DEVELOPMENT OF CONDUCTIVELY COOLED 2MICRON LASER OSCILLATORS

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ABSTRACT

We are developing moderate output 2micron Q-switched laser oscillators for atmospheric CO_2 and wind profiling. These are conductively cooled and laser diode pumped solid-state lasers, which could be applicable to space-borne instruments. Output of 100mJ at 10Hz has been achieved in a Tm,Ho:YLF laser oscillator for ground based CO_2 measurement. Another type of Tm,Ho:YLF laser oscillator with 50-100mJ outpute at 20-30Hz is expected to be developed for the use of coherent Doppler lidar in the sensing network project to be extended in the area around Tokyo.

1. INTRODUCTION

National Institute of Information and Communications Technology (NICT) started a new term plan of 5 years at April 2006. The plan includes development of lidar technology for CO_2 observations from ground and airplane, and wind profile observations over the urban area. We were engaged in the technology development for space-borne Doppler lidar, which is expected to be the observation system of global measurement of wind in the troposphere [1], and have studied 2micron solid-state eye-safe lasers [2]. We achieved a Q-switched output of 460mJ at 10Hz in a Tm,Ho:YLF laser with two-stage amplifier[3]. However, we need more compact and moderate output lasers for easy operation and mobility in the new plan and also for space application using small satellite. We proceeded to develop a DIfferential Absorption Lidars (DIAL) with 2micron, conductively cooled, and laser diode pumped Tm,Ho:YLF laser for ground based CO_2 observation in the new plan. The basic pulsed laser system of 100mJ level output was tested. We also intend to develop a few pulsed lasers of smaller output for Doppler lidars, which will be used for wind profile observations around urban area. Here, we will present the status of the development of these 2micron eye-safe lasers and the future plan about the use of these lasers

2. Tm,Ho:YLF LASER FOR DIAL

Measurements of CO2 and other greenhouse gas on global scale are paid attention for the point of view of global warming. Development of airborne instrument to validate CO_2 data of space-borne instruments as OCO,

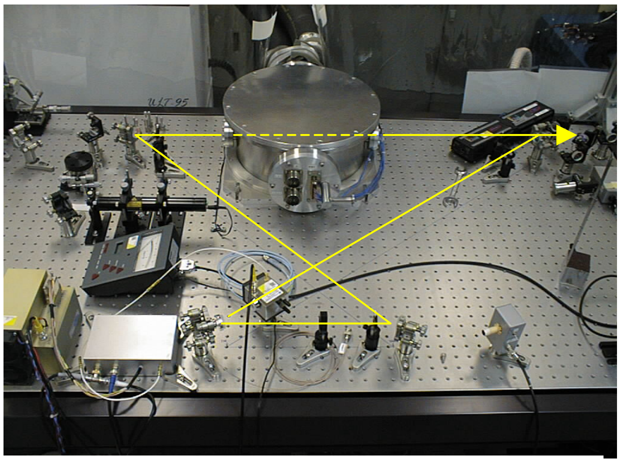

Fig.1. Picture of Tm,Ho:YLF laser for DIAL

GOSAT, etc. is needed, while new space technology for more accurate global measurements should be developed. We started to study DIAL to measure CO_2 profiles from ground and airplane for technology development and future validation experiment of space-borne observations. Tm,Ho:YLF laser is suitable for DIAL measurements of CO_2 and water vapor [4]. It emits laser pulse at wavelength around 2.05micron, where atmospheric CO_2 and water vapor have many absorption lines. A conductively cooled Tm,Ho:YLF laser oscillator of one hundred millijoule output at 10-20Hz was planned to built up. The laser will be used to develop basic technology and demonstrate the possibility of CO_2 measurement in ground-based observations. A picture of the assembled pulsed laser system in an optical table is shown in Fig.1. Unidirectional operation is performed in the ring resonator of 3m lengths. Tm,Ho:YLF laser rod is conductively cooled down to –85C and side-pumped by laser diode arrays, which is also conductively cooled to about 20C. The heat from Cu heatsink for rod is removed by cold fluorinert and that for laser diode arrays by water. These liquid cooling mechanisms for heatshinks could be replace to heat pipe and radiation cooling mechanism in space applications. The system has been operated at 10Hz and the Q-switch output pulse energy of 100mJ has been obtained (Fig.2). Pulse width at 100mJ output is about 120nsec. The system may be also operated at 20Hz. The injection seeding will enables the laser to oscillate in the single longitudinal mode needed for coherent detection. The seeding laser wavelength will be controlled to CO_2 absorption on-line and off-line for DIAL observation of CO_2 concentration.

