26PB21

Diode - pumped Tm,Ho:YAG Microchip Laser

Takeshi Yokozawa, Hayato Nakajima,
Takanobu Yamamoto and Hiroshi Hara
Ishikawajima-harima Heavy Industries Co., Ltd.
1 Shinnakahara Isogoku Yokohama Japan

The lasing characteristics of a LD pumped Tm, Ho:YAG microchip laser has been investigated. We found a threshold power of 46 mW, a maximum laser output of 47 mW and a slope efficiency of 24% at room temperature. Single longitudinal mode oscillation at the wavelength of 2.12 μ m was observed for absorbed power less than 57 mW.

Introduction

There has been some interest in the development of an eye-safe laser as a source for remote sensing [1]. Especially, a LD Pumped solid state eye-safe laser is expected as an important candidate so as to realize the compact and high efficient laser system [2].

The Tm^{3+} laser and the Ho^{3+} laser are promised to be an efficient sources in the 2μm region. In this work, we studied the lasing performance of the Ho^{3+} laser as a function of the crystal temperature and the operating condition of the LD so as to find out the optimum operating condition of the single longitudinal mode oscillation of the LD pumped microchip Ho laser.

LD pumped laser system

The experimental setup is shown in Figure 1. The laser diode for pumping the Ho laser has one watt output power with a wavelength of 785nm. We used a collimating lens with a 6 mm-focal length, a cylindrical lens with a 700 mm-focal length and a focusing lens with a 50 mm-focal length so as to focus the emitting light of the LD on the surface of the flat end of the laser crystal. The $1/e^2$ diameter of the spot size on the crystal was measured to be 145 μm x 30 μm.

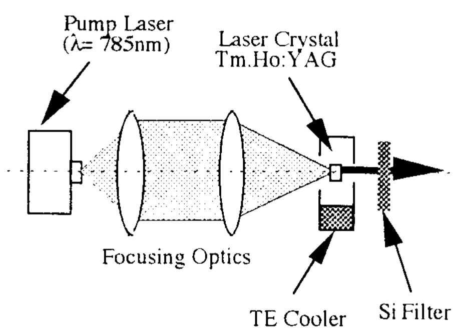

Fig.1. LD end - pumped Tm, Ho :YAG Microchip Laser.

The microchip laser used in the present study consist of 6% Tm, 0.5% Ho :YAG crystal of 1 mm thickness that formed monolithic laser cavity. It has a AR coat at 785 nm and a HR coat at 2 μm on one side where the pump beam entered and a reflectivity of 99.5% coat at 2 μm on the other side having curvature of 20 mm. The temperature of the crystal could be controlled by using a thermo electric cooler to increase the slope efficiency and to decrease threshold power of the crystal[3]. The output power was measured by the PbS detector and the power meter which was placed behind a Si plate so as to eliminate the pump light of 785 nm.

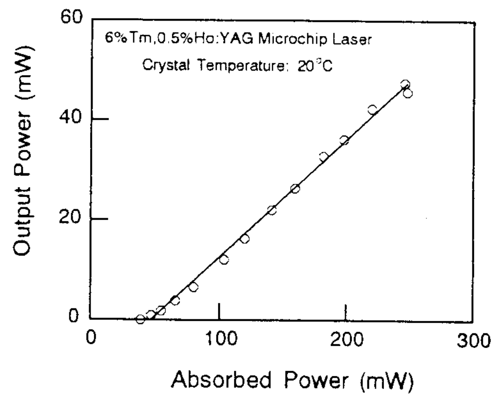

Fig. 2. Laser output as a function of the absorbed power at room temperature.

Results

Figure 2 shows the output power as a function of the absorbed power at room temperature. About 42% of the incident power of the LD was absorbed by the laser crystal. The threshold value of the microchip laser was determined to be 46.4 mW from this figure. The output power increased linearly with the increase of the absorbed power. The output power of 47.4 mW was obtained at the absorbed power of 246 mW which corresponded to a maximum power of the pumping LD. The slope efficiency of 23.5% was also achieved from the Figure.

