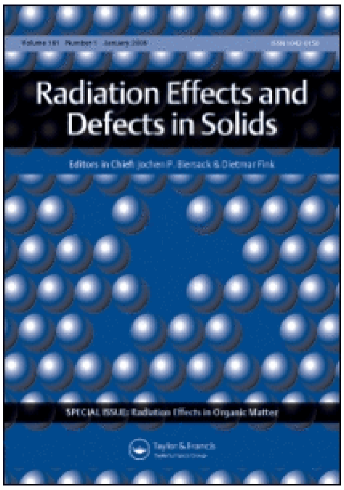

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GLASSES OF HEAVY METAL AND GALLIUM OXIDES DOPED WITH NEODYMIUM

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Optical and physical properties of a new family of Nd:BPG (Bi_2O_3–PbO–Ga_2O_3) glasses are presented at 1 mol% Nd doping level. Knoop hardness of 321 kg/mm^2 and density of 4.63 g/cm^3 were measured. These high refractive index glasses present a very large absorption cross section of 2.5×10^{-20} cm^2 at 800 nm. Emission occurs at three bands centered at 877 nm, 1066 nm and 1341 nm with a fluorescence lifetime associated to these transitions of 110 μs. At 1066 nm, the spectral linewidth is 30 nm. These properties make these glasses good candidates for laser action.

Keywords: Neodymium; Heavy metal oxide; Glasses; Rare-earth

1. INTRODUCTION

Glasses form an important class of host materials for some of the rare-earths, particularly Nd^{3+} [1]. The outstanding practical advantage compared to crystalline materials is the capability for high-energy applications [2]. The optical quality and doping homogeneity of crystalline hosts are often poorer, and the absorption lines are generally narrower. Nd^{3+} was the first trivalent rare-earth ion used in a laser and it remains widely used. Its concentration can be very high and therefore short glass samples can absorb almost all the pump radiation of diodes leading to efficient laser operation.

This work deals with optical and physical properties of a new family of neodymium doped BPG (Bi_2O_3–PbO–Ga_2O_3) glasses produced at the

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Laboratory of Glasses and Datation at Faculty of Technology of So Paulo. Previous work related to preliminary results of Nd:BPG glass optical properties were published [3].

2. EXPERIMENTAL PROCEDURE

The starting materials of Nd:BPG (17.6 mol% Ga_2O_3, 24.9 mol% Bi_2O_3, 56.7 mol% PbO and 1 mol% $Nd_2\ O_3$) are melted in air at 1000°C for approximately one hour, using a Pt crucible, then poured onto heated brass molds and annealed at 300°C for 3 hours; higher temperatures are not adequate because they cause crystallization. BPG color [4, 5] ranges from yellow to reddish amber (our host) [6] depending on melting conditions and raw materials. The addition of neodymium provides red coloration. The infrared pumping at 797 nm is performed with a GaAlAs laser diode (Spectra Diode Labs–model SDL-2382-P1), the emission is detected with a Ge detector, analyzed with a 0.5 m (Spex) monochromator and processed with a EG&G 7220 lock-in amplifier. The lifetimes of excited Nd^{3+} ions are measured using diode pumping in a Q-switched mode at 797 nm and a TDS 4210 oscilloscope. The concentration of Nd ions is determined by the X Ray Fluorescence Spectrometry with wavelength dispersion and used to obtain the absorption cross-section spectrum. The sample density is measured with the Archimedes method (accuracy of $\pm 0.01\ g/cm^3$).

3. RESULTS AND DISCUSSION

The measured knoop hardness of 321 kg/mm^2 for Nd:BPG is comparable to Nd:YLF (300 kg/mm^2). Its density is 4.63 g/cm^3, whereas for Nd:YAG it is 4.56 g/cm^3. The 1 mol% concentration of Nd ions accounts for 2.77×10^{20} $atoms/cm^3$ whereas in Nd:YAG this value is 1.38×10^{20} $atms/cm^3$.

