Microchip Nd:YVO_4 Lasers Pumped by Wavelength-Stabilized Single-Mode Laser Diode

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Abstract:

Laser diode (LD) with stabilized frequency of output light has been developed until now. In this time, we adopted a single-mode, single-wavelength LD with a stabilized frequency for a pumping LD to end-pump microchip Nd:YVO_4 lasers. In these experiment, we succeeded in obtaining higher optical-optical conversion efficiency and slope efficiency than when using conventional LD. Output laser power is insensitive to temperature of LD, and output could be kept stable and almost constant until temperature of LD was as high as 35 °C. In the future, a low-cost end-pump microchip laser that does not require a temperature control mechanism should be developed.

Keywords : Single-Mode, Nd:YVO_4, Microchip Lasers, Volume Holographic Grating

1. Introduction

Solid state lasers are compact, easily efficient and have high beam quality. The range of application of laser diode (LD) pumped lasers to the industrial field has further expanded. Various end pump microchip solid state lasers have been developed [1-5]. The microchip solid-state laser is a device that can generate a high gain with low loss in a small volume. It can obtain easily high beam quality and short pulse, and realizes a miniaturization comparable to LD. On the other hand, direct processing by LD is possible now. However, LD is extremely difficult to operate LD with the pulse duration of around ns because it connects the life shorting of LD. In this regard, end pumped microchip lasers can easily generate ns laser pulses with high instantaneous intensity.

Nd: YAG has been used as a laser media for microchip lasers. A major problem with conventional Nd: YAG, which is that the absorption bandwidth for the pump light is as narrow as less 1 nm, and when the temperature of LD rises, the peak wavelength of the output light shifts to the longer wavelength side, so adjustment mechanism for controlling LD temperature is required. Thus, the cost of the system became higher.

While, the possibility of a laser using Nd:YVO_4 crystal was reported in 1966[1]. Nd:YVO_4

crystal has a stimulated emission cross-section, which is three times higher than that of Nd: YAG. Also, Nd:YVO_4 has 7 times higher absorption coefficient at π deflection absorption than that of Nd:YAG. Higher laser power can be achieved in CW operation than that of Nd: YAG. However, a problem remains. The laser output fluctuated due to the difference in absorbed power of the pumping light at the low and high temperatures due to the shift of the peak wavelength of LD as in the case of using Nd: YAG.

Research has been conducted in the past to stabilize the output frequency by feedback of the partial output light of LD to semiconductors. We developed an end-pumped Nd: YVO_4 laser that uses an LD with a fixed wavelength of output light for excitation. Experiments for generation of repetitive pulses by Q switch and operation with CW mode were conducted. Output laser power was compared with that using conventional LD. Also, the temporal stability of the output laser power was researched.

2. Experimental setup

Fig. 1 shows a photograph of the actual microchip laser launched this time. As the laser crystal, Nd: YVO_4 crystal (size: 3 mm square, 1 mm thickness, a-cut) was used. HR coating at 1064 nm and AR coating at 809 nm were set on the excitation side of the crystal. The other side has an AR coating at 1064nm. When CW laser operation, the resonator length was set to be 10 mm. The reflectivity of the output coupling mirror was 90%. Two types of LD were used as excitation light sources. One is a conventional LD (Single mode one chip laser diode, LD 808-SE500, Tholabs) with variable wavelength, and the second is a LD (Single mode one chip laser diode, LD 808-SEV500, Tholabs) with Volume-Holographic-Grating (VHG) for partial LD optical feedback to fix the output frequency. The peak wavelengths of the output light from LDs were 808.5 nm at 25 ° C and 808.3 nm, respectively. LD was set tightly in a copper holder. A temperature control device with an electronic controller was used to control the LD temperature.

The output light from LD once entered single lens and was then collected in front of the laser media. For the pulse oscillation experiment, Cr^{4+}: YAG crystal which is a saturable absorber with an initial transmittance of 90% was used.

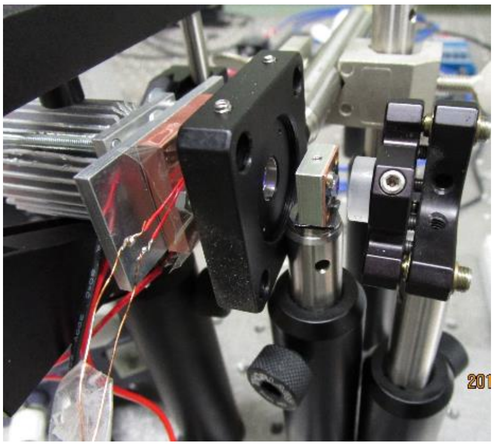


Fig.1. Photo of microchip laser.

