LEAD FLUORBORATE GLASSES DOPED WITH Er^{3+} FOR OPTOELECTRONIC DEVICES

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Abstract

Results of absorption, emission and fluorescence lifetime (for the $^4I_{15/2} \rightarrow {}^4I_{13/2}$ transition) are shown for different concentrations of Er_2O_3 varying from 0.11×10^{20} ions/cm^3 up to 11.28×10^{20} ions/cm^3. The sample with 2.20×10^{20} ions/cm^3 has emission cross-section of 0.5×10^{-20} cm^2 at 1519 nm, fluorescence effective bandwidth of 69.5 nm and fluorescence lifetime of about 1 ms. Lifetime decrease was attributed to concentration quenching and was observed for 11.28×10^{20} ions/cm^3 of Er_2O_3. A high refractive index (2.2) was measured.

1. Introduction

When erbium ions are hosted in a glass material they exhibit emission bands located at about 1500 nm and 2700 nm. The first one coincides with the telecommunication window, and has produced revolutionary changes in communication technology; this transition provides amplification near 1540 nm in erbium doped fiber amplifiers and radiation for eye safe remote sensing applications. The second one has interest in the domain of optical sources for sensors and for medicine. PbO - PbF_2 - B_2O_3 glasses are of great interest in optoelectronic devices due to their properties: large transmission window (from 400 nm up to 4 μm), high refractive index (of about 2.2) and good physical and chemical stability. We reported the results of this host doped with Yb^{3+} [1,2,3], Nd^{3+} [4], and codoped with Yb^{3+} and Er^{3+} [5]. The interesting results obtained motivated us to study Er^{3+} laser transition in this host; the samples were produced at the Laboratory of Glasses and Datation at the Faculty of Technology of São Paulo with different concentrations of Er_2O_3; results of absorption, fluorescence lifetime and emission are presented as well as Judd-Ofelt calculations. Comparisons with other known laser glasses are also performed.

2. Experiment

The samples were prepared using the following glass matrix: $38.8B_2O_3 - 27.1PbO - 34.1PbF_2$ mol%). After melting the powders in Pt crucibles at 1000°C, for one hour and a half, they are poured into pre-heated brass molds, annealed for 3 hours at 300°C (T_g temperature is of 380° C) and then cooled inside the furnace up to room temperature.The refractive index of 2.2 was determined by means of the "apparent depth method". Absorption spectrum at room temperature was recorded with a Cary Spectrometer in the 920-1120 nm range. Emission spectrum was measured using an excitation beam of 968 nm from a AlGaAs laser diode (Optopower A020) and the lifetime with pulsed laser excitation (4 ns) at 800 nm from an OPO pumped by a frequency doubled Nd:YAG laser (Quantel) .

3. Results and discussion

For the absorption measurements we obtained the spectrum shown in Fig. 1. In this spectrum we can observe nine bands related to the absorption of Er^{3+} regarding the $^2G_{9/2}$, $^4F_{3/2}$ + $^4F_{5/2}$, $^4F_{7/2}$, $^2H_{11/2}$, $^4S_{3/2}$, $^4F_{9/2}$, $^4I_{9/2}$, $^4I_{11/2}$ and $^4I_{13/2}$ transitions respectively.

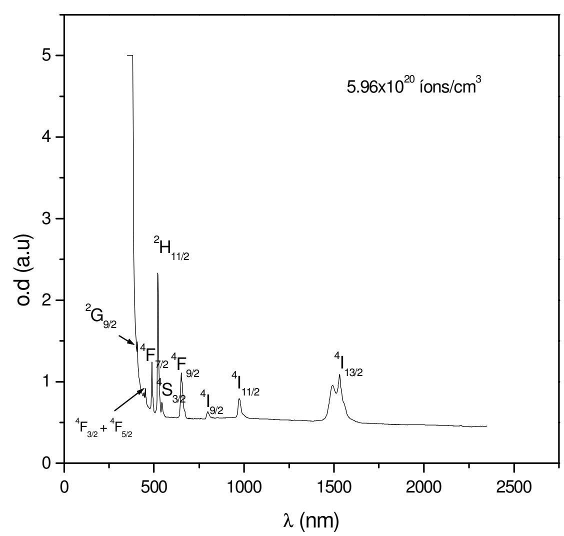

Fig. 1 - Absorption spectrum at room temperature for the lead fluoroborate glass (PbO-PbF_2-B_2O_3) doped with Er_2O_3.

