Portable THz Laser Source

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Motivation

Tera Hertz Radition

- ‚new‘ wavelength regime
- THz radiation for imaging
- THz radiation for molecular spectroscopy

INDUSTRY

TERAHERTZ's Penetrating Appeal

Imaging at terahertz frequencies offers non-ionizing penetration and spectroscopic capabilities that make it appealing for homeland security, medical, and industrial inspection applications.

By **Kristin Lewotsky**

When terahertz imaging was making headlines in the mid 1990s, courtesy of researchers at Bell Laboratories (Holmdel, NJ), the focus was frequently industrial, such as potentially measuring the water content of packaged Fig Newton cookies. Back then, says former team member Daniel Mittleman, now of Rice University (Houston, TX), the systems were room-sized and the technology limited.

Today, much has changed. Reliable terahertz sources exist, the room-sized systems have shrunk to the size of a briefcase, and more than one company sells commercial systems. The applications have changed also; today, the big targets of opportunity for terahertz imaging also include security and medical applications.

Penetrating View

The excitement about the technology stems in part from its degree of penetration. Alternatives exist, but none with the distinct advantages of the terahertz regime. Unlike x-rays, terahertz radiation is non-ionizing. Unlike ultrasound, terahertz waves can image without contact, and they can go deeper than near-IR radiation.

That capability makes terahertz imaging attractive for non-destructive testing (NDT) applications such as inspection of graphite composites. Terahertz imaging provided a means for inspecting the structure of the space shuttle, for example. The technology has gone commercial via companies like Picometrix (Ann Arbor, MI), which licensed the Bell Labs IP and

Read about the superconducting bolometer array development underway by Heinz-Wilhelm Hübers at DLR in Berlin, Germany. Go to spie.org/SPIEProfessional for the full story.

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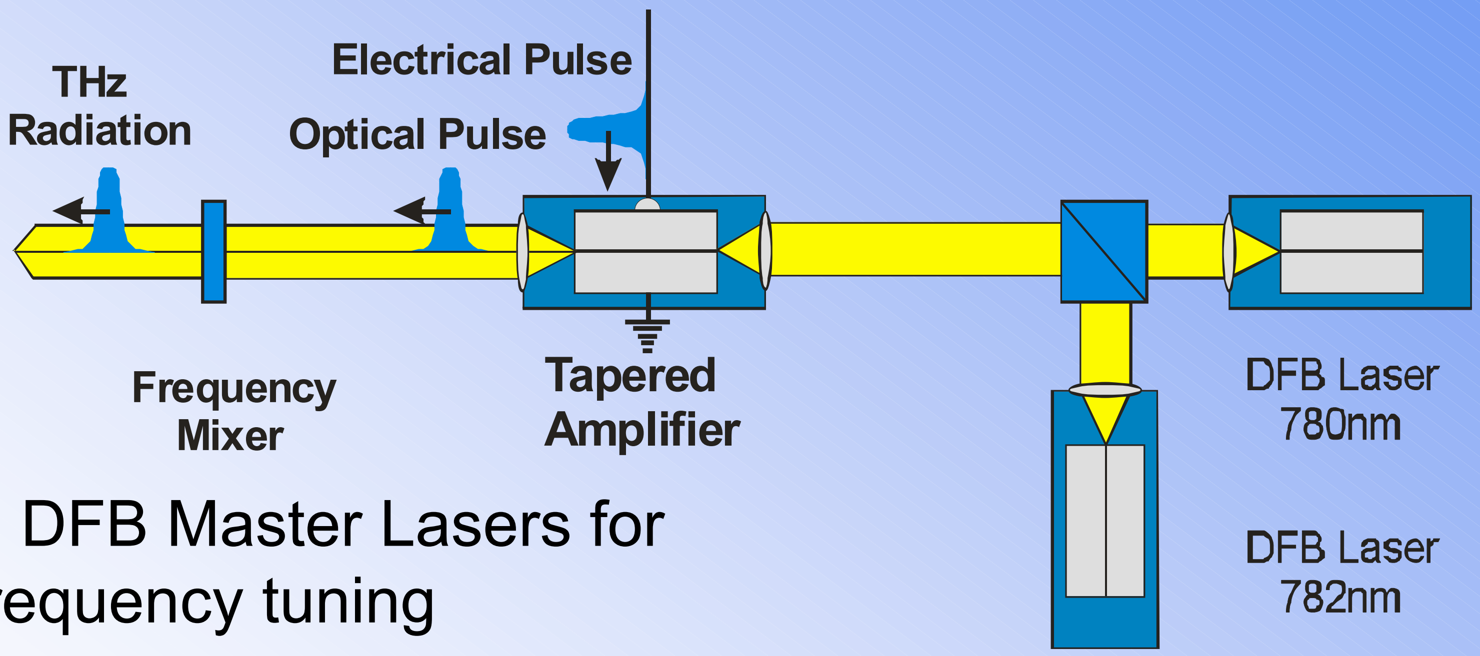
Concepts for Tera Hertz Generation