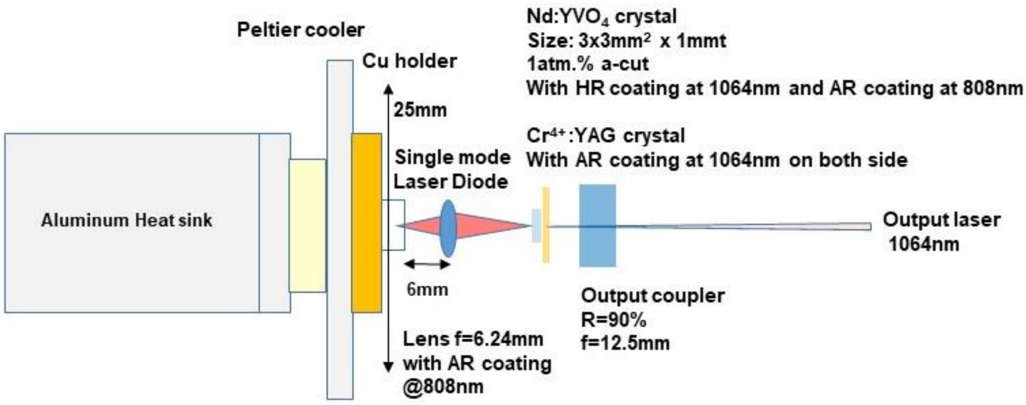


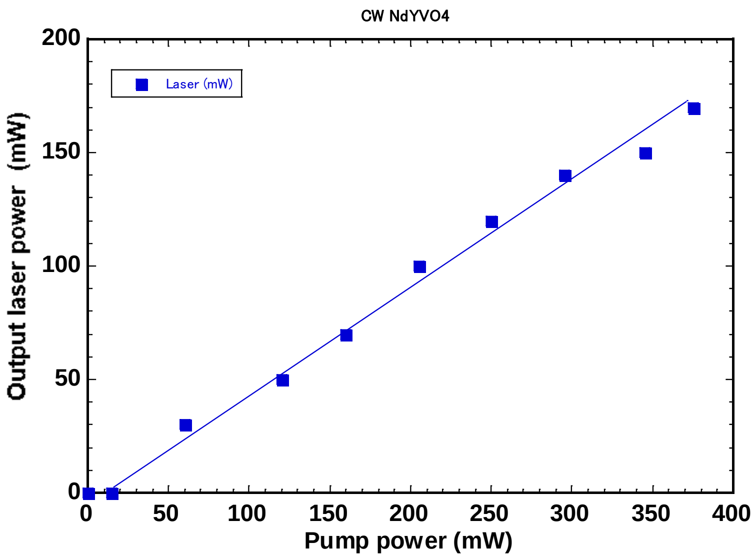
Fig.2. Experimental setup.

3. Result

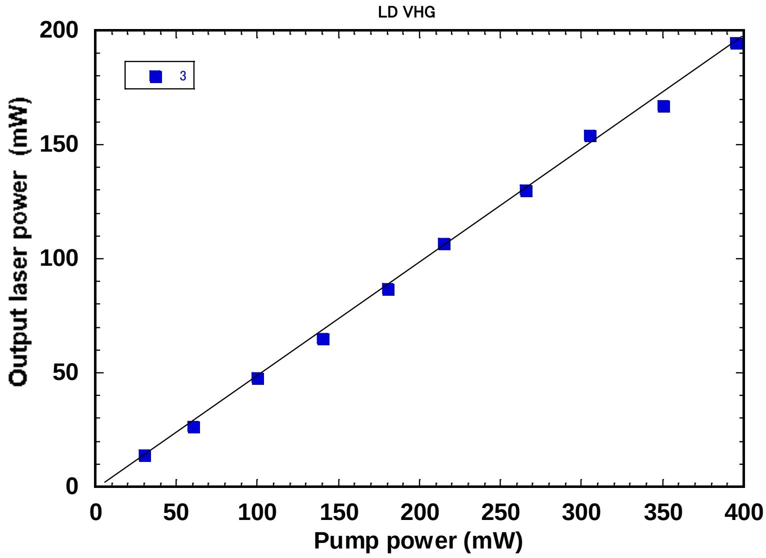
The experimental results for CW laser generation is shown in Fig.3. The spatial mode of laser output was a quasi-single mode. When a conventional LD was used, 170 mW was obtained for pumping light power of 380 mW. The oscillation threshold was 20 mW. At this time, the slope efficiency was 47%. When VHG LD was used, 200 mW was obtained for pumping light power of 400 mW. The oscillation threshold was 10 mW. At this time, the slope efficiency was 51%. When using VHG LD, the threshold was improved by half, and slope efficiency and output power were also improved. This is probably because the bandwidth of the output light from LD is narrowed to reduce the sideband, the spatial mode is improved, the divergence angle of the LD light is reduced, and the focused spot diameter of the excitation is reduced.

The reflectivity of the output coupler has not been optimized yet. It was found that when the resonator length is shortened to 5 mm, the slope efficiency is improved to 58 and the conversion efficiency is improved to 55%. If the mirror reflectivity is reduced from 90% to 80% and the resonator is optimized, a 250 mW output is achieved and the conversion efficiency is expected to reach 60%.