The absorption spectrum of Nd:BPG reveals four bands at approximately 580, 750, 800 and 880 nm, and a bulk absorption in the blue. We observe a peak absorption cross-section of $2.5 \times 10^{-20}\ cm^2$ at a wavelength of 800 nm (Fig. 1).

For 797 nm excitation, three emission bands were observed, centered at 877, 1066 and 1341 nm, corresponding respectively to the following laser transitions: $^4F_{3/2} \rightarrow {}^4I_{9/2}$, $^4F_{3/2} \rightarrow {}^4I_{11/2}$ and $^4F_{3/2} \rightarrow {}^4I_{13/2}$. At 1066 nm, we measured a 30 nm spectral linewidth and a peak emission cross-section of $1.1 \times 10^{-20}\,cm^2$ [3].

The fluorescence lifetime measured, associated to these transitions, was fitted with an exponential and the result was 110 μs (Fig. 2). The fluorescence emission peak (wavelength, width and shape), that may vary with the host [1], was observed at 877 nm, at a lower wavelength than normally observed in neodymium doped hosts.

It is known that the low vibrational frequencies of the Nd:BPG glass cation-anion bonds, such as Pb–O and Bi–O, allow good infrared transmission up to 8 μm [4, 6] and low nonradiative decay rate [7]. Besides, its high refractive index (2.5) increases the radiative decay [3]. These properties can give rise to new laser transitions and can increase the efficiency of those already used in other glass hosts.

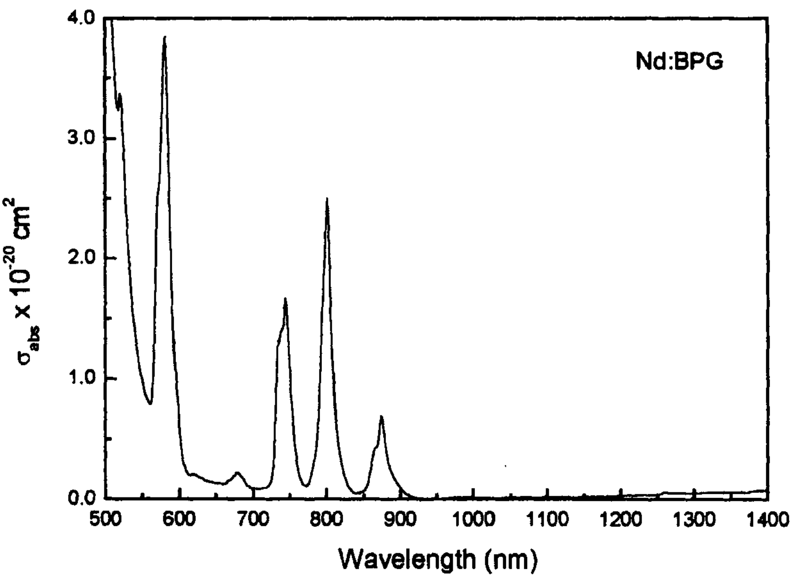

FIGURE 1 Absorption cross-section spectrum for Nd:BPG glass showing the bulk absorption in the blue.

