P2-22 Development of a 67kHz Internal OPO Laser for Heliborne Lidar System

Kaoru Asaba, Takakazu Ishii, Ryuuji Kameyama
NEC Corporation
1-10, Nisshincho, Fuchu, Tokyo 183-8501, Japan
TEL +81-42-333-1151, FAX +81-42-333-1823, E-mail: asaba@p23-24640.star.nec.co.jp
Tetsuo Shiina,
NEC Engineering, Ltd.
5-22-5, Sumiyoshi-cho, Fuchu, Tokyo 183-8502, Japan
TEL +81-42-333-9695, FAX +81-42-333-9673, E-mail: shiina@de.neec.fc.nec.co.jp
Shuichi Ashidate, Kiyoshi Kurosawa
Tokyo Electric Power Company
4-1, Egasaki-cho, Tsurumi-ku, Yokohama, Kanagawa 230-8510, Japan
TEL +81-45-585-8513, FAX +81-45-585-8520, E-mail: t0373175@pmail.tepco.co.jp

1. Introduction

We have developed a heliborne lidar system to measure the distance between power transmission lines and nearby trees. The previous system used, as a light source, a laser that output a beam with the pulse peak power of 5 kW and the pulse width of 10 ns when the wavelength was 1573 nm and the pulse repetition frequency (PRF) was 10 kHz. It was an optical parametric oscillator (OPO) with an external resonator and had an Nd:YVO_4 laser pumped by 10 W laser diode (LD) as a pump light source and used KTP ($KTiOPO_4$) for the non-linear optical crystal. The light-to-light conversion efficiency was 5%. This laser weighs 6.25 kg and its dimensions are 115 × 73 × 337 mm [1]. Improving the spatial resolution of this lidar system requires higher repetitions of the laser. Thus, the OPO with an internal resonator is used this time. The internal OPO has an OPO resonator within the pump laser resonator to utilize high power density in the pump laser resonator, which is expected to give better efficiency than the external OPO. By using the internal OPO, we have developed a laser for heliborne lidar system and it generates a pulse peak power of 6.6 kW with the 16W LD pumping power at the PRF of 67 kHz required by this system. The light-to-light conversion efficiency has also improved to 9%.

2. Structure of OPO

Figure 1 illustrates the structure of the internal OPO.

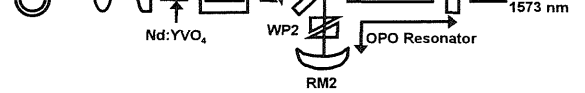

Figure 1 Structure of OPO

The LD is a type of the optical fiber coupling (SDL-3460-P6). The core diameter is 600 μm, the numerical of aperture (N.A.) is 0.2, and the maximum fiber-end output is 16 W.

Nd:YVO_4 is used as the laser crystal that comprises the non-dope section with the dimensions of 2 × 5 × 5 mm and the Nd^{3+}1at.% dope section with the dimensions of 3 × 5 × 5 mm. Pumping is provided solely from the non-dope section to prevent thermal damage to the crystal.

KTP is used as the non-linear optical crystal. The crystal length is 30 mm and the x-axis cut is applied so as to provide the signal wavelength of 1573 nm with the pump wavelength of 1064 nm.

The AO (Acousto-Optic) Q switch with the tellurium dioxide medium is used.

The pump laser resonator is implemented between the rear mirror RM1 and the output coupler O/C. To improve the internal power density of the pump laser resonator, HR coating is applied to the RM1 and O/C for 1μm. The pump laser resonator is aligned by the wedge prism WP1.

The OPO resonator is implemented between the rear mirror RM2 and the output coupler O/C through the dichroic mirror DM with AR and HR applied for 1 μm and 1.5 μm, respectively. The OPO resonator is aligned by the wedge prism WP2. The pump laser resonator and the OPO resonator share KTP and they are separated by the DM.

The dimensions of the laser oscillator, excluding the LD, are 50 × 45 × 150 mm and it weighs 350 g.

