STUDY OF THE ETU PROCESSES IN Nd^{3+} DOPED LEAD FLUORBORATE GLASSES

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ABSTRACT

In this paper we report the determination of the up conversion losses of Lead Fluorborate glasses produced at the Laboratory of Glasses and Datation at FATEC, doped with 1,75wt% of Nd_2O_3. The energy transfer up-conversion (ETU) processes start with the interaction of two neighboring ions in the metaestable upper laser level $^4F_{3/2}$. These processes cause one ion to be excited to a higher lying excited state, while the other ion decays to a lower energy state. From the analysis of the temporal evolution of the infrared emission from the $^4F_{3/2}$ state at low excitation and high excitation powers, it was possible to estimate the macroscopic ETU parameter for the studied samples. Up-conversion processes such as energy transfer can be a loss source originated in the upper laser level.

1. INTRODUCTION

High power–high brightness diode lasers are efficient sources to promote non-linear effects such as up-conversion fluorescence, in laser media. Using these effects, there are a variety of systems in which the infrared pump radiation can be converted into visible fluorescence[1]. Most of the processes rely either on excited-state absorption (ESA) or energy-transfer up-conversion (ETU) as is shown in figure 1.

In this work, we report the up conversion processes in Nd-doped fluorborate glasses. The samples with 1.75wt% of Nd_2O_3 were prepared using the following glass matrix: (wt%) 15.8 B_2O_3, 35.3 PbO and 48.9 PbF_2. The refractive index of this glass material is 2.2 and the density is 6.9g/cm^3 [1].

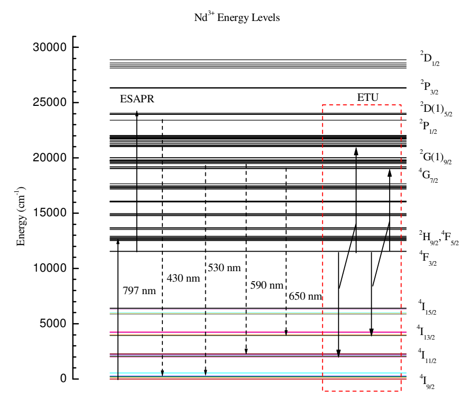

Fig. 1: Energy level diagram of Nd, showing the up-conversion processes under diode laser pumping at 797 nm and the observed anti-Stokes emissions.

Under c.w. diode laser pumping at 797 nm, non-linear effects related to up-conversion processes that causes real losses in the $^4F_{3/2}$ metastable level were observed [2]. These mechanisms have already been studied in other Nd-doped glasses [3], showing that ETU from the $^4F_{3/2}$ state constitutes an important source of loss mechanisms.

2. RESULTS AND DISCUSSION

The ETU up conversion processes can reduce the population of upper laser level or cause its lifetime shortening. As a consequence, there is an increase of the laser threshold and a reduction of energy storage efficiency. The excited state population decay of the $^4F_{3/2}$ level, assuming that the Nd^{3+} excited state is uniformly distributed thought the lattice, can be expressed by:

$$\frac{dN}{dt} = -\frac{N}{\tau} - 2W_{ETU}N^2 \qquad (1)$$

where N is the population density, τ is the fluorescence lifetime in the absence of up conversion, and W_{ETU} is the macroscopic ETU parameter. With $N(t=0)=N_0$, integration yields:

$$N(t) = \frac{N_0 \exp(-t/\tau)}{1 + 2W_{ETU}N_0\tau[1-\exp(-t/\tau)]} \qquad (2)$$

When there is no up conversion, the decay is purely exponential, whereas for $W_{ETU}\neq 0$, as $W_{ETU}N_0\tau$ increases, the decay time is shortened. The table 1 summarizes all the parameters and results obtained for the sample doped with 1.75 wt% .

The temporal evolution of the infrared emission of the $^4F_{3/2}\rightarrow{}^4F_{9/2}$ transition was obtaining exciting the samples with an OPO laser in 800 nm, and emission lifetime was obtained in 1064 nm. At low excitation powers, the decay curves for the $^4F_{3/2}$ level are nearly exponential. At higher excitation powers an increasing non-exponentiality appears.

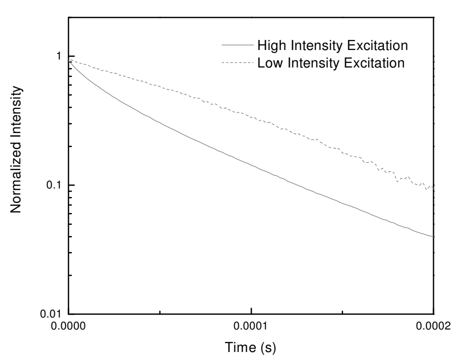

Fig. 2: Emission lifetime for the lead fluoroborate glasses doped with 1.75 w% of Nd_2O_3 ($^4F_{3/2} \rightarrow {}^4I_{11/2}$ transition).

By fitting the experimental decay shown in figure 2, to the equation 2, it was possible to obtain the macroscopic ETU parameter shown in table 1. These results are in agreement with the results obtained for other glass hosts where the ETU parameter was found to be in the range of (8-9) x 10^{-17} cm^3/s [3].

Table 1: Laser emission characteristics and ETU macroscopic parameter for fluorborate glass doped with 1.75 wt% Nd_2O_3.

Nd_2O_3 (wt%)	σ_{em} x10^{-20} cm^2	λ_P nm	τ_R μs	[Nd] x10^{18} cm^{-3}	$[N_0]$ x10^{19} cm^{-3}	W_{ETU} x10^{-17} cm^3/s
1.75	3.6	1060	313	83.12	5.75	24.33 ± 1.3

3. CONCLUSION

Laser transitions were studied in lead fluoroborate glasses doped with Nd^{3+}. The sample presents emission cross-section of $3.6\text{x}10^{-20}$ cm^2, at 1060 nm, fluorescence lifetime of 90 ms and effective fluorescence bandwidth of 30.43 nm.

The macroscopic ETU parameter has been estimated from the analysis of lifetime measurements of the $^4F_{3/2}$ level at the different initial excited populations. These values are in agreement with those previously reported in different glasses.

4.REFERENCES

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