Q-switching of Pr^{3+}-doped $LiYF_4$ Visible Lasers Pumped by a High-power GaN Diode Laser

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Abstract: Q-switching of a Pr:$LiYF_4$ laser at three visible wavelenghths pumped by a high-power GaN laser diode is demonstrated. The highest laser peak power of 79 W with a pulsewidth of 50 ns is obtained for 639 nm at 7.7 kHz

OCIS codes: (140.3540) Lasers, Q-switched (140.2020) Diode lasers, (140.3480) Lasers, diode-pumped

1. Introduction

Visible laser sources have been receiving a great deal of attention for applications such as projection displays, photo printing, material processing, and bio-imaging. Solid-state visible lasers have been achieved mainly by frequency doubling of infrared lasers [1] or up-conversion schemes [2]. Red emission (640 nm) of AlInGaP diode lasers fabricated on an off-angle substrate and with high *p*-doping has been a candidate for a red source of color laser displays [3]. However, the poor laser performance of red diode lasers at elevated temperatures of > 320 K needs powerful temperature control for their practical use in laser projector devices. Trivalent praseodymium-doped materials hold potential of a high-power visible laser medium at the transitions of blue (491nm), green (522nm), orange (607nm), and red (639nm). We demonstrated red laser CW oscillation using a GaN diode laser as a pumping source [4]. The highest laser output of 213 mW was obtained so far at the absorbed pump power of 674 mW, which corresponds to an optical.-optical conversion efficiency of 32%. An advantage of such a visible laser oscillator is that coherent ultra-violet light is obtainable with intra-cavity secondary harmonic generation (SHG).

In this paper, we report on experimental study of a Q-switched Pr:YLF laser pumped by GaN diode lasers toward pulsed intra-cavity SHG generation.

2. Experiment and Results

We used an acousto-optic (AO) modulator to achieve Q-switching operation of a Pr:YLF laser. To place the AO switch in a resonator, we designed a straight resonator as shown in Fig.1. We use a 4-mm-long Pr:YLF crystal doped with Pr^{3+} 0.5 at.%, which was cut parallel to the c-axis. At the pumping side of the crystal a flat mirror with high-reflectivity coating (*R*>99.7%) for the lasing wavelength (570–650 nm) and a high-transmission (*T*=95.2%) for the pumping wavelength is placed.

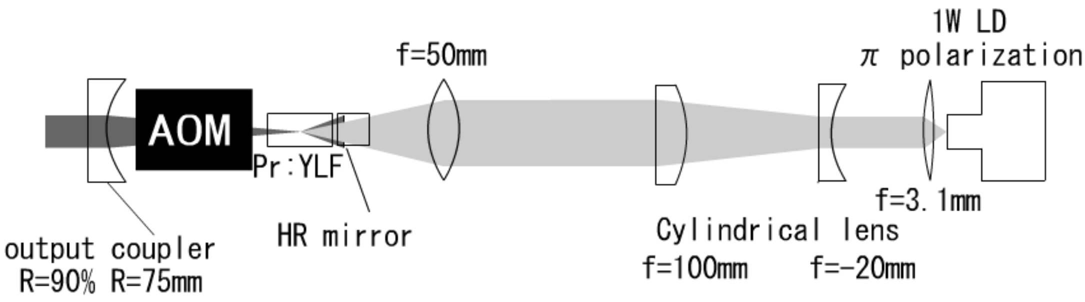

Fig. 1 Experimental setup of an AO-Q-switch Pr^{3+}:$LiYF_4$ laser pumped by a GaN laser diode.

For laser experiments the pumping source was a GaN laser diode emitting polarized light around 445 nm without particular temperature control (conventional Peltier device was used to prevent thermal damage of the laser diode). The maximum output power is 700 mW at I = 900 mA. The emission wavelength slightly shifts from 441.5 to 444.5 nm as the current increases from 300 to 900 mA when the case is kept at the room temperature. The pumping laser was collimated by an aspheric lens (the focal

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length of 3.1 mm) and shaped into a circular beam by a pair of concave and convex lenses. The lens pair compensated for astigmatism of the GaN laser diode. The pump beam was focused into the Pr:YLF crystal by a lens with a focal length of 50 mm, wherein 10% of the pumping beams energy was lost through those lenses. The output coupler is a concave mirror (R =75 mm).

Figure 2 shows the σ polarized 639 nm laser output power as a function of absorbed pumping laser power normalized by the threshold power. The ON/OFF sequence of the AO modulator was set by referring to the fluorescence lifetime of Pr^{3+} of 40 μs. Thus, the modulator was set ON for 40-120 μs. Figure 3 shows the σ-polarized 639 nm pulsed laser pulse width as a function of normalized pumping laser power *r*. The narrowest laser output pulse width of 50 ns was obtained at *r*=2.4. and at the repetition frequency of 7.7 kHz.

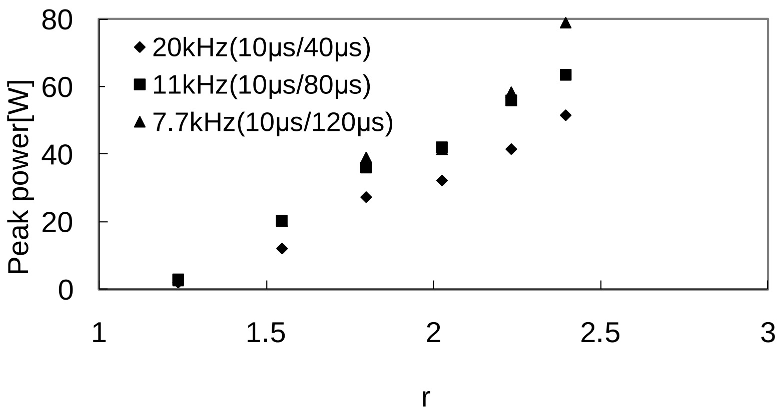

Fig.2 Plots of the output power of pulsed laser at 639 nm as a function of normalized absorbed pump power *r*. See the definition of *r* in the text

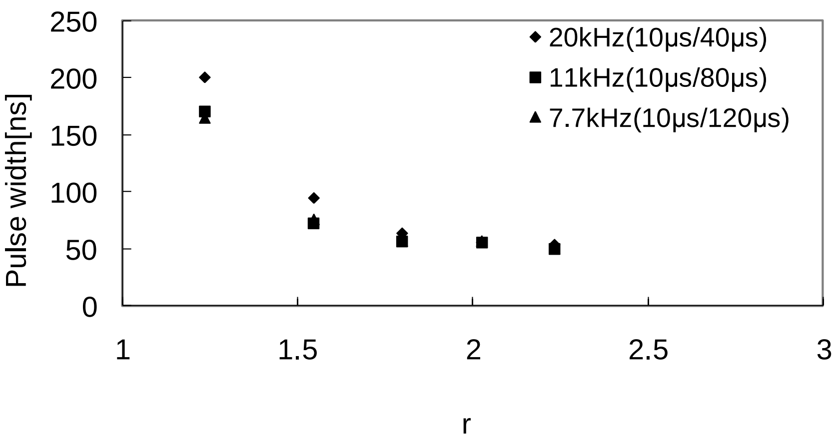

Fig.3. Plots of the pulse width of pulsed laser at 639 nm as a function of normalized absorbed pump power *r*. See the definition of *r* in the text.

We performed the similar experiments for the lasing wavelength at 607 nm and 522 nm. We will present also our latest results of intra-cavity SHG with a LBO nonlinear crystal

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