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Invited Paper

Radioluminescence Study of Sm^{3+} Doped Alkali Metals on Aluminium Phosphate Glass Systems

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Abstract. Sm^{3+} doped lithium aluminum phosphate (LAPSm), sodium aluminum phosphate (NAPSm) and potassium aluminum phosphate (KAPSm) glasses were prepared by meltquenching technique. These glasses sample have been investigated and prepared by melt-quenching technique at 1200 °C. The density and emission intensity under X-ray excitation of glass samples were investigated. The result found that, the density of NAPSm is higher value than LAPSm and KAPSm. The emission intensity under X-ray excitation of glass samples have been investigated. The result show 4 peaks radioluminescence spectra, which assigned as 562 nm, 598 nm, 644 nm and 704 nm transition of the Sm^{3+} ions. In addition, the emission intensity of NAPSm is stronger than LAPSm and KAPSm.

1. Introduction

Phosphate glasses are easy to fabricate**,** good chemical durability, ion exchangeability and excellent optical properties**.** The glass forming substrate is P_2O_5 which is high resistant to hydrofluoric acid. Adding the high concentration of rare earth ions in phosphate glasses makes it superior to silica glasses so as to be suitable for optical fiber communication field [1]. Al_2O_3 are added to glasses to improve their chemical durability and stabilized the glass through strong cross-linking between the PO_4-tetrahedra and therefore improves also the physical properties [2]**.** Sm^{3+} is chosen doped in glass system because wide range of applications such as hole burning, high-density optical storage and colour displays. The luminescent materials activated with Sm^{3+} ion have been used as red emitting phosphors due to their intense $^4G_{5/2} \rightarrow {}^4H_{9/2}$ emission in the red spectral region [3]. There are several literature review of radioluminescence such as rare-earth doped aluminum oxide [4], MnO-doped SnO-ZnO-P_2O_5 glasses [5], gadolinium calcium phosphate oxyfluoride glasses doped with Sm^{3+} [6] and Eu^{3+} doped $La_2Hf_2O_7$ nanoparticles [7].

In this work, Sm^{3+} doped alkali metals on aluminium phosphate glass systems have been fabricated and their radioluminescence (RL) properties have been investigated. In particular, the radioluminescence spectrum of the different host was studied and compared with bismuth germinate (BGO) scintillation material.

2. Experiment

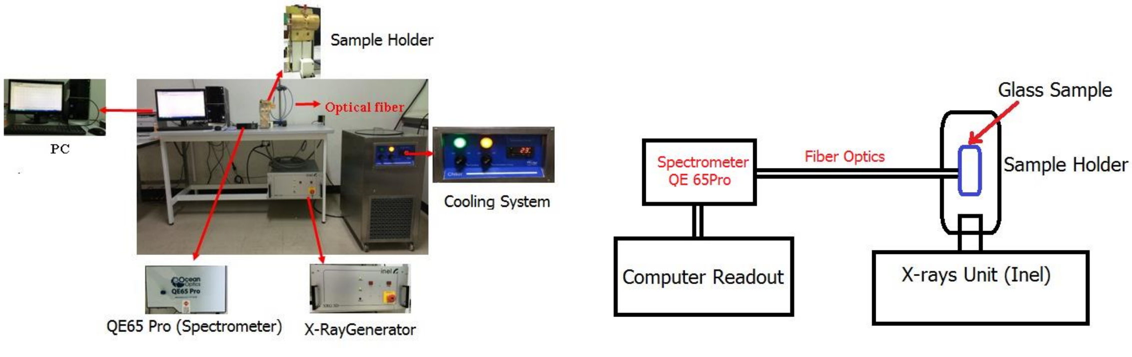
Sm^{3+} doped lithium aluminum phosphate (LAPSm), sodium aluminum phosphate (NAPSm) and potassium aluminum phosphate (KAPSm) glasses were prepared by meltquenching technique at CEGM, Nakhon Pathom Rajabhat University. These glass samples were prepared in composition $15R_2O : 20Al_2O_3 : (60\text{-}x)P_2O_5 : xSm_2O_3$ where R_2O is Li_2O, Na_2O and K_2O, respectively, and x is 1.00 mol%. The suitable amounts of high purity (99.99%) chemical reagents consist of $NH_4H_2PO_4$, K_2CO_3, CLi_2O_3, Al_2O_3 and Na_2CO_3 were used a 20 g/batch and then thoroughly mixed in a porcelain crucible. The glasses samples were melted at 1200 °C in an electrical furnace for 3 h. The temperature was sufficient to produce a clear, bubble-free melt. After complete melting, the melts were then quickly poured into a preheated stainless-steel. The quenched glasses were annealed at 500 C for 3 h to reduce thermal stress before being cooled to room temperature.