The emission spectra are demonstrated in Fig. 2. Fig 3 summarizes the spectroscopic results obtained.

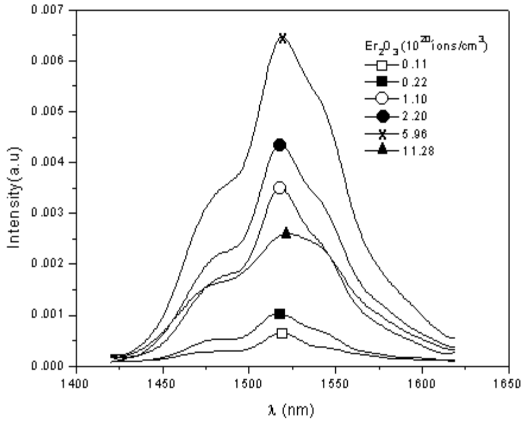

Fig. 2 – Emission spectra for PbF_2 - B_2O_3 glasses doped with Er_2O_3 1519 nm for PbO

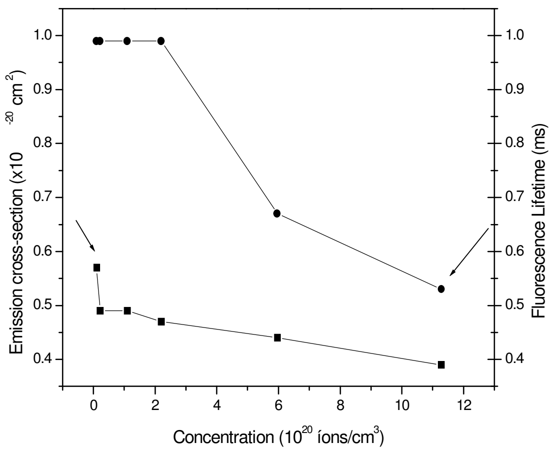

Fig. 3 - Measured lifetimes and emission cross-sections of the $^4I_{13/2} \rightarrow {}^4I_{15/2}$ laser transition for different concentrations of Er_2O_3.

An efficient host for laser operation should exhibit large emission cross-section to provide high gain, long fluorescence lifetime to minimize pump losses incurred from spontaneous emission and the possibility to incorporate a high concentration of the trivalent. Based on these considerations we remark the sample with 2.20×10^{20} ions/cm^3 with the best spectroscopic performance at 1519 nm.

5. Conclusions

Table1 compares the sample doped with 2.20×10^{20} ions/cm^3 of Er_2O_3 with the results of other know laser glasses recently published.

Table1: Spectroscopic properties of some known laser glasses and the one studied in this paper with 2.20×10^{20} ions/cm^3

Glass Composition	σ_{em} ($\times 10^{-20}$ cm^2) ($^4I_{13/2} \rightarrow {}^4I_{15/2}$)	Refractive Index
Ge-Ga-S [6]	1.05	2.15
ZBLAN [7]	0.58	1.50
Ga-La-S [8]	1.57	2.40
Silicate [9]	0.44	1.46
Pbo-PbF_2-B_20_3	0.50	2.20

It exhibits interesting spectroscopic properties for laser action at 1519 nm: emission cross-section of about 0.50×10^{-20} cm^2, comparable to the one of ZBLAN, a heavy metal fluoride laser glass, and one of the highest refractive index. Besides, a good mechanical resistance under high brightness diode laser pumping (7.5 W of diode output power) was observed.

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