ABSTRACT

INJECTION SEEDING OF A Q-SWITCHED ALEXANDRITE LASER: STUDY OF FREQUENCY STABILIZATION

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COORDINATOR: Dr. CLINTON LEE

AlGaAs diode lasers were used to injection seed a pulsed Q-switched alexandrite laser which produced a narrowband of radiation. Injection seeding is a method for achieving linewidths of less than 500 MHz in the output of broadband, tunable solid state lasers. Also, injection seeding made the frequency of the pulsed, Q-switched alexandrite laser stabilize. The AlGaAs diode lasers are available in wavelengths from 760 to 770 nm in the oxygen A band, which was used for the lidar remote sensing of atmospheric pressure and temperature. When the diode laser was set at a current of 59.8 mA and a temperature of 14.04°C, the wavelength was 767.6 nm. The average full width at half the maximum (AVG. FWHM) was 0.007 ± 0.001 cm⁻¹ and the change in wavenumber was 0.045 cm⁻¹. When seeding the pulsed Q-switched alexandrite laser, the AVG. FWHM was 0.035 ± 0.009 cm⁻¹ and the change in wavenumber was 0.021 cm⁻¹. The Q-switched alexandrite laser was injection seeded and frequency stabilization was studied. The linewidth requirement was met, but the stability requirement due to drifting in the feedback voltage to the laser diode was not. Improvements to the injection seeding of a Q-switched alexandrite laser should focus on increasing the feedback voltage to the laser diode, filtering the laser diode by using temperature controlled narrowband filters, and the use of diamond (SiC) grating placed inside the alexandrite laser's resonator cavity.
INJECTION SEEDING OF A Q-SWITCHED ALEXANDRITE LASER:
STUDY OF FREQUENCY STABILIZATION

BY

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OUTLINE

— LIDAR (LIGHT DETECTION AND RANGING)
  • USED IN THE STUDIED OF ATMOSPHERIC PRESSURE AND TEMPERATURE
  • Q-SWITCHED ALEXANDRITE LASER
  • INJECTION SEEDING

— WAVEMETER
  • USED IN DETERMINING FREQUENCY STABILIZATION

— MEASUREMENT OF He-Ne (CALIBRATION), DIODE LASER, AND SEEDED Q-SWITCHED ALEXANDRITE LASER
CONCEPT

DIODE LASERS - LOW POWER, SINGLE MODE, CW
FREQUENCY STABILIZED - LOCKED TO ATMOSPHERIC ABSORPTION LINES

PURPOSE/ADVANTAGES:

- INJECTION SEED PULSED LASERS
- FREQUENCY STABILIZE INTERFERENCE FILTERS
- ABSOLUTE FREQUENCY REFERENCE
PULSED LASER FREQUENCY STABILIZATION

ALEXANDRITE OUTPUT

OPTICAL ISOLATOR

PHOTOACOUSTIC CELL

DIODE LASER

LOCK-IN AMPLIFIER

DELAY PULSE GENERATOR

INJECTION SEEDED ALEXANDRITE LASER

FEEDBACK SIGNAL

DITHER SIGNAL

10 Hz SINE GENERATOR

TRIGGER
DIOD628.1
AVG. DATA

I = 59.8 mA
T = 14.04 C
Wavelength = 767.6 nm

INTENSITY (ARB. UNITS)