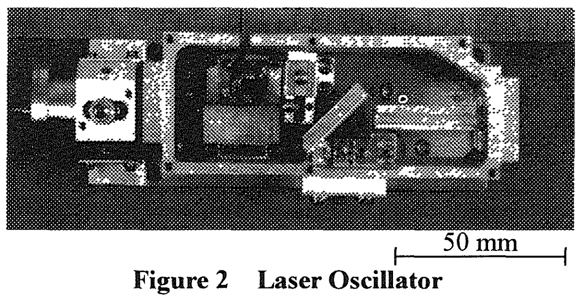

Figure 2 Laser Oscillator

3. Elimination of Multipulse

The internal OPO has a problem that it is likely to generate the second and third pulses (multipulse) several nsec after generation of the first pulse [2]. The multipulse operation causes false measurement in this lidar system and diffuses the pulse energy to lower the pulse peak power. To use the internal OPO in our system, it must be modified to generate a single pulse. Single-pulse generation in this laser was implemented by controlling the open duration of the Q switch. This enables the second and subsequent pulse energy to be used for oscillation at the next cycle when the pulse repetition time is shorter than the upper level life time of the laser medium. The laser medium is continuously pumped by the LD; thus the pumped energy of one cycle and the remainder from the previous cycle is used for pulse generation at this cycle to provide the high peak output of a single pulse.

4. Laser Characteristics

1) Output characteristics

Figure 3 shows the output characteristics. The data with the PRF of 67 kHz and 100 kHz were acquired. With the PRF of 67 kHz and the LD input of 16 W, the average power of 1.42 W, the pulse width of 3.2 ns (FWHM), and the peak power of 6.6 kW were achieved. With the PRF of 100 kHz and the LD output of 16.0 W, the average power of 1.15 W, the pulse width of 3.5 ns (FWHM), and the peak power of 3.3 kW were achieved.

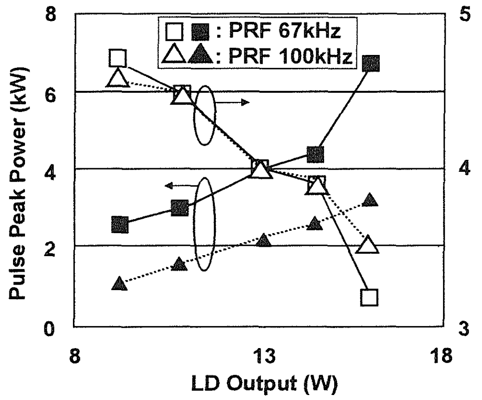

Figure 3 Input/Output Characteristics

2) Temperature characteristics

Figure 4 shows the results of the temperature test with the PRF of 67 kHz. With a temperature range from -10°C to 60°C, no significant changes were observed in the pulse peak power and the pulse width.

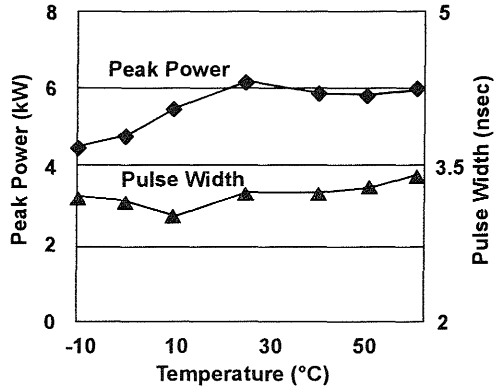

Figure 4 67kHz Temperature Characteristics Test Results

3) Vibration and shock tests

Considering the heliborne lidar system, the vibration and shock tests conformed to JIS W 7002 and conducted under the following conditions. No significant changes were observed in the laser characteristics before and after the vibration and shock tests.

Table 1 Conditions for Vibration and shock Tests

Vibration conditions	Vibration range:	5 to 200 Hz
	Vibration amplitude:	4.96 to 0.022 mm (with the maximum acceleration of 2 G fixed)
shock conditions	Pulse shape:	half-sine wave
	Acceleration:	10 G
	Operation time:	11 msec

5. Conclusion

We have developed an internal OPO laser for heliborne lidar system. A pulse peak power of 6.6 kW at the PRF of 67 kHz was achieved. With the environmental tests, we have acquired a result that this laser oscillator can be used for heliborne lidar system.

Bibliography

[1] M. Kadoya and K. Asaba, NEC Research & Development, Vol. 37, No. 3, p. 361, 1996

[2] J. Falk, et al., IEEE J. Quantum electron., QE-7, P. 356, 1971