High power $Nd:LiYF_4$ laser in quasi-continuous operation at 454nm

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There is a strong interest in solid state blue lasers, mainly for applications in data storage and display technology. Intracavity second harmonic generation (ICSHG) of neodymium lasers operating on the $^4F_{3/2} \rightarrow {}^4I_{9/2}$ transition has been demonstrated and shown good results in terms of output power and beam quality. Different kind of crystals have been employed, such as $Nd:GdVO_4$, Nd:YAG and $Nd:YVO_4$ generating wavelength in the blue of 456nm, 473nm and 457nm respectively [1-3]. However, data storage applications would benefit from even lower wavelength to increase the storage capacity on compact disks. Such a wavelength could be achieved with Nd:YLF providing 454nm (σ-polarization) and 401.5nm (π-polarization). Although high power has been demonstrated with oxides, there are still few works with Nd:YLF. In this work we present the first studies of a high power ICSHG Nd:YLF blue laser.

The Nd:YLF crystal with dimensions of 3x3x10 mm^3 had a Nd^{3+} concentration of 0.7 at% in order to reduce pump absorption and up-conversion losses inside the crystal. Additionally, the 100 μm diameter fiber coupled diode laser (Apollo Instruments) was operated in a quasi-continuous (pulses of 2ms and duty cycle of 3%) operation mode at 806nm to avoid thermal fracture. A total of 90% of the pump radiation was absorbed in the crystal. A plane – concave (ROC=100 mm) linear cavity, using mirrors that are highly reflective at 908 nm and highly transparent at 806 nm, was mounted and generated peak infrared output power of 5.5 W for 27W of absorbed pump power, resulting in a slope efficiency of 33.6% at 908nm, Fig 1b. The output was obtained by means of a quartz plate, inserted inside the cavity at an angle close to the Brewster angle and 2.5% of calculated total reflectivity (Fig 1a). The SHG was studied using three type I nonlinear crystals; 10 mm and 15 mm long BiBO and a 10mm long LBO. The nonlinear crystal was introduced close to the flat output mirror. Due to the higher nonlinearity of the BiBO crystal, $d_{eff(BiBO)} = 3.44$pm/V against $d_{eff(LBO)} = 0.801$pm/V, higher blue output power was obtained with the 15mm long BiBO. The qcw output power of 3.5 W in the blue, obtained in this research, is the highest reported so far; Fig 1c.

The efficiency of the SHG is proportional to the square of the beam waist inside the nonlinear crystal and the square of the nonlinear effective coefficient. Since the beam waist is still much larger (around 90μm) than permitted by the Raleigh range, a new cavity in L configuration with smaller beam waist at the nonlinear crystal should result in higher blue output power.

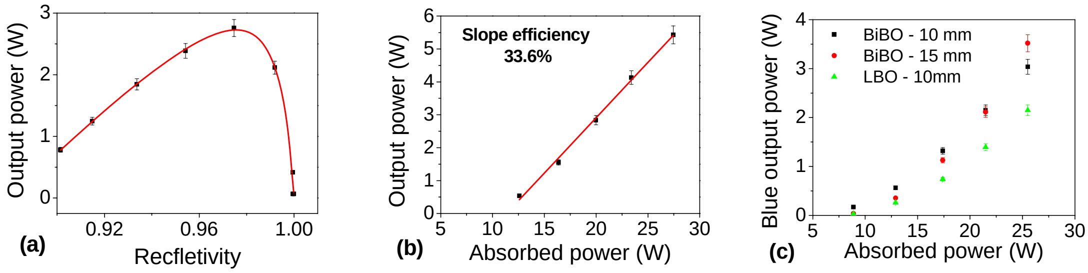

Fig. 1: (a) Infrared output power as function of the reflectivity of the mirror (b) Infrared output power as function of the absorbed power when using the optimum output coupling (T = 2.5%) and (c) Blue output power as a function of the absorbed power using different lengths of LBO and BiBO crystals.

References

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