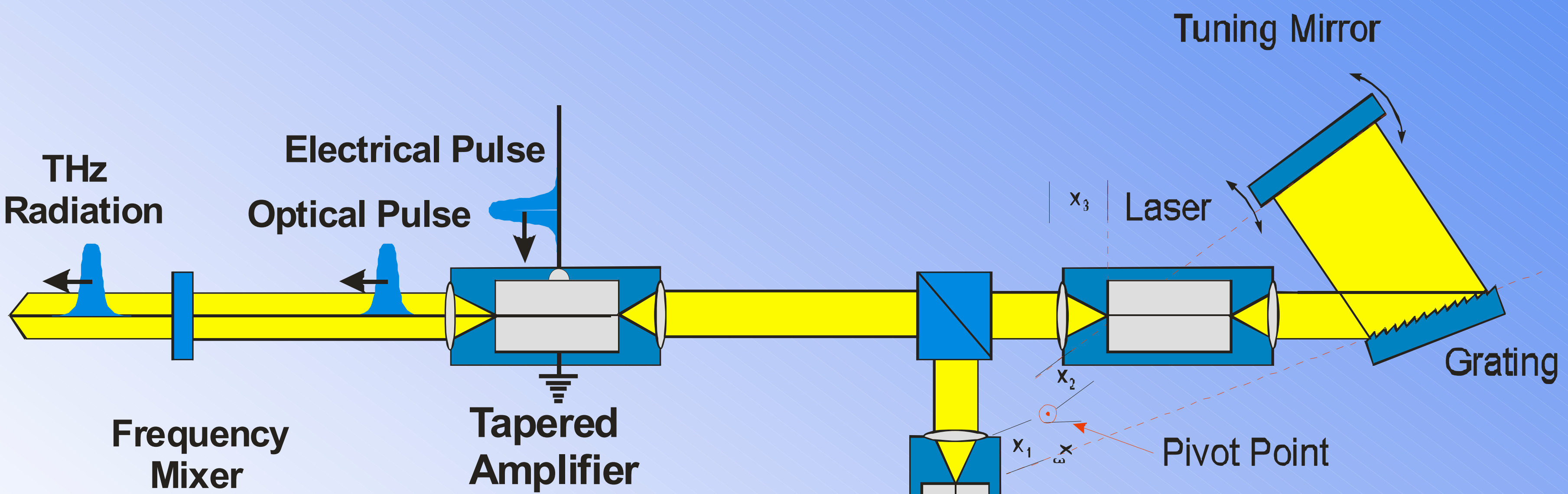
- direct generation via Quantum Cascade Lasers
  - technology still needs to develop
- THz generation via Frequency Mixing of Solid State Lasers
  - generation via beating of two TiSa lasers
- THz radiation via Frequency Mixing of Diode Lasers
  - Master Oscillator Power Amplifier configuration
- Conversion of beat frequency via Frequency Mixers