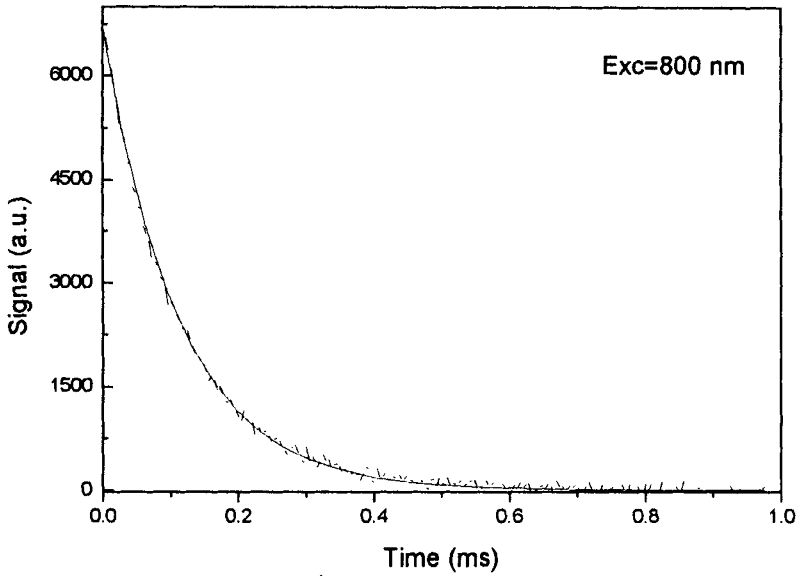

FIGURE 2 Decay of the $^4F_{3/2}$ level of Nd:BPG glass after a Q-switched pulse from a 797 nm diode laser. The experimental data and the exponential fit (continuous line) are shown.

Using the approach employed for Nd:YLF [8], we calculated the widely used Judd-Ofelt parameters (Ω_t) [9–11] for Nd:BPG:

$$\Omega_2 = 0.95 \times 10^{-20}\text{cm}^2 \quad \Omega_4 = 2.01 \times 10^{-20}\text{cm}^2 \quad \Omega_6 = 4.30 \times 10^{-20}\text{cm}^2$$

The Ω_4/Ω_6 ratio governs the branching ratio (β_R) from $^4F_{3/2}$ state. For Nd:BPG glass this value is of 0.47 [3].

CONCLUSION

Optical and physical properties of Nd:BPG glasses are presented at 1 mol% Nd doping level. This host was not doped with rare- earth before. A good mechanical resistance under high-brightness diode laser pumping was observed because of the 321 kg/mm^2 knoop hardness, comparable to Nd:YLF. The density of 4.63 g/cm^3, comparable to Nd:YAG, was also measured. A spectral linewidth of 30 nm is measured for the 1066 nm fluorescence emission. A large absorption cross- section of 2.5 $\times$ 10^{-20}

cm^2 was measured at 800 nm; for Nd:YAG this value is of 1.5×10^{-19} cm^2. These properties offer considerable potential for wavelength tunability and generation of short laser pulses.

Acknowledgments

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References

[1] Weber, M. J. (1990). *J. Non-Cryst. Solids*, **123**, 208.
[2] Koechner, W. *Solid State Laser Engineering* (Springer-Verlag, Berlin, 1996), 3rd ed., Chap. 2 and Chap. 3.
[3] Kassab, L. R. P., Tatumi, S. H., Mendes, C. M. S., Courrol L. and Wetter, N. U. (2000). *Optics Express* **6**, 104.
[4] Dumbaugh, W. R. (1986). *Physics and Chemistry of Glasses*, **27**, 119.
[5] Huang, H. H., Ray C. S. and Day, D. E. (1994). *J. Am. Ceram Soc* **77**, 1017.
[6] Clemente, J. G., Kassab L. R. P. and Tatumi, S. H. "Study of Glasses Containing Heavy Metal and Gallium Oxides," in *Proceedings of the 4th Brazilian Symposium on Glasses and Related Materials* (Ouro Preto, MG, Brazil, 1999), pp. 27.
[7] Amorim H. T. *et al*, (1998). *J. of Luminescence*, **78**, 271.
[8] Li, C., Guyot, Y., Linares, C., Moncorg R. and Joubert, M. F. "Radiative Transition Probabilities of Trivalent Rare-Earth Ions in $LiYF_4$, " in *Proceedings on Advanced Solid-State Lasers*, Albert A. Pinto, Tso Yee Fan, Vol. V of OSA Proceedings Series (Optical Society of America, New Orleans, LA., 1993), pp. 91–95.
[9] Judd, B. R. (1962). *Phys. Rev.*, **127**, 750.
[10] Ofelt, G. S. J. (1962). *Chem. Phys*, **37**, 511.
[11] Chen, C. Y., Sibley, W. A., Yeh W. A. and Hunt, C. A. (1989). *J. of Luminescence*, **43**, 185.