The experimental results for pulsed laser generation using a saturable absorber is shown in Fig.4. When a conventional LD was used, 130 mW was obtained for the pumping light power of 480 mW. The oscillation threshold was 200 mW. At this time, the slope efficiency was 50% and the efficiency was 27%. When VHG LD was used, 155 mW was obtained for the LD excitation light power of 470 mW. The oscillation threshold was 60 mW. The oscillation threshold was improved to 1/3. The repetition rate of the generated laser pulsed changed from 400kHz to 830kHz. At this time, the efficiency was 33%. The reflectivity of the output coupler is not optimized here either.

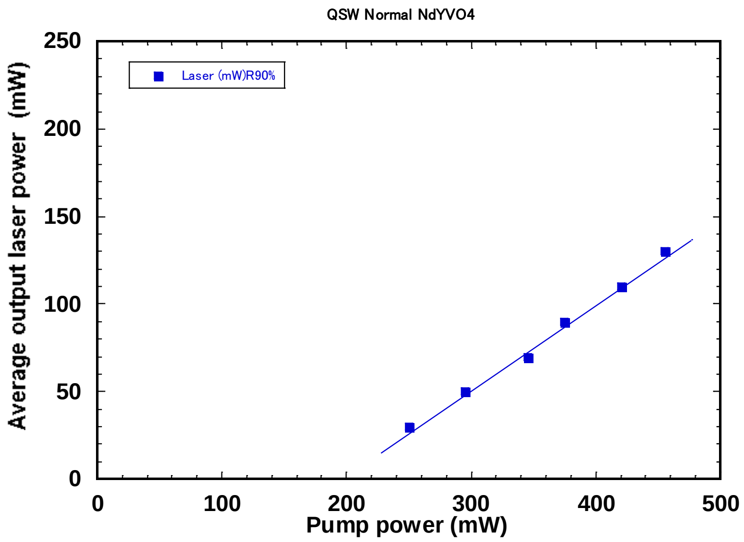


(a)

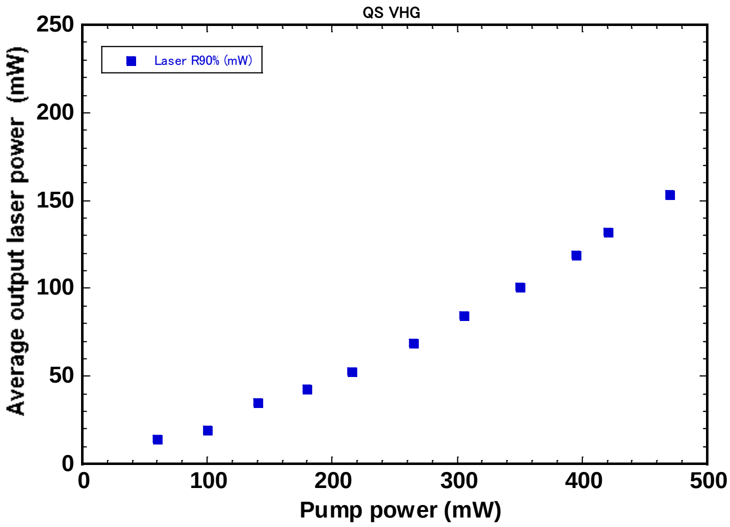


(b)

Fig.3 Output laser power (a) Using normal LD, (b) Using WHG LD.



(a)



(b)

Fig.4. Average output laser power. (a) Using normal LD, (b) Using WHG LD.

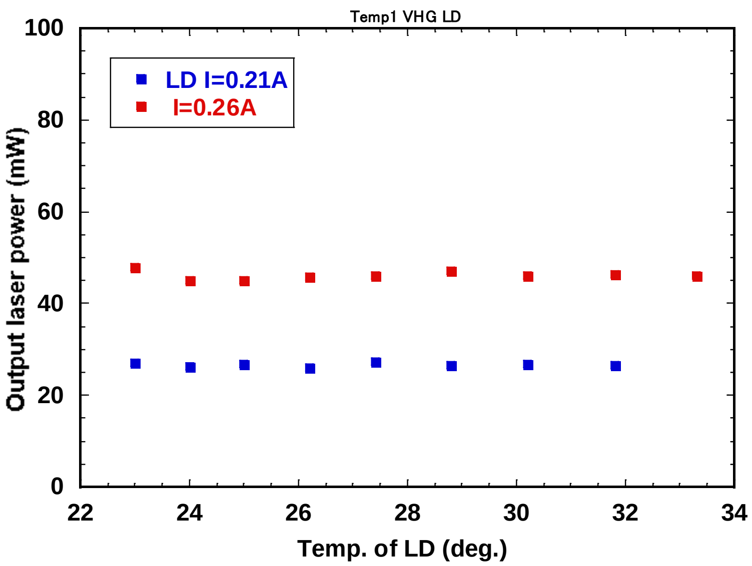


Fig.5. Stability of laser power for LD temperature

Experimental result for the stability of laser power with respect to LD temperature is shown in Fig. 5. However, it is an oscillation output in CW mode. As a result of the measurement, the laser output was stable up to 35 °C. The excitation power was 100 mW. The current was controlled constant. Below 23 °C could not set due to a problem with the cooling mechanism.

References

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