Realization with DFB Lasers



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

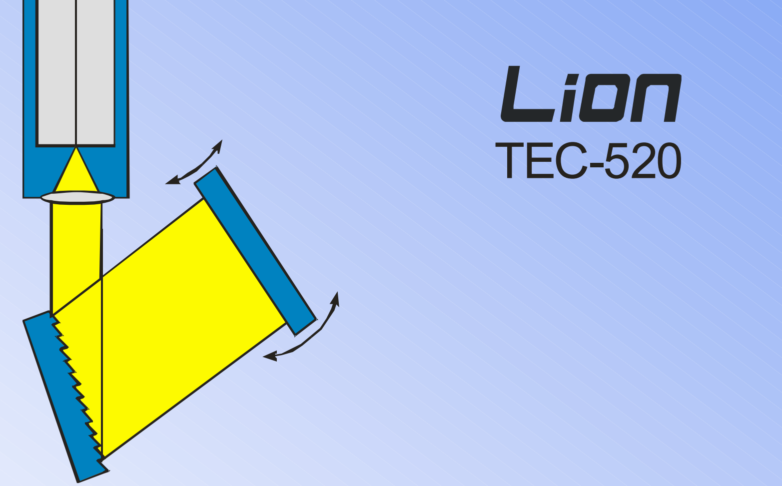
Realization with External Cavity Diode Lasers



