/2}$	0.41	1.36	0.40	1.61	0.36	1.65
$^4F_{9/2}$	4.55	4.39	4.34	4.17	4.04	3.94
$^4I_{9/2}$	0.51	0.58	0.49	0.41	0.54	0.33
$^4I_{11/2}$	1.02	1.58	1.21	1.83	1.32	1.90
$^4I_{13/2}$	3.75	3.41	4.39	3.93	4.45	4.01
rms dev	±0.71		±0.97		±0.94	

Table 5: Judd-Ofelt intensity parameters ($\Omega_\lambda \times 10^{-20}$) ($\lambda=2, 4, 6$) (cm^2) of Er^{3+} ions doped with 1.0, 1.5 and 2.0 mol% LMBBPE glass matrices.

Glass matrix	Ω_2	Ω_4	Ω_6	Ω_4/Ω_6
LMBBPE1.0	5.89	1.857	2.506	0.741
LMBBPE1.5	5.95	1.251	2.965	0.421
LMBBPE2.0	6.41	0.956	3.002	0.318
BOTNZER[17]	4.60	0.74	1.26	0.59
B1TNZER[17]	6.15	1.08	1.22	0.88
0.1[18]	2.715	2.340	1.262	
1.0[18]	0.505	0.348	0.149	

As given in Table 7, the direct and indirect optical band gaps decrease from 3.133 and 2.745eV to 2.974 and 2.515eV, respectively, as the concentration of Er^{3+} ions is increased up to 2 mol %. The fundamental absorption edges of the spectra shift towards the higher wave lengths with increasing Er_2O_3 content. Decrement in optical band gap is due to decrease in the average of bond energy. The increment of erbium content in the present glass hosts cause a decrease in the compactness of the network and formation of the non-bridging oxygens(NBO) [3].

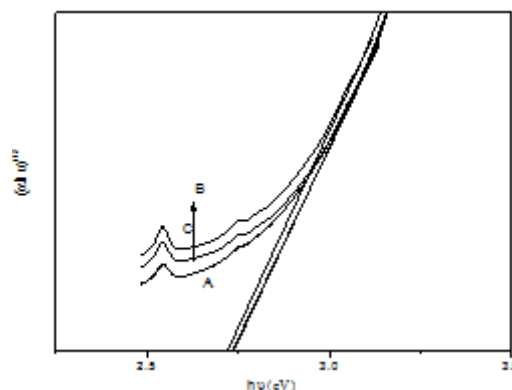


Figure 2 (a): Indirect band gap energy profile of (A) LMBBPE1, (B) LMBBPE1.5 and (C) LMBBPE2 glasses

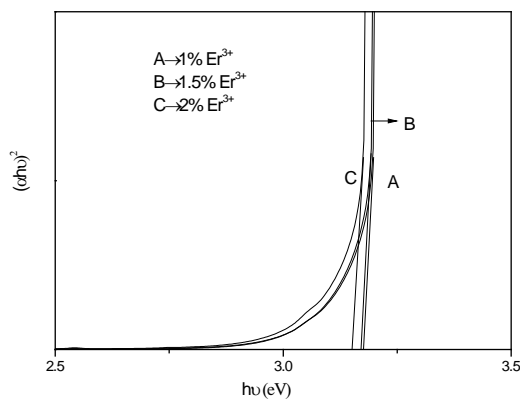


Figure 2 (b): Indirect band gap energy profile of (A) LBBMBPE1, (B) LBBMBPE1.5 and (C) LBBMBPE2 glasses.

Table 7: Optical band gap of indirect transition and direct transition of Er³⁺ ions doped with 1.0, 1.5 and 2.0 mol% LBBMBPE glass matrices.

Band gap	LBBMBPE1.0	LBBMBPE1.5	LBBMBPE2.0
Indirect transition	2.745	2.651	2.515
Direct transition	3.133	3.016	2.974

Table 6: Estimated values of spontaneous emission probabilities (A), and branching ratios (β) of emission transitions of Er³⁺ ions doped with 1.0, 1.5 and 2.0 mol% LBBMBPE glass matrices.

