206 W continuous-wave TEM_{00} mode 1064 nm beam generation by a laser-diode-pumped Nd:YAG rod laser amplifier

Susumu Konno,[a)] Shuichi Fujikawa, and Koji Yasui
Advanced Technology Research and Development Center, Mitsubishi Electric Corporation, 8-1-1 Tsukaguchi, Amagasaki, Hyogo 661-8661, Japan

(Received 5 June 2001; accepted for publication 6 August 2001)

We demonstrate a 206 W 1064 nm beam generation at a beam quality of $M^2=1.34$ with a Nd:YAG laser amplifier system. We also report on an efficient 150 W TEM_{00} mode diode-pumped Nd:YAG rod laser. [DOI: 10.1063/1.1409332]

Many industrial and scientific applications require laser beam sources with high output power and high beam quality. The output power scaling of TEM_{00} mode beam sources are of primary importance.

To date, over 100 W nearly diffraction limited output from an ytterbium doped fiber laser was reported.[1] However, diode-pumped solid-state lasers can deliver more power,[2–6] especially in the pulse mode operation. Recently, single-transverse-mode output power of 234 W was reported based on a Yb:YAG zig-zag slab laser.[7] However, rod crystals are widely used in industrial application fields because the fabrication and mounting of a rod crystal is easy and cost effective.

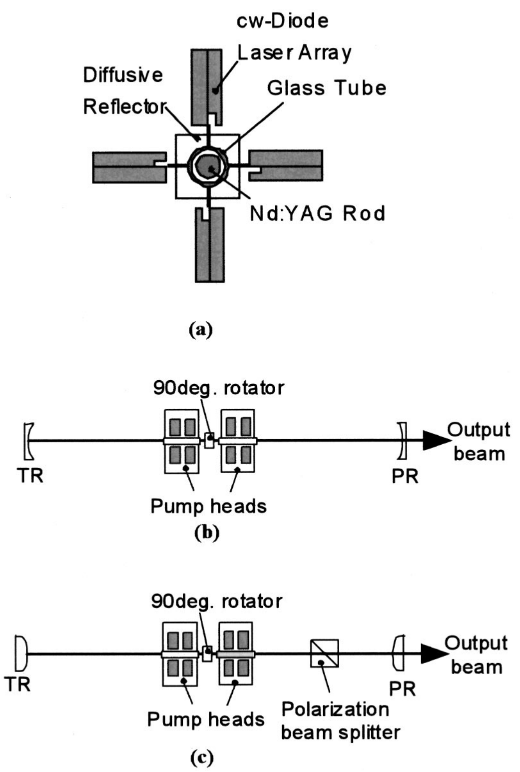

FIG. 1. Schematical view of the (a) pump module, and resonator configurations for (b) random polarized operation, and (c) linearly polarized operation is shown.

In this work, we report on an efficient 153 W TEM_{00} mode 1064 nm beam generation by a laser-diode-pumped Nd:YAG rod laser. In addition, we demonstrate a 206 W TEM_{00} mode infrared beam generation with a Nd:YAG laser amplifier.

Figure 1(a) shows a schematic edge view of the pump module. Each pump head contained eight 1 cm long linear continuous-wave diode arrays (808 nm wavelength and 40 W rated average output power) and a Nd:YAG rod (4 mm in diameter and 70 mm length with 0.6% Nd doping). The Nd:YAG rod was surrounded by a flow tube and a diffusive reflector. Details of the pumping configuration were reported elsewhere.[8]

Figures 1(b) and 1(c) show schematic drawings of the experimental setup for random and linearly polarized operation. A quartz 90° polarization rotator was placed between two pump heads for polarization dependent bifocusing compensation.[9] For a random polarized operation, the pumping part was positioned between two concave mirrors (radius of curvature=75 mm), a full reflector, and a 78% reflector, separated by 950 mm. The laser output power and the beam quality was plotted in Fig. 2. A linearly polarized operation was obtained in a 950 mm convex–convex [radius of curvature=100 mm, $R=77\%$, (R: reflectivity of the out coupling mirror)] resonator, with a polarization beam splitter [$T_p>95\%$, $R_s>99.9\%$, and $T_p/T_s>1000{:}1$, (T_p: p-polarized light transmittance, T_s: s-polarized light trans-

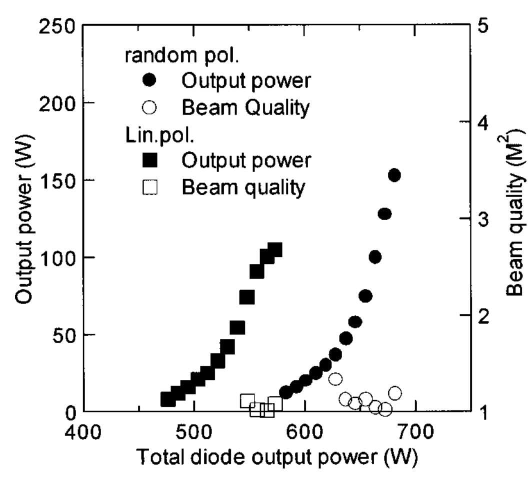

FIG. 2. Random and linearly polarized TEM_{00} mode laser performances are shown.