- 2 Littman/Metcalf Master Lasers for frequency tuning

- Pulsed Tapered Amplifier

- Frequency Mixer

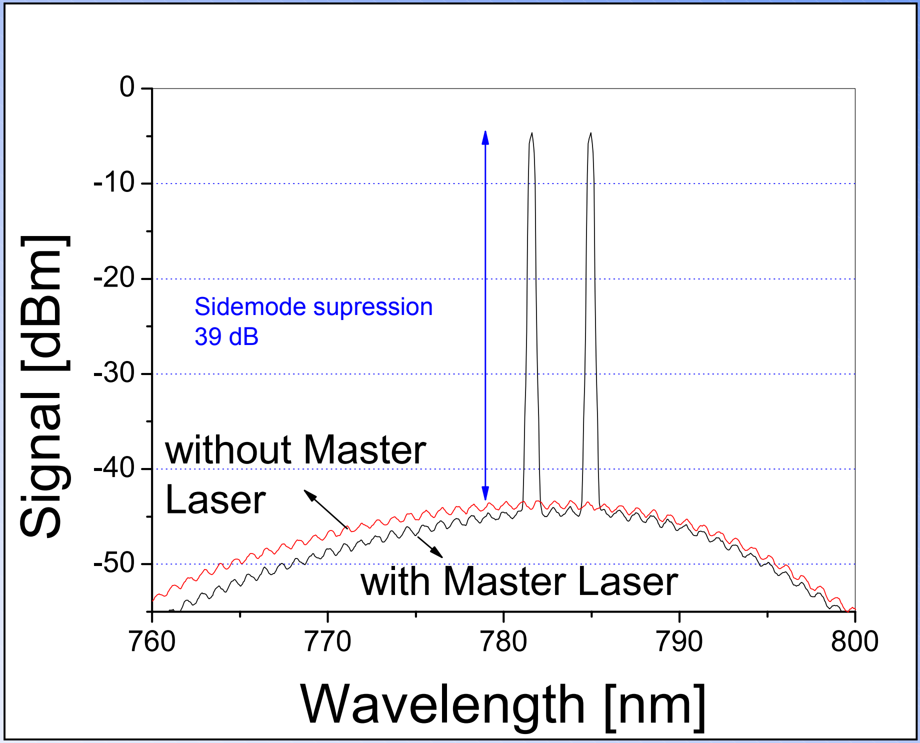


Results

Tera Hertz Radition

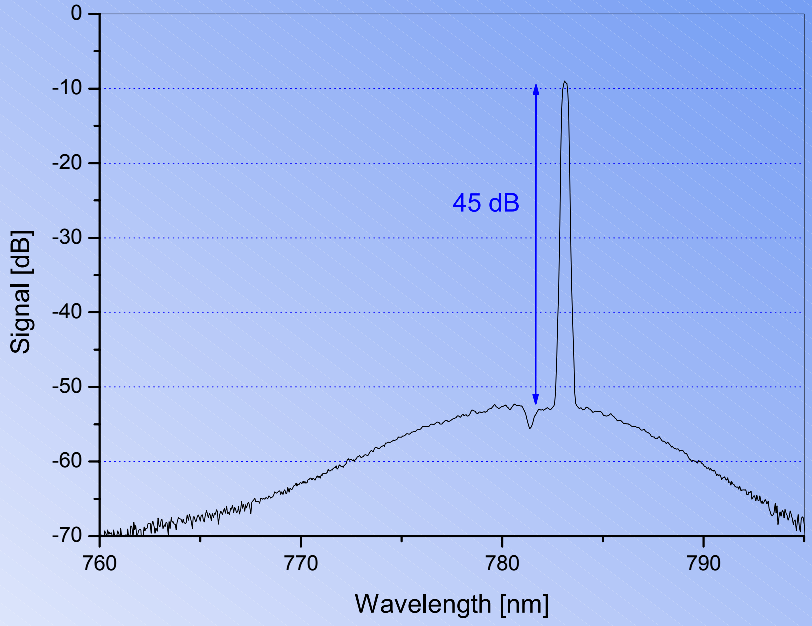
- tunable THz Radiation
- Continuously Frequency Tuning from 0 THz to more than 2 THz
- Question:
  Tuning Performance of
  - DFB THz System
  - ECDL THz System

