International Archive of Applied Sciences and Technology
Int. Arch. App. Sci. Technol; Vol 10 [1] March 2019 : 106-108
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www.soeagra.com/iaast.html

IAAST
ONLINE ISSN 2277- 1565
PRINT ISSN 0976 - 4828

CODEN: IAASCA RESEARCH ARTICLE
DOI: .10.15515/iaast.0976-4828.10.1.106108

Optical properties of Dy^{3+} and Nd^{3+}-ions doped oxy-fluoride glasses

Susheela K. Lenkennavar[1, 2], Madhu. A[1], M.K. Kokila*[1]
[1]Department of Physics, Bangalore University, Bangalore -560 056, India
[1, 2] Department of Physics, FMKMC College, Constituent College of Mangalore University, Madikeri-571 201, India
*E-mail: drmkkokila@gmail.com

ABSTRACT
Potassium-zinc-boro-oxy-fluoride glasses were doped with Dy^{3+} and Nd^{3+}-ions for visible and NIR applications. To understand the optical properties of these samples in visible and NIR excitation 386 nm and 808 nm was selected the analysis was carried forward in detail. With the transition $^4F_{3/2} \rightarrow {}^4I_{11/2}$ of Nd^{3+} doped are representing NIR application where as the Dy^{3+} doped glasses $^4F_{9/2} \rightarrow {}^6H_{13/2}$ visible emission application are represented.
Keywords: NIR, Optical properties, Vissible Application

Received 13.12.2018 Revised 08.01.2019 Accepted 11.02.2019

CITATION OF THIS ARTICLE
Susheela K. Lenkennavar, Madhu. A, M.K. Kokila. Optical properties of Dy^{3+} and Nd^{3+}-ions doped oxy-fluoride glasses. Int. Arch. App. Sci. Technol; Vol 10 [1] March 2019 : 106-108

INTRODUCTION

The visible luminescence of Dy^{3+} consists of narrow lines in the blue (470–500 nm, $^4F_{9/2} \rightarrow {}^6H_{15/2}$) and yellow (570–600 nm, $^4F_{9/2} \rightarrow {}^6H_{13/2}$) region. This yellow line strongly influenced be environment also called as hypersensitive transition ($\Delta L = 2$, $\Delta J = 2$). It also observed that with appropriate ratio of yellow-to-blue (Y/B) intensity ratio, Dy^{3+} ion can emit white light [1]. Nd^{3+} ions due to their efficient infrared $^4F_{3/2} \rightarrow {}^4I_{13/2,11/2,9/2}$ with emissions at wavelengths around 1350, 1064 and 946 nm which finds potential applications in the fields of laser and infrared optical communications [2]. The low field strength cations such as K^+ are added to improve mechanical properties which are prerequisite for a good laser glass. It is desirable that the laser glass has a large emission cross-section, long fluorescence lifetime and narrow emission bandwidth [3].Few reports observed improved optical properties for Nd^{3+} ion with partial substitution of ZnO with ZnF_2 in a binary zinc tellurite glass system [4].Considering all above key elements along with glass former borate present glasses are synthesised and characterized to observe the optical behaviour for LED/ laser applications in single dopant and co-dopant cases.

MATERIAL AND CHARACTERIZATIONS

Matrix: $20K_2O$-$10ZnO$-$10ZnF_2$-$(60-x)$ B_2O_3, where x=0 and 1 mol% Nd^{3+} and Dy^{3+}. Another sample with 0.5mol% of both rare earths was used. All samples were synthesised using conventional melt quenching technique. Approximately 10 g batch compositions of the materials were melted in a crucible at 1050^0C for about 1 h and annealed to remove thermal stress developed during rapid quenching. All samples were amorphous in nature and further optical properties at room temperature like absorption spectrum was recorded using (Perkin Elmer Lambda-950) spectrophotometer in the range of 300-1000 nm, with a spectral resolution of 0.1 nm. The emission and lifetime measurements were done using spectrofluorimeter (Edinburgh FLS980) by exciting the samples with 386 nm.

RESULTS AND DISCUSSION

Optical properties

Absorption spectra represents shown in Fig 1 the rare earth doped (Nd^{3+} and Dy^{3+} ions) different transition states in the range 300-1000 nm. Nd^{3+} doped glasses KN and KDN represents the transition from ground state ($^4I_{9/2}$) to the excited states ($^2P_{1/2}$,$^2D_{5/2}$), $^2D_{3/2}$, ($^2G_{5/2}$, $^2K_{15/2}$), $^4G_{9/2}$, $^4G_{7/2}$, ($^4G_{5/2}$, $^2G_{7/2}$), $^2H_{11/2}$, $^4F_{9/2}$, ($^4S_{3/2}$, $^4F_{7/2}$), ($^4F_{5/2}$, $^2H_{9/2}$) and $^4F_{3/2}$ respectively [2]. It is seen that, among all, the transition $^4I_{9/2} \rightarrow$ ($^4G_{5/2}$, $^2G_{7/2}$) is more intense and called as hypersensitive transition. Dy^{3+} doped glasses KD and KDN represents $^6H_{15/2}$-$^6P_{7/2}$, $^6P_{5/2}$, $^4M_{9/2}$, $^4K_{17/2}$, $^4G_{11/2}$, $^4I_{15/2}$, $^4F_{9/2}$, $^6F_{3/2}$, $^6F_{5/2}$, $^6F_{7/2}$ transitions [5].