PIXEL NUMBER

0 50 100 200 300 400 500 600 700 800 900 1000

300 250 200 150 100
<table>
<thead>
<tr>
<th>LASER DIODE</th>
<th>AVG. FWHM (cm**-1)</th>
<th>SPECTRAL RANGE (MHz)</th>
<th>CHANGE IN WAVENUMBER (cm**-1)</th>
<th>CHANGE IN SPECTRAL RANGE (MHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIOD627.X</td>
<td>0.009 ± 0.001</td>
<td>270 ± 30</td>
<td>0.010</td>
<td>300</td>
</tr>
<tr>
<td></td>
<td>I = 60.0 mA</td>
<td>T = 14.05 °C</td>
<td></td>
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<tr>
<td></td>
<td>WAVE-LENGTH = 766.0 nm</td>
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</tr>
<tr>
<td>DIOD628.X</td>
<td>0.007 ± 0.001</td>
<td>210 ± 30</td>
<td>0.045</td>
<td>1350</td>
</tr>
<tr>
<td></td>
<td>I = 59.8 mA</td>
<td>T = 14.04 °C</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>WAVE-LENGTH = 767.6 nm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*DIOD709.X</td>
<td>0.008 ± 0.001</td>
<td>240 ± 30</td>
<td>0.003</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>T = 10.89 °C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>WAVE-LENGTH = 759.5 nm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>**DIOD710.X</td>
<td>0.008±0.001</td>
<td>240 ± 30</td>
<td>0.027</td>
<td>810</td>
</tr>
<tr>
<td></td>
<td>I = 60.5 mA</td>
<td>T = 10.83 °C</td>
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<tr>
<td></td>
<td>WAVE-LENGTH = 759.6 nm</td>
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<td></td>
</tr>
<tr>
<td>**DIOD716.X</td>
<td>0.007 ± 0.001</td>
<td>210 ± 30</td>
<td>0.005</td>
<td>150</td>
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<tr>
<td></td>
<td>WAVE-LENGTH = 760.4 nm</td>
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</tbody>
</table>

* For DIOD709.X I = 60.7 mA;  *New Laser Diode; **Same current and Temperature.
SEED628.1
AVG. DATA

Edge of Oxygen line with error signal.

Wavelength = 767.6 nm
SEED628.4
AVG. DATA

Edge of Oxygen line with error signal.

Wavelength = 767.6 nm
SEEDN702.7

AVG. DATA

On the oxygen line with error signal.
Wavelength = 768.3 nm

INTENSITY (ARB. UNITS)

PIXEL NUMBER

0 100 200 300 400 500 600 700 800 900 1000

300 250 200 150 100 50 0
<table>
<thead>
<tr>
<th>SEED LASER</th>
<th>AVG. FWHM (cm$^{-1}$)</th>
<th>SPECTRAL RANGE (MHz)</th>
<th>CHANGE IN WAVENUMBER (cm$^{-1}$)</th>
<th>CHANGE IN SPECTRAL RANGE (MHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEED628.X WAVELENGTH = 767.6 nm</td>
<td>0.014 ± 0.003</td>
<td>420 ± 90</td>
<td>0.027</td>
<td>810</td>
</tr>
<tr>
<td>EDGE OF OXYGEN LINE WITH ERROR SIGNAL</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SEEDN628.X WAVELENGTH = 767.6 nm</td>
<td>0.035 ± 0.009</td>
<td>1050 ± 270</td>
<td>0.021</td>
<td>630</td>
</tr>
<tr>
<td>ON THE OXYGEN LINE WITH ERROR SIGNAL</td>
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</tr>
<tr>
<td>SEEDN702.X WAVELENGTH = 768.3 nm</td>
<td>0.018 ± 0.007</td>
<td>540 ± 210</td>
<td>0.007</td>
<td>210</td>
</tr>
<tr>
<td>ON THE OXYGEN LINE WITH ERROR SIGNAL</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>*SEED710.X WAVELENGTH = 759.6 nm</td>
<td>0.008 ± 0.002</td>
<td>240 ± 60</td>
<td>0.030</td>
<td>900</td>
</tr>
<tr>
<td>BETWEEN OXYGEN</td>
<td></td>
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<tr>
<td>*shows several modes.</td>
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CONCLUSIONS:

SUCCESSFUL INJECTION SEEDING OF ALEXANDRITE LASER

MET THE LINEWIDTH REQUIREMENT

• BUT FAILED STABILITY REQUIREMENT - DRIFTING

IMPROVEMENTS TO INJECTION SEEDING Q-SWITCHED ALEXANDRITE LASER:

• INCREASED FEEDBACK VOLTAGE TO THE LASER DIODE
• FILTER LASER DIODE
  • • TEMPERATURE CONTROLLED NARROWBAND FILTERS

ALEXANDRITE LASER:

• DIAMOND GRATING (SiC, GROOVED BY EXCIMER LASER)