Optical Spectra

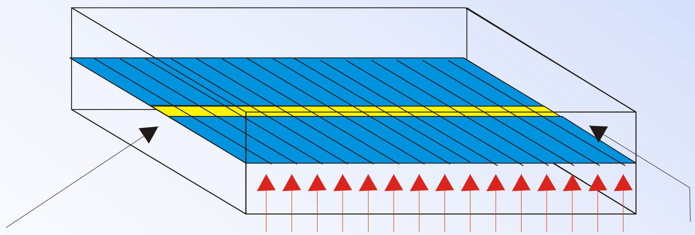


Characterization of DFB Laser Modulation

Spectrum

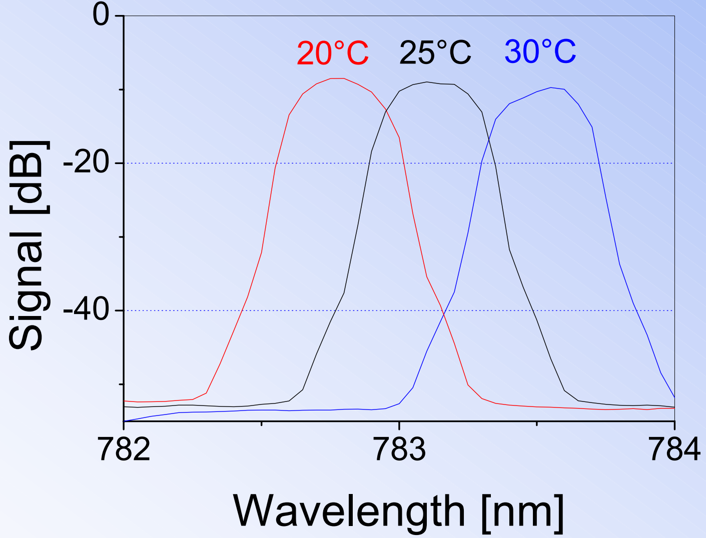


Microscopic Structure

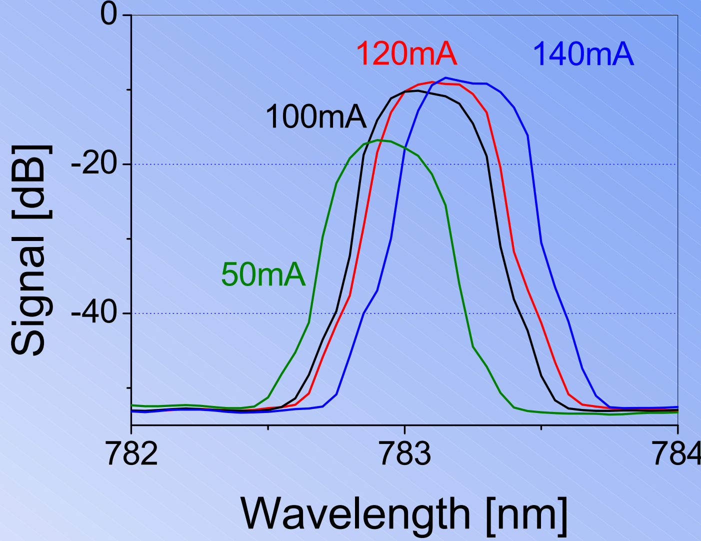


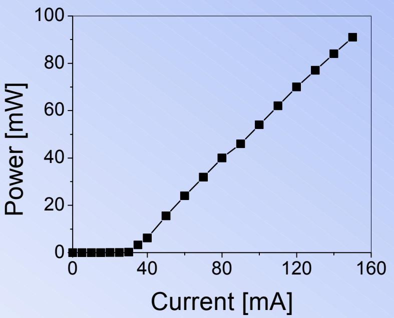
Characterization of DFB Laser Modulation

