



HAL
open science

**FLUORESCENCE DYNAMICS IN SOME
SOLID-STATE LASER MATERIALS EMITTING IN
THE INFRARED REGION: Ho³⁺ DOPED LiYF₄
SINGLE CRYSTALS AND FLUORIDE GLASSES**

J. Rubin, A. Brenier, R. Moncorge, C. Pedrini, B. Moine, G. Boulon, J.
Adam, J. Lucas, J. Henry

► **To cite this version:**

J. Rubin, A. Brenier, R. Moncorge, C. Pedrini, B. Moine, et al.. FLUORESCENCE DYNAMICS IN SOME SOLID-STATE LASER MATERIALS EMITTING IN THE INFRARED REGION: Ho³⁺ DOPED LiYF₄ SINGLE CRYSTALS AND FLUORIDE GLASSES. *Journal de Physique Colloques*, 1987, 48 (C7), pp.C7-367-C7-369. 10.1051/jphyscol:1987788. jpa-00227092

HAL Id: jpa-00227092

<https://hal.science/jpa-00227092>

Submitted on 4 Feb 2008

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

FLUORESCENCE DYNAMICS IN SOME SOLID-STATE LASER MATERIALS EMITTING IN THE INFRARED REGION : Ho³⁺ DOPED LiYF₄ SINGLE CRYSTALS AND FLUORIDE GLASSES

J. RUBIN, A. BRENIER, R. MONCORGE, C. PEDRINI, B. MOINE,
G. BOULON, J.L. ADAM*, J. LUCAS* and J.Y. HENRY**

CNRS UA-442 et Celphyra, Université Claude Bernard, Lyon I,
43, Bd du 11 novembre 1918, F-69622 Villeurbanne Cedex, France

* CNRS UA-254, Université Rennes I, F-35042 Rennes Cedex,
France

** LETI, CENG, BP 85 X, F-38041 Grenoble Cedex, France

In the present work, we report on the optical properties of Er³⁺ and Ho³⁺ ions embedded in some solid-state materials. YLiF₄ single crystals are one of them. The other class consists of fluoride glasses, well-known for their wide range of transparency particularly in the mid-infrared region. Their compositions are the following : ZBLA:Er³⁺:Ho³⁺ : 57ZrF₄ - 34BaF₂ - (5-x-y)LaF₃ - 4AlF₃ - xHoF₃ - yErF₃
BATY:Er³⁺:Ho³⁺ : 20BaF₂ - 28.75AlF₃ - 22.5ThF₄ - (28.75-x-y)YF₃ - xHoF₃ - yErF₃
BIZYT:Er³⁺:Ho³⁺ : 30BaF₂ - 30InF₃ - 20ZnF₂ - (10-x-y)YF₃ - 10ThF₄ - xHoF₃ - yErF₃.

The study consists of recording and analyzing the experimental time-dependences of emitting level fluorescences in the infrared and visible ranges. The optical processes are described in terms of rate equations which apply because fast diffusion is generally involved between the Er³⁺ sensitizers.

We have studied in details the emission processes in Er³⁺ singly doped YLiF₄ single crystals [1,2] and shown that in heavily doped samples, energy transfer mechanisms occur through several modes including up-conversion and cross-relaxation transfers (right part of figure 1). The same dynamics is observed in the fluoride glasses. In particular, self-quenching mechanisms within Er³⁺ ions of the green fluorescence originating from ⁴S_{3/2}, represented as ⁴S_{3/2}, ⁴I_{15/2} → ⁴I_{9/2}, ⁴I_{13/2} and ⁴S_{3/2}, ⁴I_{15/2} → ⁴I_{13/2}, ⁴I_{9/2}, are shown to be very efficient as the Er³⁺ concentration increases (table 1).

The infrared fluorescence processes of directly excited Ho³⁺ ions were analyzed as a function of the Ho³⁺ concentration. The increase of the ⁵I₇ level lifetime with Ho³⁺ concentration in YLiF₄ and in fluoride glasses only at low concentrations, is interpreted by a reabsorption of the 2 μm emission by the ⁵I₈ ground state. Such Ho³⁺ concentration dependence is not observed for ⁵I₆. The high Ho³⁺ concentration behaviour (> 1 %) for ⁵I₇ is the same as for ⁵I₆ : the decrease of the lifetime is due to the diffusion and trapping of energy.

A detailed analysis of the $Er^{3+} \rightarrow Ho^{3+}$ energy transfer mechanisms was carried out in $YLiF_4:Er^{3+}, Ho^{3+}$ single crystals for various laser excitations in the excited states of Er^{3+} ions in the visible and infrared regions [3]. In fluoride glasses, these transfers were studied only under infrared laser excitation in the $^4I_{13/2}$ and $^4I_{11/2}$ levels. The fluorescence dynamics is well described by our models and therefore quite well understood. In the table 2 are gathered the quantum efficiencies of some energy transfers in the infrared. Special attention was drawn on the different excitation channels which populate 5I_7 lowest excited state of Ho^{3+} , owing to the prime interest of the $^5I_7 \rightarrow ^5I_8$ $2 \mu m$ infrared laser transition. Three main channels, called IR1, IR2 and RED are shown to be efficient, as indicated in the left part of the figure 1. The relative contributions of each channel of excitation to the 5I_7 level of Ho^{3+} are calculated and are represented in table 3 as a function of the Er^{3+} excitation level for three bi-doped $YLiF_4:50 \% Er^{3+}, x \% Ho^{3+}$ ($x = 0,5, 2, 5$) single crystals.