By applying Archimedes principle, the weight of the prepared glass samples in air and in xylene by using a 4-digit sensitive microbalance (AND, HR-200). Then, the density, ρ, was determined from the relation:

$$\rho = \frac{w_a}{w_a - w_b} \times \rho_b \tag{1}$$

where w_a is the weight in air, w_b is the weight in xylene, and ρ_b is the density of xylene (ρ_b = 0.863 g/cm^3).

X-ray induced optical luminescence spectra were measured using a Cu target x-ray generator (Inel , XRG3D-E : X-Ray generator). X-ray source operating at 50 kV and 30 mA for all samples. The spectrometer (QE65 Pro, Ocean Optics) with optical fiber were used for detected emission spectra. The experimental setup of x-ray induced optical luminescence spectrometer is shown in Fig. 1.



(a) (b)

Fig. 1. (a) photograph of the radioluminescence spectrometer (b) diagram for measuring the radioluminescence spectra at NPRU

3. Result and Discussion

The results found that all glass samples are clear, homogenous and increased yellow color with increasing the concentration of Sm_2O_3 in Fig. 2. Table 1 shows the value of density of LAPSm, NAPSm and KAPSm. The result found that, the density of NAPSm is higher value than KAPSm and LAPSm.

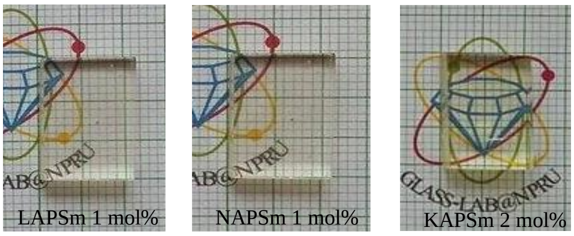


Fig. 2. Glass samples of LAPSm, NAPSm and KAPSm

Table 1 Density of glass sample LAPSm, NAPSm and KAPSm

Glass sample	Density [g/cm^3]
LAPSm	2.5663 ± 0.0023
NAPSm	2.6396 ± 0.0004
KAPSm	2.6557 ± 0.0005

The emission intensity under X-ray excitation of glass samples it can be seen in Fig. 3. The result show 4 peaks radioluminescence spectra, which assigned as 562 nm, 598 nm, 644 nm and 704 nm transition of the Sm^{3+} ions. In addition, the result show NAPSm is stronger than LAPSm and KAPSm, respectively. These glass samples is compared with that of the commercial $Bi_4Ge_3O_{12}$ (BGO) scintillation crystal as can be seen in Fig. 4. The emission intensity of NAPSm at 598 nm is 2.1 times stronger than that of BGO crystal at 517 nm under the same experiment conditions [6].