Temperature Tuning



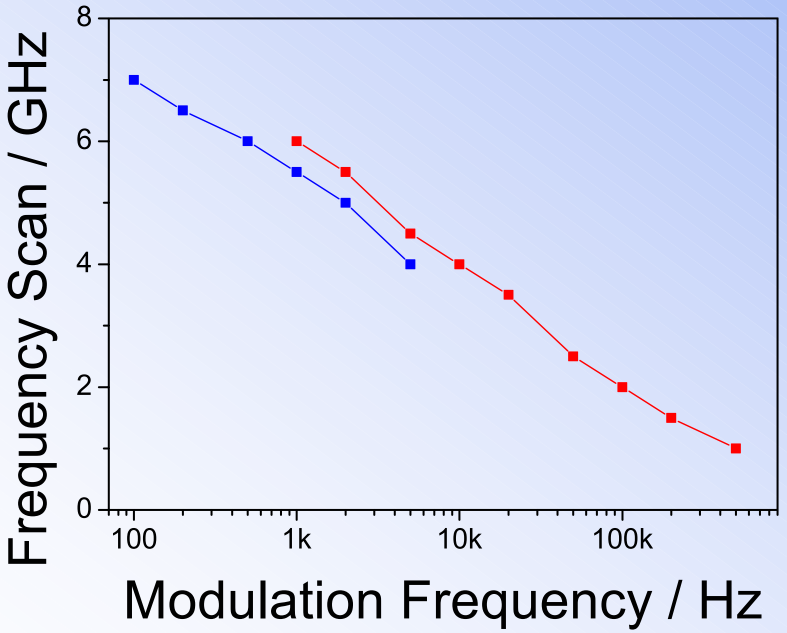
Injection Current Tuning



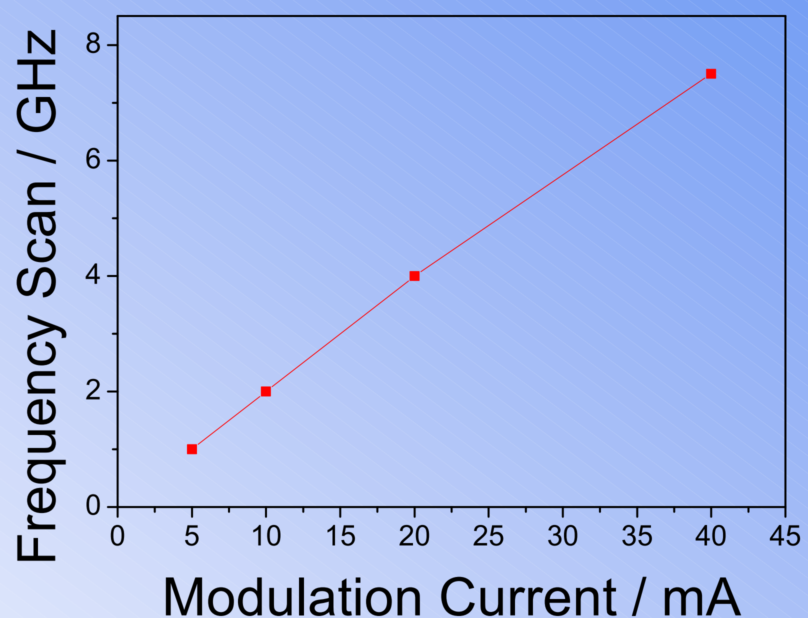


Characterization of DFB Laser Modulation

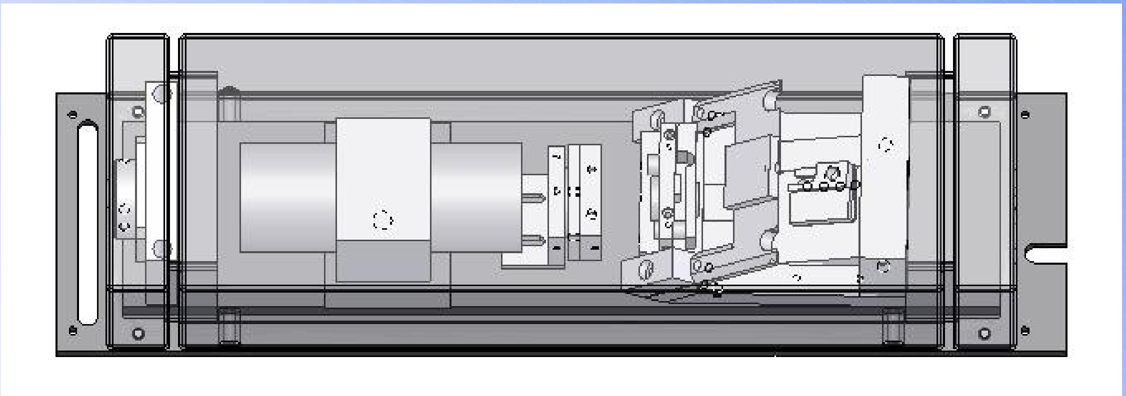
Frequency Variation

