Portable THz Laser Source

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Motivation

Tera Hertz Radiation

- 'new' wavelength regime
- THz radiation for imaging
- THz radiation for molecular spectroscopy
Technology

Concepts for Tera Hertz Generation

• direct generation via Quantum Cascade Lasers
  - technology still needs to develop

• THz generation via Frequency Mixing of Solid State Lasers
  - generation via beating of two TiSa lasers

• THz radiation via Frequency Mixing of Diode Lasers
  - Master Oscillator Power Amplifier configuration

• Conversion of beat frequency via Frequency Mixers
Realization with DFB Lasers

- 2 DFB Master Lasers for frequency tuning
- Pulsed Tapered Amplifier
- Frequency Mixer

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Realization with External Cavity Diode Lasers

- 2 Littman/Metcalf Master Lasers for frequency tuning
- Pulsed Tapered Amplifier
- Frequency Mixer

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**Results**

**Tera Hertz Radiation**
- tunable THz Radiation
- Continuously Frequency Tuning from 0 THz to more than 2 THz
- Question: Tuning Performance of
  - DFB THz System
  - ECDL THz System

**Optical Spectra**

![Graph showing optical spectra with and without master laser, showing Sidemode suppression of 39 dB.](http://www.sacher.de)
Characterization of DFB Laser Modulation

Spectrum

Microscopic Structure

AR-Coating  Bragg Grating  HR-Coating

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Characterization of DFB Laser Modulation

Temperature Tuning

Injection Current Tuning

![Graph showing temperature tuning and injection current tuning for DFB laser modulation with wavelength [nm] and signal [dB] on the x-y axis.](http://www.sacher.de)
Characterization of DFB Laser Modulation

Frequency Variation

Amplitude Variation

Frequency Scan / GHz

Modulation Frequency / Hz

Frequency Scan / GHz

Modulation Current / mA
Characterization of ECDL Tuning

The High Power Littman-Metcalf Design

common design  new design
Characterization of ECDL Tuning

Motor Tuning

- Coarse Tuning: > 25nm
- Minimal step: 1.2 pm

Piezo Tuning

- Piezo Tuning: > 0.25nm
- Minimal step: 1MHz

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Characterization of ECDL Linewidth

Linewidth

measured via a heterodyne experiment with two Littman-Metcalf lasers

\[ \Delta \nu \approx 100 \text{ kHz in 1 ms} \]
Characterization of Tapered Amplifier

PI Curve

Master Laser Power = 11.6mW

Saturation Curve

Master Laser Current

Slave Laser Current = 2200mA

Power Master Laser

Power: 1.5W

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Characterization of Tapered Amplifier

ns Optical Pulses for different operation conditions

- Repetition Rate: 500 kHz
- Pulse width: 20 ns

<table>
<thead>
<tr>
<th>Signal [a.u.]</th>
<th>Time [ns]</th>
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<tbody>
<tr>
<td>20ns (Duty Cycle 1%): 3.4nVs</td>
<td></td>
</tr>
<tr>
<td>40ns (Duty Cycle 2%): 3.9nVs</td>
<td></td>
</tr>
<tr>
<td>60ns (Duty Cycle 3%): 5.9nVs</td>
<td></td>
</tr>
<tr>
<td>80ns (Duty Cycle 4%): 7.7nVs</td>
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<tr>
<td>100ns (Duty Cycle 5%): 9.5nVs</td>
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Duty Cycle 3 (1494kHz): 2.4nVs
Duty Cycle 4 (2015kHz): 2.3nVs
Duty Cycle 5 (2509kHz): 2.3nVs
Characterization of Tapered Amplifier

Excellent Beam Quality

- $M^2 < 1.2$
Tera Hertz Radiation

- tunable THz Radiation
- Continuously Frequency Tuning from 0 THz to more than 2 THz
- Excellent Tuning Performance of both
  - DFB THz System
  - ECDL THz System

Optical Spectra

Sidemode supression 39 dB
without Master Laser
with Master Laser

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Application and Outlook

Impact

- Keystone to break-thru of THz applications
- Two alternative solutions for various applications
- Small footprint and minimum weight
- Alternative to Solid State THz Solutions
- Reasonable priced
- Optimized for field applications

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Examples for Customized THz Systems