Comparative optical study and 2 μm laser performance of the Tm^{3+} doped oxyde crystals: $\text{Y}_3\text{Al}_5\text{O}_{12}$, YAlO_3 , $\text{Gd}_3\text{Ga}_5\text{O}_{12}$, Y_2SiO_5 , $\text{SrY}_4(\text{SiO}_4)_3\text{O}$

R. Moncorge, H. Manaa, M. Koselja, G. Boulon, C. Madej, J. Souriau, C. Borel, Ch. Wyon

► To cite this version:

R. Moncorge, H. Manaa, M. Koselja, G. Boulon, C. Madej, et al.. Comparative optical study and 2 μm laser performance of the Tm^{3+} doped oxyde crystals: $\text{Y}_3\text{Al}_5\text{O}_{12}$, YAlO_3 , $\text{Gd}_3\text{Ga}_5\text{O}_{12}$, Y_2SiO_5 , $\text{SrY}_4(\text{SiO}_4)_3\text{O}$. Journal de Physique IV Proceedings, 1994, 04 (C4), pp.C4-377-C4-379. 10.1051/jp4:1994490 . jpa-00252753

HAL Id: jpa-00252753

<https://hal.science/jpa-00252753>

Submitted on 1 Jan 1994

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.

Comparative optical study and 2 μm laser performance of the Tm^{3+} doped oxyde crystals: $\text{Y}_3\text{Al}_5\text{O}_{12}$, YAlO_3 , $\text{Gd}_3\text{Ga}_5\text{O}_{12}$, Y_2SiO_5 , $\text{SrY}_4(\text{SiO}_4)_3\text{O}$

R. MONCORGE, H. MANAA, M. KOSELJA, G. BOULON, C. MADEJ, J.C. SOURIAU*, C. BOREL* and Ch. WYON*

LPCML, Université de Lyon I URA 442 du CNRS, 69622 Villeurbanne, France

* LETI-CEA, Tech. Avancées, DOPT/SMDO 85X, 38041 Grenoble, France

1. Introduction

In our search for new 2 μm laser materials we have grown and studied Tm^{3+} doped Y_2SiO_5 (YSO) [1], $\text{SrY}_4(\text{SiO}_4)_3\text{O}$ (SYS) [2] and $\text{Gd}_3\text{Ga}_5\text{O}_{12}$ (GGG) [3] single crystals, and compared their laser performance, in the same conditions, to that of Tm^{3+} doped $\text{Y}_3\text{Al}_5\text{O}_{12}$ (YAG) and YAlO_3 (YAP). These identical experimental conditions, such as the length of the laser rods and their dopant concentration, are found not to be so adequate for all the systems since the oscillator strength of the transition corresponding to the pumping wavelength ($^3\text{H}_6 \rightarrow ^3\text{H}_4$ in the case of diode or Ti-sapphire laser pumping around 795 nm) can be very different from one system to the other and also because the laser emission wavelength does not always correspond to a real four-level laser operation at room temperature.

2. Experimental results

We first give in the figures 1 and 2 the room temperature polarized absorption spectra around 800 nm (which of particular interest for Ti:S and diode laser pumping) and the room temperature absorption and stimulated emission cross section spectra around 2 μm of SYS:Tm^{3+} for two reasons: first, because no such data are available in the literature, second, in order to show the particularity of this system with respect to the others, i.e. a very strong absorption coefficient around 790 nm which could allow laser operation with very thin samples.

We also give in the tables 1 and 2 the results of a Judd-Ofelt analysis of the polarized absorption spectra of all these compounds in terms of the Judd-Ofelt parameters Ω_2 , Ω_4 and Ω_6 , and the values of the 1/e fluorescence time constants of the fluorescences coming from the $^3\text{H}_4$ and $^3\text{F}_4$ levels after $^3\text{H}_4$ pulsed laser excitation and as a function of Tm^{3+} concentration.

In the end we show in Figure 3 and in Tables 3 and 4 the laser curves which were obtained by pumping the various systems longitudinally in the same conditions (in the same as described earlier [1]). The pump wavelength was tuned and the crystal rod rotated for maximum absorption.

