P2-21 Compact All Solid-State Q-switched Nd:YAG Lasers for Doppler Lidars

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1. Introduction

For applications in optical space communication and remote sensing, e.g., Doppler lidar and remote gas sensing, efficient high-average power and compact pulsed laser systems are required with single transverse and longitudinal mode with narrow linewidth operation.

A number of efforts have been achieved for single mode selection of solid state lasers. For instance, an injection seeding1) is widely used for single frequency operation of high-power Q-switched lasers. In this scheme, however, a seeding laser is required and the frequency jitter inherent in the seeding is larger than several 10 MHz, which limit the performance of high-accuracy coherent remote sensing applications such as Doppler lidars.

To achieve single frequency operation without seeding lasers, composite cavities2), such as Michelson-type interferometric resonators, are also used for gas laser oscillation. On the other hand, CW Single-frequency oscillation has been achieved with nonplaner monolithic ring lasers or MISER3). But the output power of these lasers are limited below 1 W, and a Q-switched oscillation with monolithic ring lasers using saturable absorbers is also limited 4), 5). Higher power CW operation with single-narrow frequency was achieved with ring cavity configuration6). However, high average power Q-switched single frequency lasers are not yet obtained with simple arrangement.

2. Design of compact Q-switched lasers

We require the following conditions of the lasers for the direct-detection Doppler lidars for wind profiling; a) single transverse and longitudinal mode with less than few MHz frequency stability and linewidth, which corresponds to the accuracy of 0.1 m/s of the wind velocity7), b) higher average power than 1 W, for high signal-to-noise detection, c) high efficiency, d) simple and compact structure for stable and portable lidar systems.

To achieve these requirements, we have designed the Q-switched ring cavity Nd:YAG laser shown in Fig. 1. A Faraday isolator of a TGG crystal is used with a half wave plate and two Brewster plates to ensure a unidirectional oscillation. The rotation angle of the polarization was ~5 degree with magnetic field of 6.0×10^{-2} T. An AO Q-switch is used for efficient, high repetition rate pulse operation. For compact and stable oscillation, the length of the cavity was limited to 500 mm. Two fiber-coupled 15 W diode lasers have been used for efficient end pumping of the Nd:YAG rod. The spot size of the diode laser beam was 0.5 mm. A concave mirror with 3 m curvature was used for stable operation with adequate mode-matching efficiency. A 1 mm diameter aperture was inserted in the cavity to ensure the single transverse mode operation.

3. Experimental results and discussions

Fig. 2 shows the relation between the laser output power and the diode laser pump power. Slope efficiency of 17 % was obtained. Maximum output power was 1.3 W in CW operation for the pump power of 23 W. Q-switched single frequency oscillation was realized with this ring laser. The average output power was 1.2 W with the output energy of 1.2 mJ at 1 kHz repetition rate of 200 ns pulse width at 23 W pump power. Observed spectrum of single frequency is shown in Fig. 3.

The round trip loss of the cavity derived from unsaturated gain of the laser rod corresponds to 35 %, and elimination of the loss is necessary for achieving higher power output of the laser. For long term stable single frequency oscillation, an etalon plate is also necessary to insert in the ring cavity. A LBO crystal is used for an efficient harmonic generation of the laser output for use in the Doppler lidar experiments[7].

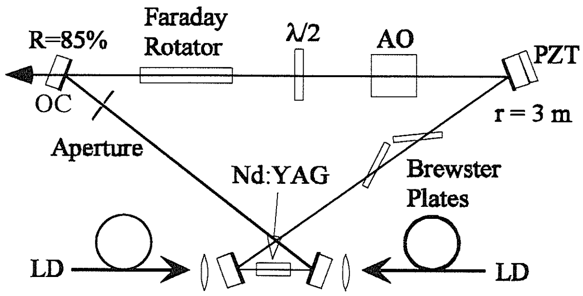

Fig.1 Schematic diagram of the single frequency unidirectional ring cavity laser.

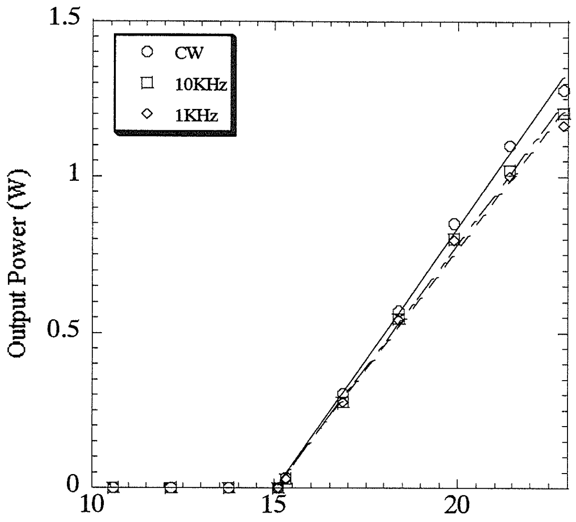

Fig.2 Output power versus pump power of the diode laser-pumped laser.

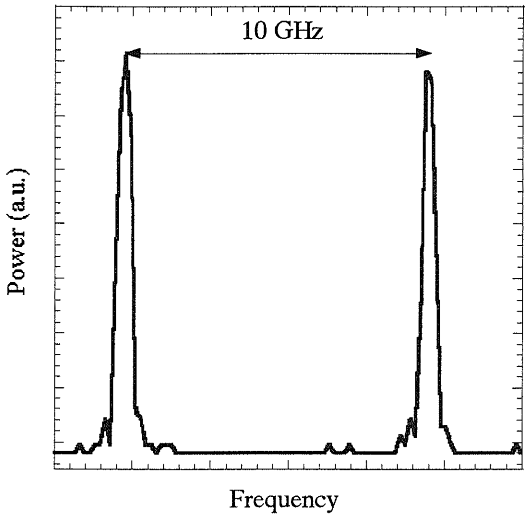

Fig.3 Single laser frequency output observed by the scanning Fabry Perot interferferometer.

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