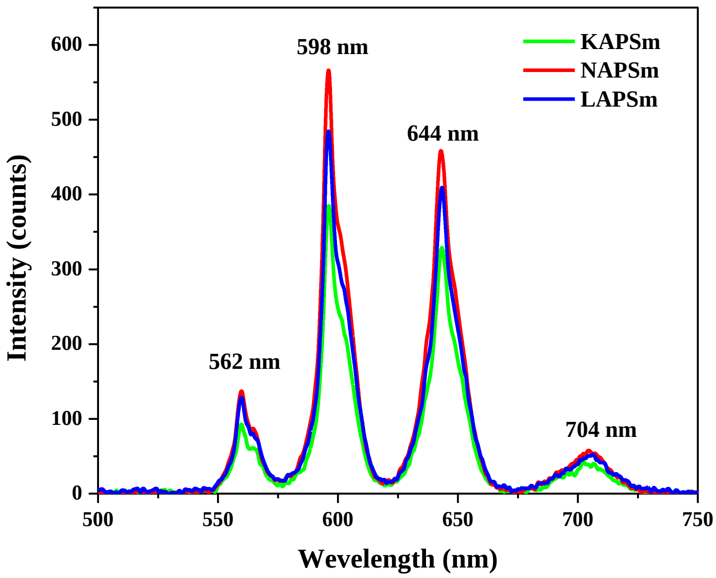


Fig. 3. Radioluminescence emission spectra of LAPSm, NAPSm and KAPSm

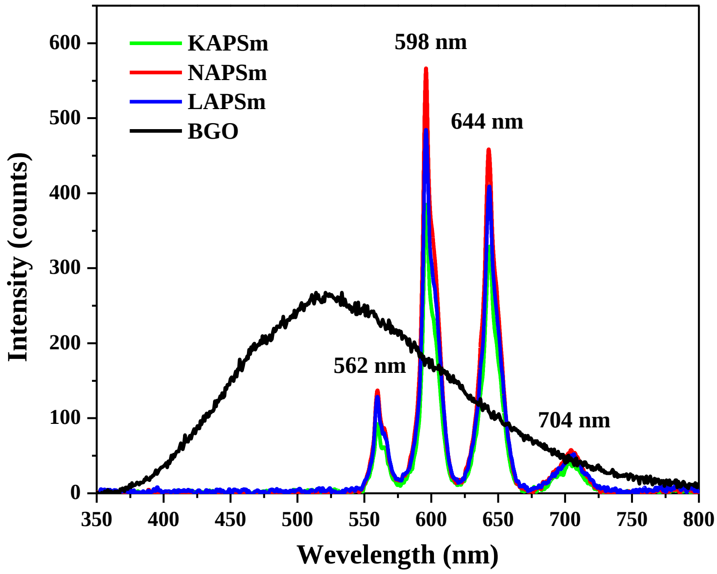


Fig. 4. Comparison radioluminescence emission spectra between BGO and LAPSm, NAPSm and KAPSm

4. Conclusion

Sm^{3+} doped alkali metals on aluminium phosphate glass systems were prepared by melt-quenching technique. The density and emission intensity under X-ray excitation of glass samples were investigated. The result found that, the density of NAPSm is higher value than LAPSm and KAPSm. Emission intensity, the result show 4 peaks in radioluminescence spectra, which assigned as 562 nm, 598 nm, 644 nm and 704 nm transition of the Sm^{3+} ions. In addition, the emission intensity of NAPSm is stronger than LAPSm and KAPSm.

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References

[1] D. Shajan, P. Murugasen, and S. Sagadevanc, "Studies on structural, optical and spectral properties of europium oxide doped phosphate glasses", **Optik,** Vol. 136, pp. 165–171, 2017.

[2] H. A. Othman, G. M. Arzumanyan and D. Moncke, "The influence of different alkaline earth oxides on the structural and optical properties of undoped, Ce-doped, Sm-doped, and Sm/Ce codoped lithium alumino-phosphate glasses", **Optical Materials**, Vol. 62, pp. 689-696, 2016.

[3] M. Manhas, V. Kumar, V. Sharma, O. M. Ntwaeaborwa, and H.C. Swart, "Effect of alkali metal ions (Li^{+}, Na^{+} and K^{+}) on the luminescence properties of $CaMgB_2O_5$: Sm^{3+} nanophosphor", **Nano-Structures & Nano-Objects,** Vol. 3, pp. 9–16, 2015.

[4] M. Santiago, V. S. deBarros, H. J. Khoury, P. Molina and D. R. Elihimas, "Radioluminescence of rare-earth doped aluminium oxide", **Applied Radiation and Isotopes**, Vol. 71, pp. 15-17, 2012.

[5] H. Masai, Y. Hino, T. Yanagida and Y. Fujimoto, "Photoluminescence and radioluminescence properties of MnO-doped SnO–ZnO–P_2O_5 glasses", **Optical Materials**, Vol. 42, pp. 381-384, 2015.

[6] P. Meejitpaisan, S. Insiripong, C. Kedkaew, H. J. Kim and J. Kaewkhao, " Radioluminescence and optical studies of gadolinium calcium phosphate oxyfluoride glasses doped with Sm^{3+}", **Radiation Physics and Chemistry**, 2016.

[7] K. Wahid, M. Pokhrel and Y. Mao, "Structural, photoluminescence and radioluminescence properties of Eu^{3+} doped $La_2Hf_2O_7$ nanoparticles", **Journal of Solid State Chemistry,** Vol. 245, pp. 89-97, 2017.