3. Conclusion

The SYS:Tm³⁺ system have a higher laser threshold and a smaller laser slope efficiency than the other compounds. However this is not the end of it because, as mentionned above, this system is strongly absorbing at the pump wavelength and it is probable that most of the excitation pump power was already absorbed within the first millimeter which is not a good condition, especially for a quasi-three level laser system. Consequently substantial improvements can be expected by using thinner samples. Improvements are expected too in the case of YSO:Tm³⁺ and YAP:Tm³⁺ because larger absorption and stimulated emission cross sections can be found for crystals oriented along D2 [1] and c [4] and for light polarized along D1 and a directions respectively

Acknowledgments: Many thanks are expressed to Dr. M. Malinowski who provided us with a YAG sample from Mr. Z. Frukacz (ITME, Poland).

References

1. C. Li, R. Moncorgé, J.C. Souriau, Ch. Wyon; Opt. Comm. 101, 356 (1993)
2. C. Li, R. Moncorgé, J.C. Souriau, C. Borel, Ch. Wyon; Phys. Stat. Sol. (to be published)
3. A. Brenier, G. Boulon, C. Madej, C. Pedrini; J. Lumin. 54, 271 (1993)
4. H. Manaa, V. Wiedeman, R. Moncorgé, M. Koselja, J.C. Souriau; this Proceedings, paper VP 20

Permanent address: PRECIOSA S.A., Turnov, Tcheque Republic

Figure 1: Room temperature absorption spectra of SYS:Tm³⁺ around 800 nm

Matrices	$\Omega_2 \times 10^{-20}$ cm ²	$\Omega_4 \times 10^{-20}$ cm ²	$\Omega_6 \times 10^{-20}$ cm ²	$\delta_{RMS} \times 10^{-20}$ cm ²
SYS	4.93	1.36	0.67	0.18
YSO	2.43	1.74	0.66	0.14
YAG	0.7	1.2	0.5	---
YAP	0.67	2.30	0.74	---

Table 1: Judd-Ofelt parameters determined in Tm³⁺ doped YAG, YAP, YSO and SYS

Figure 2: Room temperature absorption and stimulated emission cross section spectra of SYS:Tm³⁺ in the infrared

Etats Excités	CYS			SYS			YSO			YAP			YAG		
	1%	5%	10%	1%	5%	10%	1%	5%	10%	1%	5%	10%	1%	5%	10%
3H_4	42* (66.5)	7.2* (21.7)	2.2* (6)	65* (94)	9.6* (31.5)	2.9* (17)	79* (104)	6* (15)	1.7* (5)	296* (435)	9.4* (30.2)	2.3* (16.8)	465	35	8.5
3F_4 monode	53	12	2.5	85	17	3.5	40	3.6	1	217	7.9	1.6	226	21	4.5
τ déclin μs	479	104	30	743	163	47.6	1560	980	440	4462	2155	520* (994)	11300	8500	4600

Table 2: 1/e fluorescence time constants in
1%, 5% and 10% Tm^{3+} doped CYS, SYS, YSO, YAP
and YAG (long time values in parenthesis)
CYS = $CaY_4(SiO_4)_0$

Matrice hôte	Concentration	Orientation des barreaux $\square \rightarrow$	Longueur (en mm)
YSO	5%	D1	4
YAG	~ 5% *	isotrope	5
YAP	~ 5% *	<100>	5
GGG	5%	isotrope	5
SYS	5%	<100>	5

* donnée non connue précisément

Table 3: Laser crystals characteristics

Matrice hôte	$I_{\text{thé}}/I_{\text{inc}}$ %	λ laser (en nm)	$\sigma_e(\lambda_{\text{laser}})$ $\times 10^{-21} \text{ cm}^2$	seuil absorbé (en mW)	rendement diff. en puissance absorbée
YSO	92	~ 2.05	~ 2	176-200	17.8
YAG	85.2	~ 2.01	2.2	65-74	22.2
YAP	94	~ 1.98	~ 5	108-110	14.7
GGG	72	1.99 **	*	165	15.5
SYS	100	1.99	2.2	315	10.5

* donnée inconnue

** donnée à confirmer

Table 4: Laser performances

Figure 3: Laser curves