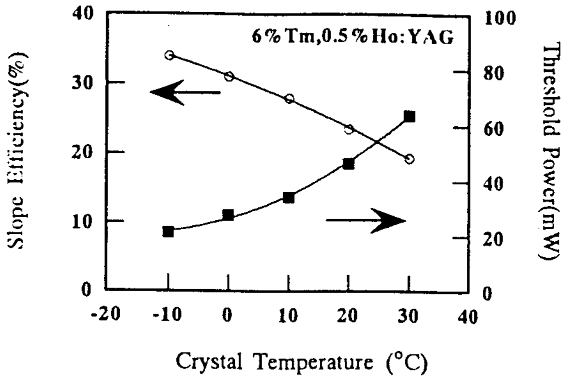

Fig. 3. Slope efficiency and threshold power of the Tm, Ho :YAG microchip laser as a function of the crystal temperature.

Figure 3 presents the threshold power and the slope efficiency of the laser as a function of the crystal temperature. The slope efficiency of 34% and the threshold power of 21.2 mW were obtained at the crystal temperature of -10°C. The Slope efficiency increased about 1.7 times higher than that and the threshold power decreased about 3 times smaller than that at the temperature of 30°C when decreasing the temperature to -10°C. The threshold power depends on the crystal temperature more sensitivity than the slope efficiency depends on that.

The output spectrum of the Tm, Ho :YAG microchip laser is illustrated in Fig.4. In the case of the absorbed power of 246 mW, two longitudinal modes oscillation was observed near wavelengths of 2121 nm and 2122 nm. The longitudinal mode spacing was comparable to calculated value from the microchip geometry. The decrease of the spectrum near 2121 nm was more drastic than that near 2122 nm when decreasing the absorbed power and finally the single longitudinal mode oscillation near 2122 nm was achieved for absorbed power below 57.3 mW. The maximum power for the single longitudinal mode oscillation was measured to be 3.5mW.

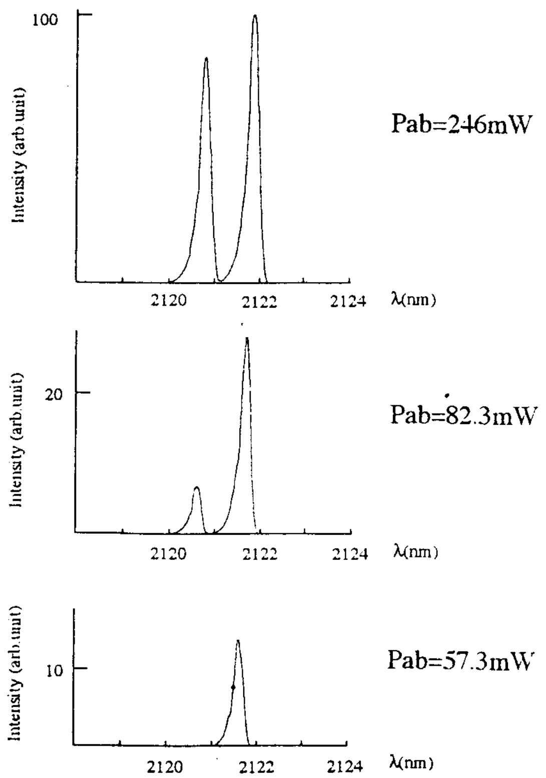

Fig. 4. Lasing spectrum of the Tm, Ho :YAG microchip laser versus the wavelength for three values of absorbed power at crystal temperature of 10 °C.

Conclusion

The room temperature lasing of the 6%Tm, 0.5%Ho :YAG microchip laser are obtained. The lasing characteristics was improved with decreasing the crystal temperature. The single longitudinal mode oscillation of the wavelength near 2122 nm was achieved for the microchip laser.

The authors would like to acknowledge Professor N. Djeu of University of South Florida for supplying the microchip crystal and helpful suggestions.

This research was supported through in part of Special Coordination Funds of the Science and Technology agency of the Japanese Government.

References

1. John G. Daly, " Mid-Infrared laser applications " , SPIE Vol. 1419, p.94, 1991
2. Tso Yee Fan and Robert L. Byer, "Diode Laser-Pumped-Solid-State Lasers", IEEE J. Quantum Electron. , vol. 24, No. 6, pp.895- 912, 1988
3. Thomas J. Kane and Tracy S. Kubo, Diode-Pumped Single-Frequency Lasers and Q-Switched Laser Using Tm:YAG and Tm, Ho :YAG, OSA Proceedings on Advanced Solid-State Lasers, H. P. Jenssen and G. Dube , eds. (Optical Society of America, Washington, DC 1991),Vol.6, pp. 136-139