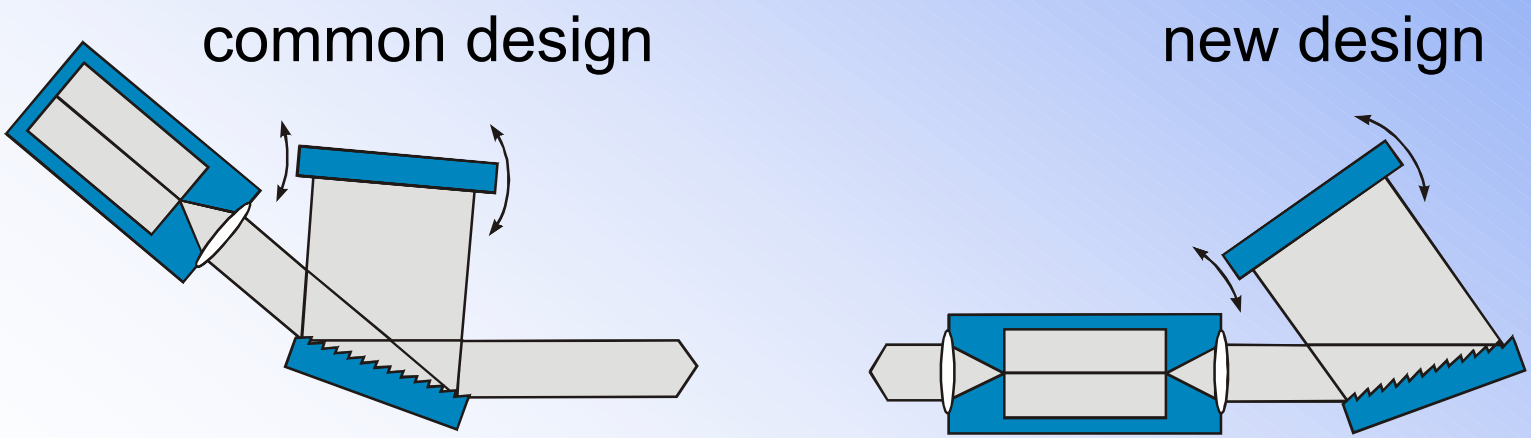


Amplitude Variation



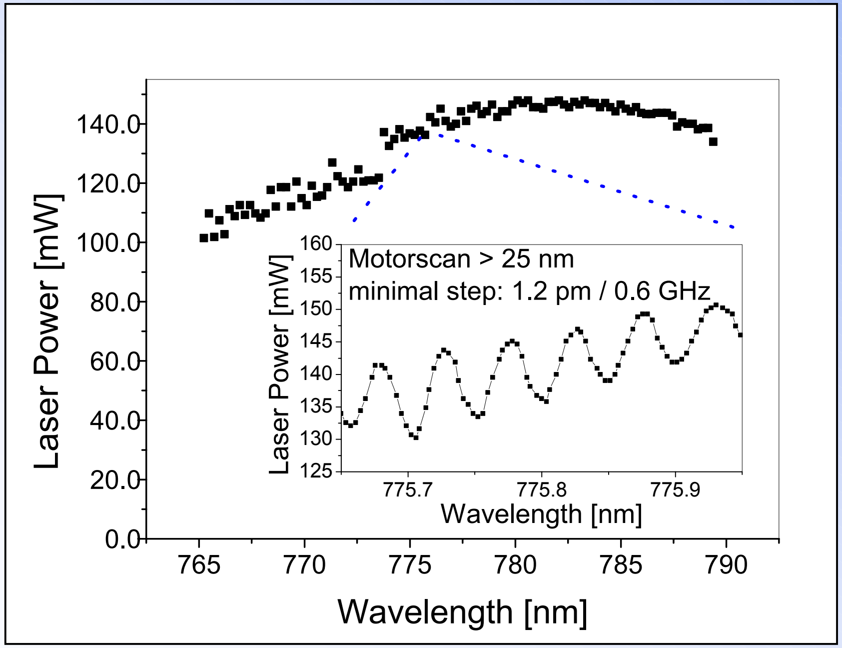
The High Power Littman-Metcalf Design





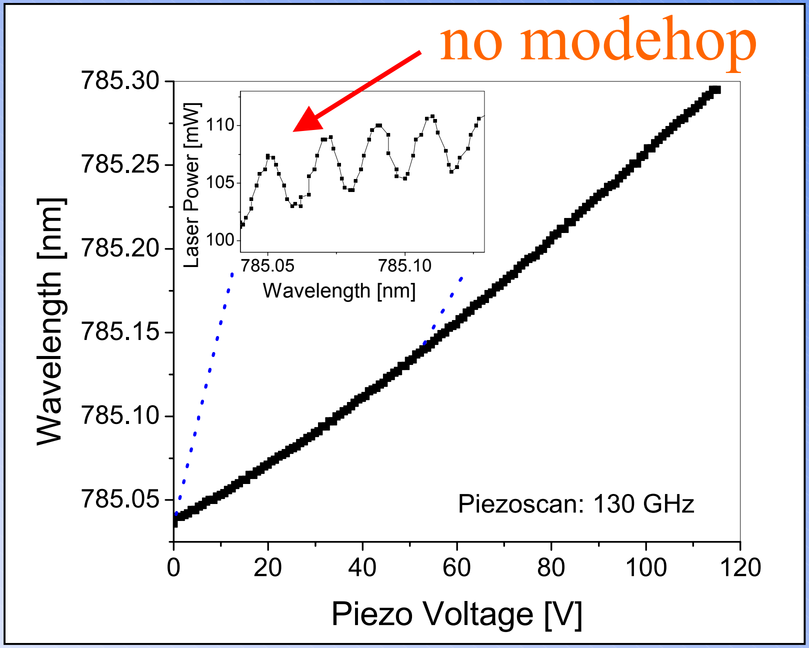
Characterization of ECDL Tuning

Motor Tuning



Coarse Tuning: > 25nm
