Conductive-cooled 2micron laser development for CO$_2$ and wind measurements

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Measurements of atmospheric CO₂

Anthropogenic emission  7.2 ± 0.3
Atmospheric CO₂ increase  4.1 ± 0.1
Ocean sink  2.2 ± 0.5
Land sink  0.9 ± 0.6

GtC/year (IPCC FAR) (2000–2005)

Uncertainty

GOSAT

Night high latitude

Aerosols

Active Sensing

Air-borne CO₂ DIAL

Ground-based CO₂ DIAL

CO₂ line

On line

Off line

Clouds, Aerosols

CO₂, CH₄
Ground-based wind measurements

Sensing Network Project

The atmosphere over the urban area of Tokyo will be observed by Wind Profiler, Doppler lidar.

Range > 20km is needed.

We need more power!

- 2µm
- 7mJ at 100pps
- Future Now
  - 50-100mJ at
  - 30pps

\[ S/N \propto \frac{P}{\sqrt{N}} \]
- 7 segments pumping configuration

Composite Tm(4%), Ho(0.4%): YLF
Side pump configuration
7-segments heat sink
28 package LD

100mJ oscillator at 2μm and 500mJ amplifier are usable.

Expensive not compact
Moderate output laser development

Pumping head for Φ=4mm, L=44mm Tm,Ho:YLF rod

- 12 LD packages
- Rod cooling down to -80°C in vacuum container
- LD controlled to about 20°C in vacuum container
Long pulse experiments

Multi-mode
Fabry-Perot type
Rod temperature $\sim -80^\circ C$

![Graph showing LD output vs. long pulse output](image)

Output window: 80%

- ○: 10Hz
- △: 20Hz
- ×: 30Hz

Tm, Ho: YLF
Output characteristics of Tm,Ho:YLF laser in a ring resonator configuration of 3.86m

- Pulse energy
- Pulse width at 20Hz

Input: 1.4 J/pulse
QSW out: 101mJ/pulse
Pulse width: 125ns
Ground-based CO$_2$ DIAL/Wind Doppler Lidar

![Block diagram of coherent DIAL]
Coherent 2-µm Differential Absorption and Wind Lidar (Co2DiaWiL)
Example of observation

Beat signal

50mJ at 20Hz

Spectrum

Now operated with 80mJ at 30Hz
LOS Velocity to Range

80mJ at 30Hz

Velocity measurements up to 23-25km in 10min.
New laser head for air-borne CO$_2$ DIAL/Wind Doppler lidar

- Same basic design as the ground based CO$_2$ DIAL
- Tm,Ho:YLF rod ($\Phi=4\text{mm, } L=44\text{mm}$), (test for Tm,Ho:LLF rod)
- Rod cooling down to -80C in vacuum container
- 12 LD packages

Objective Output
50-80mJ at 30-40Hz
New laser head for air-borne CO₂ DIAL/Wind Doppler lidar
New laser head for air-borne CO₂ DIAL/Wind Doppler lidar

**Long pulse experiments**

- Multi-mode
- Fabry-Perot type
- Rod temperature ~ −80°C

![Graph](image)

**Tm,Ho:LLF rod**

**Tm,Ho:YLF rod**
New test laser for air-borne CO₂ DIAL/Wind Doppler lidar

400mm

660mm
# Concept and simulation studies for 2micron Integrated path differential absorption (IPDA) lidar

<table>
<thead>
<tr>
<th>Name</th>
<th>Concept</th>
<th>on/off (mJ)</th>
<th>repetition</th>
<th>Telescope Dia.</th>
</tr>
</thead>
<tbody>
<tr>
<td>FACTS</td>
<td>2micron double wing</td>
<td>75/25</td>
<td>10Hz</td>
<td>1m</td>
</tr>
<tr>
<td>Ehret et al.</td>
<td>2micron wing</td>
<td>80/70</td>
<td>50Hz</td>
<td>1.5m</td>
</tr>
<tr>
<td></td>
<td>Direct detection</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Direct detection</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

NICT Conductive-cooled 2micron laser Oscillator

\[ \leq 100\text{mJ} \quad \leq 30\text{Hz} \text{ (limit of LD driver)} \]\n
2micron laser Amplifier

\[ \sim 500\text{mJ} \quad 10\text{Hz} \]

NICT Conductive-cooled 2micron laser seems to be fit to the Direct detection IPDA lidar.
Conclusions

- We have developed a ground-based DIAL/Wind Doppler lidar (Co2DiaWiL) on an optical table with a 2 µm conductive-cooled Tm,Ho:YLF laser of 50-80mJ output at 30Hz.
- The output of the slave laser will reach to 100mJ at 30Hz.
- Laser amplifier of 500mJ level is available.
- A compact mobile CO₂ DIAL/WIND system will be developed and used for the air-borne and ground-based observations. (Validation experiments of GOSAT)
- These output power may be large enough for some kinds of space-borne CO₂ DIAL and Wind Doppler lidar.
- The conductive-cooled lasers could be applicable to space-borne 2µm DIAL and Wind lidar for global CO₂ and wind measurements.