Transition		LBBMBPE1.0		LBBMBPE1.5		LBBMBPE2.0	
SLJ	SL'J'	A	β	A	β	A	β
⁴ I _{13/2}	⁴ I _{15/2}	488.1	0	3.956	0	4.079	0
⁴ I _{11/2}	⁴ I _{13/2}	101.4	0	0.056	0	0.042	0
	⁴ I _{15/2}	570.4	0.00	40.16	0.00	39.51	0.00
⁴ I _{9/2}	⁴ I _{11/2}	6.385	0.03	599.1	0.04	595.5	0.04
	⁴ I _{13/2}	231.2	0.05	654.2	0.04	594.9	0.04
	⁴ I _{15/2}	345.8	0.08	852.9	0.05	650.2	0.04
⁴ F _{9/2}	⁴ I _{9/2}	15.62	0.81	12726	0.85	12562	0.86
	⁴ I _{11/2}	293.6	0	0.077	0	0.061	0
	⁴ I _{13/2}	222.8	0.00	86.65	0.00	91.03	0.00
	⁴ I _{15/2}	4429	0.01	99.57	0.01	95.96	0.00
⁴ S _{3/2}	⁴ F _{9/2}	2.531	0.05	966	0.05	957.7	0.05
	⁴ I _{9/2}	234.9	0.93	16927	0.93	17567	0.93
	⁴ I _{11/2}	163	0.00	2.762	0.00	2.786	0.00
	⁴ I _{13/2}	2125	0.09	245.1	0.08	240.6	0.08
	⁴ I _{15/2}	78.03	0.06	183.1	0.06	183.6	0.06
² H _{11/2}	⁴ S _{3/2}	0.079	0.81	2464	0.82	2487	0.82
	⁴ F _{9/2}	86.23	0.02	91.33	0.03	92.17	0.03
	⁴ I _{11/2}	108.9	0.00	15.68	0.00	16.31	0.00
	⁴ I _{13/2}	978.6	0.05	336	0.07	340.8	0.07
	⁴ I _{15/2}	17447	0.04	201	0.04	185.6	0.04
⁴ F _{7/2}	² H _{11/2}	3.117	0.89	4194	0.88	3886	0.87
	⁴ S _{3/2}	0.067	0.01	6.537	0.01	6.421	0.01
	⁴ F _{9/2}	40.36	0.39	273.2	0.46	275.4	0.58
	⁴ I _{9/2}	531.8	0.59	244.2	0.41	192	0.40
	⁴ I _{11/2}	714.7	0.15	112.5	0.14	112.3	0.14
	⁴ I _{13/2}	1247	0.84	666.1	0.85	677.4	0.85
	⁴ I _{15/2}	11344	1	554.2	1	555.4	1

Table 8: Estimated values of radiative lifetimes (τ_R) of emission transitions of Er³⁺ ions doped with 1.0, 1.5 and 2.0 mol% LBBMBPE glass matrices.

SLJ	SL'J'	τ _R (μs)	τ _R (μs)	τ _R (μs)
⁴ I _{13/2}	⁴ I _{15/2}	2049	1804	1800
⁴ I _{11/2}	⁴ I _{13/2} , ⁴ I _{15/2}	1488	1284	1266
⁴ I _{9/2}	⁴ I _{11/2} , ⁴ I _{13/2} , ⁴ I _{15/2}	1714	1908	2110
⁴ F _{9/2}	⁴ I _{9/2} , ⁴ I _{11/2} , ⁴ I _{13/2} , ⁴ I _{15/2}	202	211	226
⁴ S _{3/2}	⁴ F _{9/2} , ⁴ I _{9/2} , ⁴ I _{11/2} , ⁴ I _{13/2} , ⁴ I _{15/2}	384	335	333
² H _{11/2}	⁴ S _{3/2} , ⁴ F _{9/2} , ⁴ I _{11/2} , ⁴ I _{13/2} , ⁴ I _{15/2}	53.7	55.3	53.4
⁴ F _{7/2}	² H _{11/2} , ⁴ S _{3/2} , ⁴ F _{9/2} , ⁴ I _{11/2} , ⁴ I _{13/2} , ⁴ I _{15/2}	72	67.2	69.2

4. Conclusions

A novel multi component Erbium doped borophosphate glasses were developed by varying the mol% of Er³⁺ constituent heavy metal oxides PbO and Bi₂O₃. The inter electronic repulsion parameter ratios E¹/E³ and E²/E³ observed in all the glasses do not deviate much from the hydrogenic ratios and indicate that the radial properties (radial distribution function) of all these glasses are similar. The higher values obtained for Ω₂ in all glasses indicate that the Er³⁺ ion is subjected to higher covalency with low symmetry. The band gap of all the glasses studied shows that decreasing trend with the increment of Er³⁺ content. It appears that the LBBMBPE1 glass among other glasses exhibits significant values in its radiative life times for all transitions reported. Further the optical band gaps evaluated for these glasses both for direct and indirect transitions showed lower values reflecting their goods witching action. From our analysis it is suggested that the LBBMBPE1 glass is a good lasing candidate.

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