[a)]Electronic mail: konno@lap.crl.melco.co.jp

TABLE I. Maximum output power, efficiency, and beam quality of laser performances in Fig. 2 are presented.

	Maximum output power	Optical-to-optical conversion eff.	Electrical efficiency	Beam quality at the maximum output power
Random polarization	153 W	22.4%	10.9%	$M^2 = 1.18$
Linear polarization	105 W	18.3%	8.6%	$M^2 = 1.08$

mittance, and R_s: s-polarized light reflectivity)]. The laser performance was also plotted in Fig. 2. Based on the previously reported calculation,[5] these resonators were designed to provide stable operation near the highest rated diode output power. The beam quality was measured with a Coherent's M^2 meter. Table I summarizes the experimental results in Fig. 2.

We attempted to enhance the TEM_{00} mode output power by amplification. Figure 3 shows an experimental setup of the laser amplifier. Without the polarization beam splitter, the resonator in Fig. 1(c) produces a random polarized 110 W 1064 nm beam at a beam quality of $M^2 = 1.1$, with 575 W laser diode (LD) pump power. This laser was used as an oscillator in the amplifier system and was driven at 575 W LD pump power. The output beam from the oscillator was introduced into the amplifier through two folding mirrors. The amplifier pumping part consisted of two pump heads and a 90° polarization rotator. The pump head configuration is the same as that described in Fig. 1(a). Each pump head contained 16 linear laser-diode arrays (808 nm wavelength and 25 W rated diode output power) and a Nd:YAG rod (3 mm in diameter and 105 mm length with 0.6% Nd doping). The beam diameter at the Nd:YAG rod in the amplifier is calculated to be 1.3 mm ($1/e^2$ clip level).

Figure 4 shows the 1064 nm average output power of the amplifier system as a function of the amplifier LD pump power. A maximum output power of 206 W was obtained at a beam quality of $M^2 = 1.34$ with 800 W amplifier pump LD power. At the maximum output power, the amplification ratio and small signal gain of the amplifier is calculated to be 0.274 and 1.58, respectively.

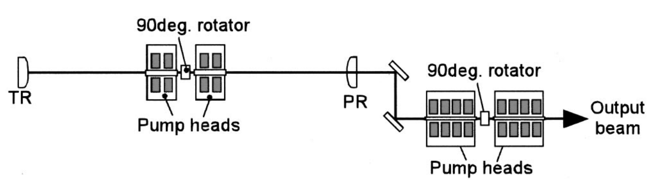

FIG. 3. Schematical view of the Nd:YAG rod laser amplifier configuration is shown.

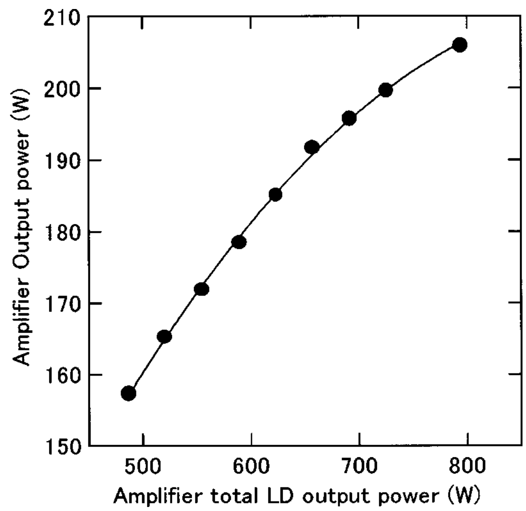

FIG. 4. Nd:YAG laser amplifier output power as a function of amplifier LD output power is shown.

In summary, we report on the efficient operation of a continuous wave over 100 W TEM_{00} mode laser-diode-pumped Nd:YAG laser in random and linearly polarized operation. Further, we demonstrate a 206 W of continuous-wave TEM_{00} mode 1064 nm beam generation with a Nd:YAG laser amplifier system.

The authors thank M. Tanaka for supporting and encouraging their research.

[1] V. Dominic, S. MacCormack, R. Waarts, S. Sanders, S. Bicknese, R. Dohle, E. Wolak, P. S. Yeh, and E. Zucker, Electron. Lett. **35**, 1158 (1999).
[2] S. C. Tidwell, J. F. Seamans, and M. S. Bowers, Opt. Lett. **18**, 116 (1993).
[3] D. Golla, M. Bode, S. Knoke, W. Schone, and A. Tunnermann, Opt. Lett. **21**, 210 (1996).
[4] R. J. Shine, Jr., A. J. Alfrey, and R. L. Byer, Opt. Lett. **20**, 459 (1995).
[5] S. Konno, S. Fujikawa, and K. Yasui, Appl. Phys. Lett. **70**, 2650 (1997).
[6] M. Karszewski, U. Brauch, K. Contag, S. Erhard, A. Giesen, J. Johannsen, C. Stewen, and A. Voss, OSA Proc. Adv. Solid-State Lasers **26**, 296 (1998).
[7] G. D. Goodno, S. Palese, J. Harkenrider, and H. Injeyan, OSA Proc. Adv. Solid-State Lasers **3**, MA2-1 (2001)
[8] S. Fujikawa, T. Kojima, and K. Yasui, IEEE J. Sel. Top. Quantum Electron. **3**, 40 (1997).
[9] K. Yasui, Appl. Opt. **35**, 2566 (1996).