Laser operation of $Nd_x:Y_yGd_{1-x-y}LiF_4$ mixed crystals

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Nd:YLF continues to be an excellent laser medium for near infrared high power lasers, especially for Q-switched and amplifier applications where its long storage lifetime is of advantage. The material Nd:GLF has several spectroscopic advantages compared to Nd:YLF when considering its use for high power laser action under diode pumping. It has a much larger absorption peak at 797 nm that permits good overlap with the large emission bandwidth of diode bars and a higher segregation coefficient, which permits higher doping levels and therefore higher gain under diode pumping. Also, Nd:YLF has very strong lifetime quenching under intense pumping conditions due to up-conversion, which hampers its efficient use for amplifier or Q-switching purposes. Therefore a compromise between doping level and pumping intensity must be made. In Nd:GLF, an almost three times smaller ESA cross-section has been reported that permits an effective use of its high Nd doping capability[1].

So far laser action in Nd:GLF has been hampered by poor crystal quality. It has been shown that micro-defects are present in $Nd_x:Y_yGd_{1-x-y}LiF_4$ crystals even when co-doping with up to 28 mol% Yttrium [2]. Good quality crystals are achieved for Yttrium concentrations of around 50 mol%. This mixed crystal has a longer lifetime of 520 microseconds when compared to the 480 microseconds of Nd:GLF and a 9 % larger emission bandwidth when compared to Nd:YLF as seen in figure 1.

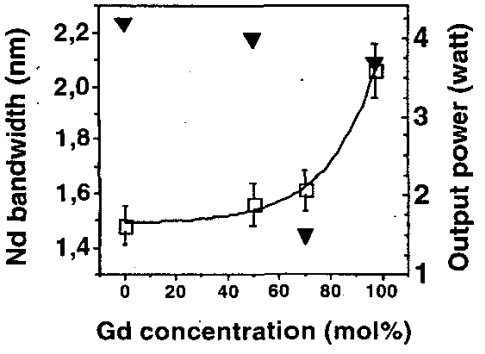

Figure 1
Squares: Bandwidth of the $Nd_x:Y_yGd_{1-x-y}LiF_4$ crystal as a function of the gadolinium concentration.
Triangles: Achieved output power as a function of the gadolinium concentration.

The laser cavity employed a 20 watt diode bar and a beam shaper for the longitudinal pump set-up and a hemispherical laser resonator. We tested four crystals with a length of 3 to 5 mm and with 0 mol%, 50 mol%, 70 mol% and 100 mol% of gadolinium, all cut at Brewster angle. For 13 watt of pump power the output power was 4.2 W, 4.0 W, 1.5 W and 3.7 W, respectively. The absorption of the 792 nm pump radiation was 81%, 65%, 65% and 74 %, respectively. From the results it can be clearly seen that the crystal with 50 mol% of gadolinium, although having the smallest absorption due to its reduced length of only 2.9 mm, gives a better result than the 3.2 mm long Nd:GLF crystal (100 mol% gadolinium) and a much better result than the crystal with 70 mol% of gadolinium. The Nd:YLF crystal gave a slightly better result when compared to the 50 mol% Gd crystal due to its length of 5 mm and therefore its higher absorption.

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[1] Courrol L.C., Maldonado E.P., Gomes L., Vieira Jr N.D.,Ranieri I.M., Morato S.P. "Diode pumping Nd-laser efficiency limitations due to up-conversion processes in Nd:YLF and Nd:GLF". Optical Materials 14, p. 81-90, 2000

[2] Ranieri I.M., Morato S.P., Courrol L.C., Maldonado E.P., Wetter N.U., Vieira Jr N.D., Baldochi S.L., Shimamura K.F.T. "Growth of LiY1-xLuxF4 crystals under CF4 atmosphere". Journal of Alloys and Compounds 344, p. 203-206, 2002

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