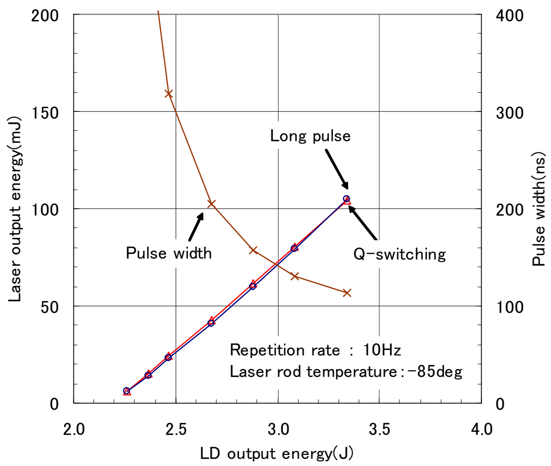

Fig.2 Output energy and pulse width of laser

3. MODERATE OUTPUT ENERGY LASER

We are also developing lasers for wind measurements in 'sensing network project'. The sensing network project in the new plan of our institute will be extended over urban area of Tokyo. In this project, detail environmental and meteorological information obtained with a group of instruments over the area should be collected instantly through network.

Doppler lidars connected with network are one of key component in this project. We need two or three Doppler lidars in the project. The area to be covered for the measurement extends to about 20-30km. Then, we need moderate output lasers for Doppler lidars. These lasers will be also used for applications of coherent lidar system in air-born experiments. The required characteristics of these lasers are as followed,

- moderate output: 50-100mJ at 20-30Hz
- compact and high efficiency for mobile system
- laser diode pump, conductive cooling.

We decided to use Tm,Ho:YLF laser rod first for the lasers fulfilling above requirements, and change it to Tm,Ho:LuLiF if necessary. A laser oscillator will realize the required output power and compactness. We are investigating a few configurations of pumping modules using triangle laser rod, slender cylinder laser rod, and laser rod with grooves. Some of these modules are in trial manufacture. The laser should have a mechanism to use injection seeding and cavity length needed for pulse width enough to realize required accuracy of wind measurement, but not so long for compactness. Cavity structure is designed to use in unidirectional operation. Seeding mechanism is also necessary. If we adopt more efficient laser rod like Tm,Ho:LuLiF, realization of higher efficiency in generating laser pulse and reduction of power consumption may be possible. As pumping wavelength for Tm,Ho:LuLiF is almost the same for Tm,Ho:YLF, we can change the Tm,Ho:YLF rod to Tm,Ho:LuLiF one in the same setting to get better efficiency. Considering of CO_2 and H_2O lines in the wavelength region of 2micron solid-state lasers, these can be also used as a transmitter for DIAL. Smaller pulse energy and compactness of this type of laser in the comparison with that shown in the previous chapter are favorable to realize mobility of the instruments, which is important in the sensing network project and in air-born experiments.

4. CONCLUSIONS

We are developing conductively cooled eye-safe laser oscillators. Tm,Ho:YLF laser for ground based DIAL measurement of CO_2 was operated in 100mJ output at 10Hz. Moderate output lasers for Doppler lidars is needed to be used in sensing network project. Compact, laser diode pump, and conductively cooled Tm,Ho:YLF(or Tm,Ho:LuLiF) lasers are expected to be used for measurements of wind and carbon-dioxide profiles in the ground and air-borne experiments. As we will use coherent detection in these experiments, injection seeding will be applied to these lasers for line narrowing and wavelength control.

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