Diode-Pumped Nd:GAGG—LBO Laser at 531 nm

J. Zou\textsuperscript{a},*, H. Chu\textsuperscript{b}, and L. R. Wang\textsuperscript{c}

\textsuperscript{a} Electronic and Information Engineering College, Changchun University, Changchun, 130022, China
\textsuperscript{b} College of Quartermaster Technology, Jilin University, Changchun 130062, China
\textsuperscript{c} Management Office of Scientific Research, Changchun University, Changchun, 130022, China

*e-mail: zouji888@sina.com
Received September 28, 2011; in final form, September 29, 2011; published online February 6, 2012

Abstract—We report a green laser at 531 nm generation by intracavity frequency doubling of a continuous wave (cw) laser operation of a 1062 nm Nd:GAGG laser under in-band diode pumping at 808 nm. A LiB\textsubscript{3}O\textsubscript{5} (LBO) crystal, cut for critical type I phase matching at room temperature is used for second harmonic generation of the laser. At an incident pump power of 18.5 W, as high as 933 mW of cw output power at 531 nm is achieved. The fluctuation of the green output power was better than 3.5% in the given 4 h.

DOI: 10.1134/S1054660X12030334

1. INTRODUCTION

Diode-pumped Nd-doped crystal lasers operating in the infrared [1–7] and visible [8–14] spectral regions have wide applications in the fields of industry, defense, medical treatment, and scientific research. Compact lasers that emit a few watts of green power are attractive for display, medical, and spectroscopic applications [15–18]. Such lasers could also become critical components of an all-solid-state compact UV source [19–24]. In 1988, Kuwano et al. [25], had first developed Nd-doped GAGG as a laser material. In 2009, the crystal growth and characterization of Nd:GAGG was reported. The absorption and emission spectra of the Nd:GAGG crystal at room temperature have been studied. With a laser-diode as the pump source, cw laser performance at 1.06 \mu m of Nd:GAGG crystal was demonstrated for the first time. The maximum power of 2.44 W from Nd:GAGG laser was obtained with the optical conversion efficiency 28.5%, and slope efficiency of 28.8% [26]. In 2010, the cw and passively Q-switched operation of a diode-end-pumped Nd:GAGG laser at 1062 nm was realized. The highest cw laser output power of 5.7 W was achieved with an optimized cavity. With Cr\textsuperscript{4+}:YAG as the saturable absorber, the passively Q-switched Nd:GAGG laser was achieved for the first time [27]. To the best of our knowledge, the corresponding frequency doubled green lasers have not been reported. In this paper, an efficient cw 531 nm intracavity frequency-doubling blue laser based on diode pumped Nd:GAGG /LBO is demonstrated. With an incident pump power of 18.5 W, up to 933 mW of blue laser emission at 531 nm is achieved.

\textsuperscript{1} The article is published in the original.

2. EXPERIMENTAL SETUP

The experimental setup is shown in Fig. 1. The pump source was a fiber-coupled cw diode laser with wavelength 808 nm. The diameter of the fiber core was 400 \mu m with a numerical aperture of 0.22. The coupling optics consists of two identical plano-convex lenses with focal lengths of 15 mm used to reimagine the pump beam into the laser crystal at a ratio of 1:1.

The laser crystal used in the experiment was 0.7 at% Nd:GAGG. The crystals’ thickness was 5 mm, it is wrapped with indium foil and mounted at a TEC (thermal electronic cooled) copper block, and the temperature is maintained at 18°C. The whole cavity is also cooled by TEC. Both sides of the laser crystal were coated for high transmission (HT) at 1062 and 531 nm. The first plane mirror M1 of the cavity is HT at 808 nm and highly reflective (HR) at 1062 nm. The second plane mirror M2 (Roc = 50 mm) is an output coupler, which was coated with HR at 1062 nm and HT at 531 nm. Finally, the thirdly mirror M3 (Roc = 200 mm) was coated with HR 1062 and 531 nm. The LBO crystal cut for type-I critical phase matching ($\theta = 90^\circ$, $\varphi = 11.5^\circ$ with $d_{\text{eff}} = 0.832 \text{pm/V}$) was chosen as the nonlinear crystal. The size of the LBO crystal is $2 \times 2 \times 10 \text{ mm}^3$ and both end facets of the LBO crystal are HT coated at 1062 and 531 nm to reduce the reflection losses in the cavity.

3. RESULTS

The green output power at 531 nm versus the incident pump power is shown in Fig. 2. When the incident pump power is 18.5 W, the laser yielded 933 mW of cw green output power at 531 nm. With this configuration, we recorded an oscillation threshold at 3.3 W. The beam quality of the 531 nm emission measured by a Laser Beam Diagnostics is shown in Fig. 3. The $M^2$ factors are 1.22 and 1.14 in $X$ and $Y$ directions respec-
The asymmetry of the $M^2$ factor in two directions is a result of the walk-off between the fundamental wave and the second in the direction of the LBO. The stability testing is carried out by monitoring with a Field-Master-GS powermeter at 10 Hz. The fluctuation of the output power is about 3.5% in 4 h. Figure 4 shows the spectra of 531 nm green light which was detected using the grating spectrometer.