P2-25 Comparison of Lasing Performance of Tm,Ho:YLF Laser using Single and Double Cavities

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1 Introduction

An eye-safe 2μm Tm,Ho:YLF operated in either the cw or pulse oscillation mode has the potential application in laser remote sensing. Especially, a Ho-doped laser has an advantage for suppression of a relaxation oscillation (Elder et al., 1998). On the other hand, the YLF crystal as a host crystal has excellent characteristics such as a low thermal lens effect because of negative dn/dt (Razunova et al., 1996), and an easy polarized oscillation because of its uniaxial structure. In addition, relatively long lifetime of a Tm,Ho:YLF laser as compared with a Tm,Ho:YAG laser (Payne et al., 1992) is useful for Q-switch operation. Although there are several techniques for obtaining stable single-longitudinal mode oscillation of Tm Ho:YLF laser, adoption of a microchip laser with the double cavity is considered to be one of the most suitable methods (Yokozawa et al., 1998). In this work we report comparison of the lasing performances of single-longitudinal mode Tm,Ho:YLF lasers using single and double cavity configurations, respectively.

2 Experimental Setup

In a single cavity configuration we coated the laser mirrors directly on both surfaces of the laser crystal. As shown in Fig.1a, on one surface of this crystal coated is a total reflector having a high transmission (over 97% for the pumping wavelength at 785nm) and a high reflection (over 99.5% for the lasing wavelength at 2.1μm). The opposite surface of the crystal is coated with a 99% reflection mirror at 2.1μm. As a result, it is a single flat-flat cavity configuration having a 0.7mm cavity length. On the other hand, Fig.1b shows the double cavity configuration where a dielectric mirror with a high transmission at 785nm and a high reflection for 2.1μm is coated directly on to the surface of the laser crystal, while the other surface of the crystal is uncoated but merely polished. Slightly separated from the polished surface of the crystal, an output mirror having a 99% reflectivity at 2.1μm is employed. It should be noted that such a space between the output mirror and the polished surface of the laser crystal plays an important role as an etalon whose distance can be controlled easily by adding voltage directly to the mirror holder made of PZT ceramics.

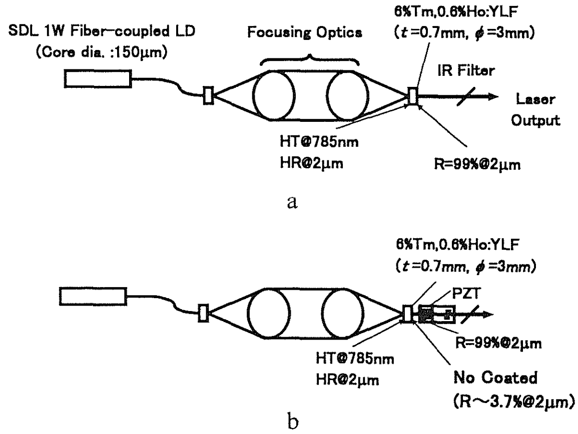

Figure 1. An experimental setup for present experiments. (a) A Tm,Ho:YLF microchip laser with a single cavity configuration. (b) A Tm,Ho:YLF microchip laser with a double cavity configuration.

The YLF crystal was oriented with a-axis parallel to the polarization vector of the pump laser (π-polarization). A 6%Tm,0.6%Ho:YLF crystal of 0.7mm thickness was chosen for the present experiments. The crystal was cooled by using a thermoelectric cooler to keep its temperature at room temperature. A 1W laser diode at 785nm was coupled through a 150μm-diameter fiber to the focusing optics as the pumping source. Output from the optical fiber was focused on to the total reflector through a compensated optics with a 10mm focal length lens. The minimum spot size of the pumping beam was measured to be 150μm and was kept constant during the experiments. The output power of the Tm,Ho:YLF lasers was measured by using a power meter in combination with an optical filter that cuts off the unabsorbed pump light. The single longitudinal mode oscillation was measured with the use of a scanning Fabry-Perot interferometer, while the laser wavelength was measured by using a monochrometer.

3. Results

Figure 2 shows a single-longitudinal-mode output power as a function of the absorbing pump power for both the single and the double cavity configurations.

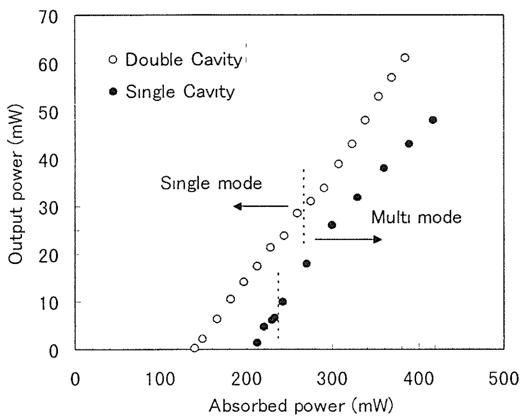

Figure 2. An output power of Tm,Ho:YLF laser for both cavity configurations in the single mode oscillation as a function of the absorbing power. The crystal temperature is kept at room temperature during experiments.

The lasing threshold for a double cavity is measured to be 140mW, which is lower than the 210mW obtained for the single cavity. This improved threshold value can be explained by the role of the air gap etalon in a double cavity. The effective reflectivity of the output mirror for the double cavity changes as the oscillation wavelength varies. In our measurements, the peak effective reflectivity for the double cavity configuration was estimated to be 99.3%, while it was 99.0% for the single cavity configuration. When increasing the pump power from 140mW to 260mW without changing the pumping beam profile, the single-longitudinal mode output power from a double cavity laser configuration increases linearly up to 30mW. Above 30mW, a single longitudinal mode oscillation could not be obtained, though we have varied the distance of the air gap etalon. In contrast to the double cavity configuration, single-longitudinal mode output from a single cavity configuration was merely up to 7mW. Between 7mW to 15mW laser outputs, we observed two longitudinal mode oscillations, and above 15mW, these are three oscillation modes observed. Present results showed the fact that the gain profile is wider than the longitudinal mode distance to the short cavity length, even though the laser cavity-length is 0.7mm. Therefore we could not obtain a high power single-longitudinal mode oscillation, unless we had effective tuning mechanisms. The slope efficiency for both cases has the same dependency on the pumping power, for which double cavity configuration has a small cavity loss. The threshold for the double cavity configuration, however, is about half of that of the single cavity configuration.

4. Conclusion

We have compared the lasing performance of a single- and a double-cavity Tm,Ho:YLF lasers. The maximum single longitudinal mode output power at 2.06μm from a double-cavity laser was measured to be up to 30mW, as compared to the 7mW from a single-cavity laser. Our results present that a double cavity configuration appears to be a more excellent method so as to achieve a stable single-mode oscillation as well as a wide tuning range for a 2μm Tm,Ho:YLF laser.

5. Acknowledgement

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