NIR emission (luminescence) spectra for KN and KND glasses were recorded in the wavelength region 800 – 1400 nm using 808 nm laser as excitation source and are depicted in the Fig. 2 (b). Three emissions are assigned to the transitions from $^4F_{3/2}$ to $^4I_{9/2}$, $^4I_{11/2}$ and $^4I_{13/2}$. Among all transitions NIR $^4F_{3/2} \rightarrow {}^4I_{11/2}$ at 1056 nm is highest in intensity. The emission spectrum was recorded in the wavelength range of 400–800nm by exciting to 386nm which represents four transitions $^4F_{9/2}$- $^6H_{15/2,\ 13/2,\ 11/2,9/2}$. Among all transitions at 575nm corresponding to the $^4F_{9/2}$- $^6H_{13/2}$ yellow emission. For visible excitation Luminescence decay for KD is 0.452 ms, KDN is 0.163 ms where as for NIR excitation KDN is 26 µs and KN is 46 µs.

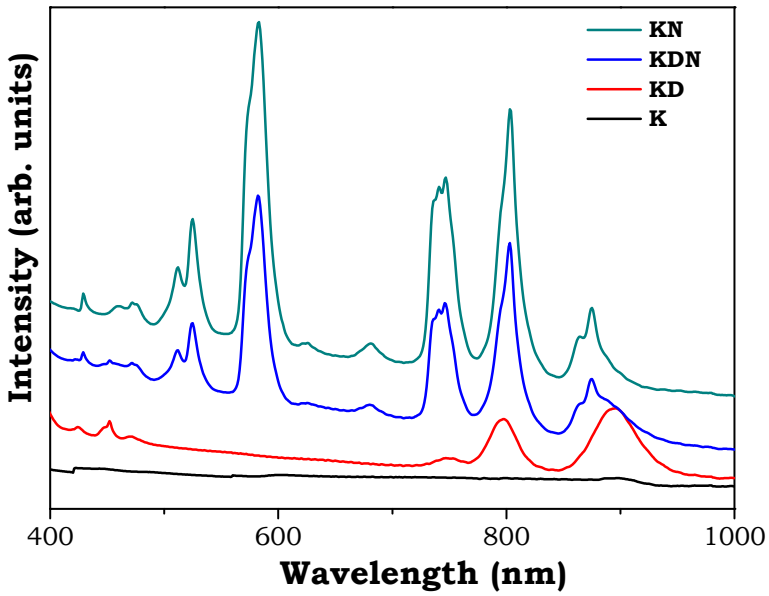

Fig 1. Absorption spectra of all glasses.

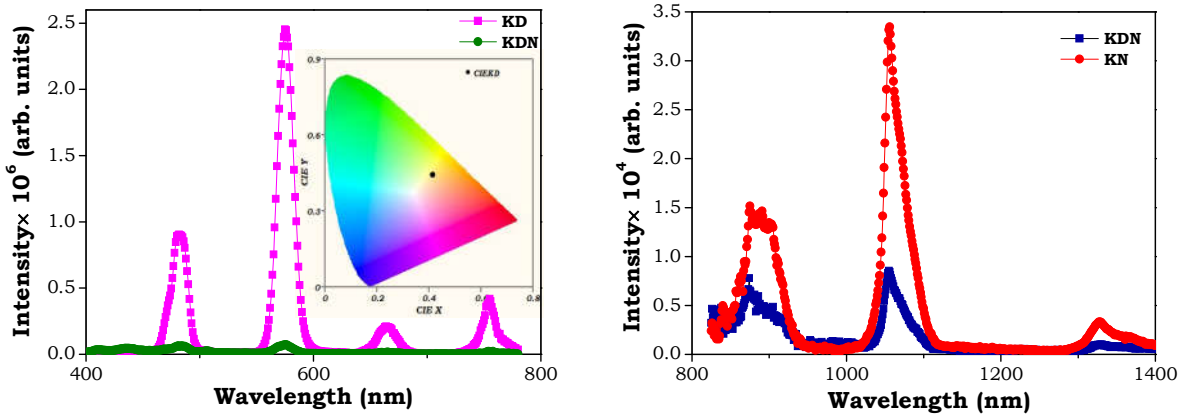

Fig 2.(a) Emission spectra of all glasses $^4F_{9/2} \rightarrow {}^6H_{13/2}$ transitions (yellow ,575nm) and (b) NIR excitation,$^4F_{3/2} \rightarrow {}^4I_{11/2}$ (1056nm)

CONCLUSIONS

Potassium-zinc-boro-oxy-fluoride doped with Dy^{3+} and Nd^{3+}-ions glasses were prepared and characterized to understand optical properties. The Dy^{3+} doped glasses show for visible and Nd^{3+}doped glasses represent NIR applications. Intensity of Dy^{3+} doped glasses show highest intensity in the yellow region. The present host is suitable for visible emission applications.

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