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Up-conversion in YLF:Yb,Tm Laser Crystals.

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SUMMARY

The importance of development of the visible lasers emitting in the green-blue spectral range under the laser-diode pumping enforces search for the new and optimization of the known active media for lasers pumped via up-conversion schemes. The YLF:Tm crystals are well-known active media for lasing on a number of lines over a wide spectral range from 0.450 to 2.35 μm upon selective laser, laser diode, and flash lamp pumpings, including up-conversion and "avalanche" excitation mechanisms.

In this work we have studied in details the Yb ⇔ Tm nonradiative energy transfer processes in the YLF:Tm,Yb, responsible for population of the 1G4 thulium level upon Yb or Tm selective laser excitation. Concentration series of YLF : Tm (0.5-10 at.%) crystals, YLF:Tm(0.5%),Yb(5%) and YLF:Tm(1%),Yb(10 at.%) crystals were examined under selective pumping at ytterbium $^2F_{5/2}$ or thulium levels. The experimental studies were provided by spectroscopic methods including the kinetic spectroscopy with selective laser excitation. The method of model quantum mechanical calculation was employed for theoretical estimation of the energy transfer microparameters and macrorates. The microparameters and the rates of the energy transfer via the cross-relaxation schemes are determined.

Applicability of balance rate equations to description of kinetics of population and decay of the excited Yb and Tm states is studied. It is shown that coupling of the doping Yb and Tm ions in a number of cases cannot be treated within the framework of the standard transfer models under dipole-dipole interaction and high rates of migration. It is concluded that the process of population of the $^1G_4$ thulium level is greatly affected by up-conversion processes not only from the $^3H_4$ level but also from the $^3F_4$ one which proceeds within the static decay model and the transfer rate via the resonant scheme 1. $(^2F_{5/2} \rightarrow {}^2F_{7/2})_{Yb}$~>$(^3F_4 \rightarrow {}^3F_2)_{Tm}$ exceeds by the order of magnitude the transfer rate from the $^3H_4$ level via the nonresonant scheme 2. $(^2F_{5/2} \rightarrow {}^2F_{7/2})_{Yb}$~>$(^3H_4 \rightarrow {}^1G_4)_{Tm}$. The values of up-conversion microparamers are equal to $6 \cdot 10^{-39}$ and $8 \cdot 10^{-41}$ $cm^6 sec^{-1}$ for the above pointed scheme 1 and 2 correspondingly.

The spectroscopic model of the active medium on the YLF : Tm,Yb crystals is proposed and the optimal composition of co-dopants are discussed.

**The work was supported by Russian Foundation for Basic Researches. Grant No. 97-02-16439*

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THE UP-CONVERSION PROCESSES EFFICIENCY IN DIODE PUMPED Nd:GdLiF$_4$

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Intense yellow and green fluorescences are usually observed during high-power diode lasers pumping at a variety of Nd laser media. In the $GdLiF_4$:Nd crystals, these anti-Stokes fluorescences resulted mainly from the excited-state absorption of pumping radiation (ESAP) or the energy-transfer up-conversion (ETU) mechanisms.

The ESAP cross-section σ*(λ), due to $^4F_{3/2} \rightarrow {}^2P_{1/2}$ transition, was derived from McCumber relations[1] and evaluated to be 4.5 x10^{-21} cm^2 at 797 nm

The critical radius and the transfer constants were evaluated for the ETU processes, where two excited Nd^{3+} ions in the $^4F_{3/2}$ multiplet can exchange energy, leaving the donor in the $^4G_{7/2}$ multiplet (or the $^2G(1)_{9/2}$ multiplet) and the acceptor in the $^4I_{13/2}$ (or $^4I_{11/2}$) state. Assuming a dipole-dipole interaction between two neighboring Nd^{3+} ions in the excited state separated by the distance R, one can obtain a microscopic ETU rate given by $K_{D\text{-}A}(R)=(C_{D\text{-}A}/R^6)$, where $C_{D\text{-}A}$ is the transference constant (cm^6/sec) .A model to estimate the microscopical probability of the energy-transfer up-conversion was obtained using the overlap integral method based on the Förster-Dexter theory [2]. The calculated values for the microscopic parameters are given in table 1.

Nd-Nd interaction	$C_{D\text{-}A}(cm^6/s)$	R_c(Å)
$(^4F_{3/2}/^4F_{11/2})$ – 1.05 μm	3.7 x10^{-39}	20.4
$(^4F_{3/2}/^4F_{13/2})$ – 1.3 μm	6.1 x10^{-39}	21.4

Table 1. Microscopic ETU parameters.

Considering a simplified system it was possible to estimate the up-conversion processes efficiency (η_{uc}) at the laser threshold by relating the $^4F_{3/2}$ level N_2^1 population with and without the up-conversion process. The up-conversion efficiency is given by:

$$\eta_{uc} = \frac{N_2^1}{N_2^1(\sigma^* = 0; K = 0)}$$

In our experiment, the laser threshold was around 1 W, corresponding to a pumping intensity of $I_p \cong 1.4$ KW/cm^2. For this threshold intensity, the calculated up-conversion efficiency are around and 8% (GLF). These processes cause important losses for the system increasing the power intensity to reach the laser threshold condition.

References

1. D. E. McCumber, Phys. Rev. 136, 954, (1964).
2. T. Förster, Ann. Phys. (Germany), 2, 55, (1948). D. L. Dexter, J. Chem. Phys., 21,236, 1953.