ACKNOWLEDGMENTS

This work was supported by the DRET grants # 84.071 and # 85/217.

REFERENCES

1. R. RUBIN, A. BRENIER, R. MONCORGE and C. PEDRINI
J. Lumin. 36, 39 (1986).
2. A. BRENIER, J. RUBIN, R. MONCORGE and C. PEDRINI
J. Less Common Metals 126, 203 (1986).
3. J. RUBIN, A. BRENIER, R. MONCORGE and C. PEDRINI
To be published in J. Phys. Paris, October 1987.

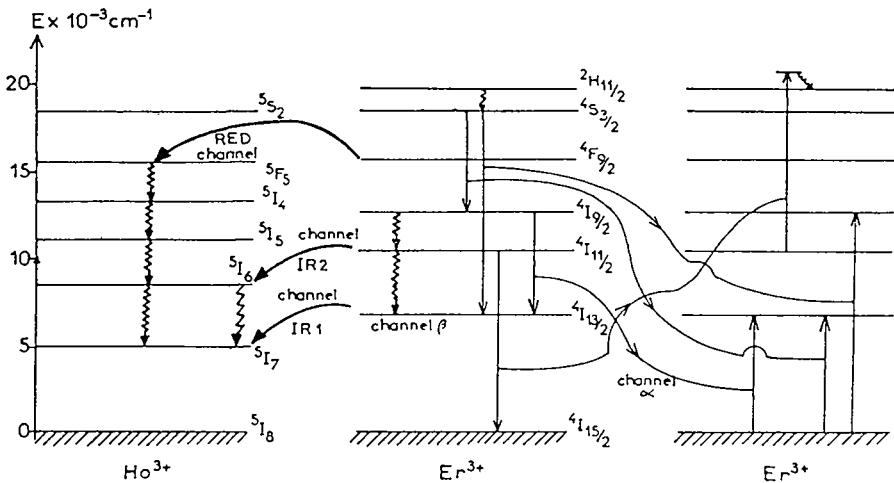


Figure 1

Main channels of Ho^{3+} excitation via $Er^{3+} \rightarrow Ho^{3+}$ energy transfer and self-quenching mechanisms within Er^{3+} ions

BIZYT, % Er	0.1	1	8.5	10
η_T (%)	17	43	97	98

Table 1

Samples	Er ³⁺	Ho ³⁺	η_{T1}	η_{T2}	η_{T2}^*
YLiF ₄	50	0.5	75	50	24
		2	93	73	38
		5	96	83	50
BIZYT	9	1	23	19	
	5	5	76	46	
	1	9		24	
BATY	27.75	1	55	31	
	10	1	53	53	

Table 2

Quantum efficiencies of energy transfers

(i) $\eta_{T1} : {}^4I_{13/2} \text{ Er}^{3+} \rightarrow {}^4I_{15/2} \text{ Ho}^{3+}$

(ii) $\eta_{T2} : {}^4I_{11/2} \text{ Er}^{3+} \rightarrow {}^4I_{15/2} \text{ Ho}^{3+}$ (excitation in ${}^4I_{9/2}$ of Er³⁺)

(iii) $\eta_{T2}^* : {}^4I_{11/2} \text{ Er}^{3+} \rightarrow {}^4I_{15/2} \text{ Ho}^{3+}$ (excitation in ${}^4I_{11/2}$ of Er³⁺)

Exc	Ho ³⁺ concentration					
	0.5 %		2 %		5 %	
${}^4I_{13/2}$	IR ₁ 100 %		IR ₁ 100 %		IR ₁ 100 %	
${}^4I_{11/2}$	IR ₁ 57%	IR ₂ 43%	IR ₁ 79%	IP ₂ 21%	IR ₁ 94%	IR ₂ 6%
${}^4I_{9/2}$	IR ₁ 92%	IR ₂ 8%	IR ₁ 82%	IR ₂ 18%	IR ₁ 66%	IR ₂ 34%
${}^4F_{9/2}$	IR ₁ ?	RED ?	IP ₁ 88%	RED 12%	IP ₁ 26%	RED 74%
${}^2H_{11/2}$	IP ₁ 100 %		IR ₁ 72%	IR ₂ 28%	IR ₁ 88%	IP ₂ 12%

Table 3

Relative contribution of each channel of excitation to the 5I_7 level of Ho³⁺ as a function of the Er³⁺ excitation level.