Minimal step: 1.2 pm

Piezo Tuning

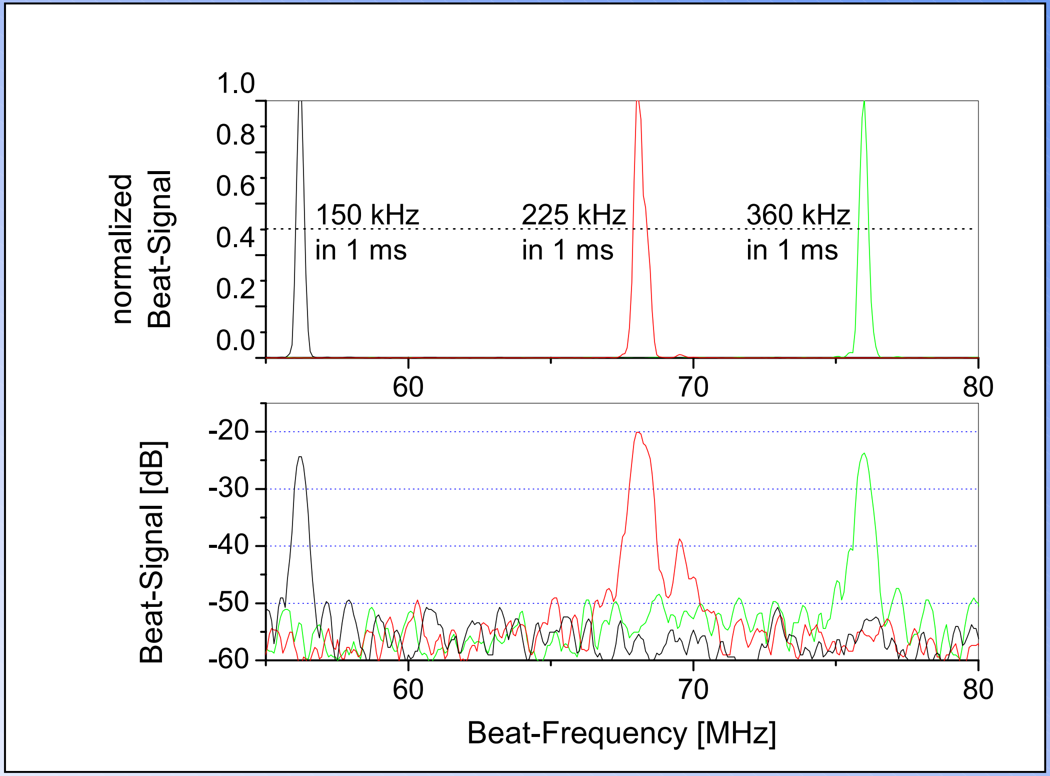


Piezo Tuning: > 0.25nm
Minimal step: 1MHz

Characterization of ECDL Linewidth

Linewidth

measured via a heterodyne experiment with two Littman-Metcalf lasers

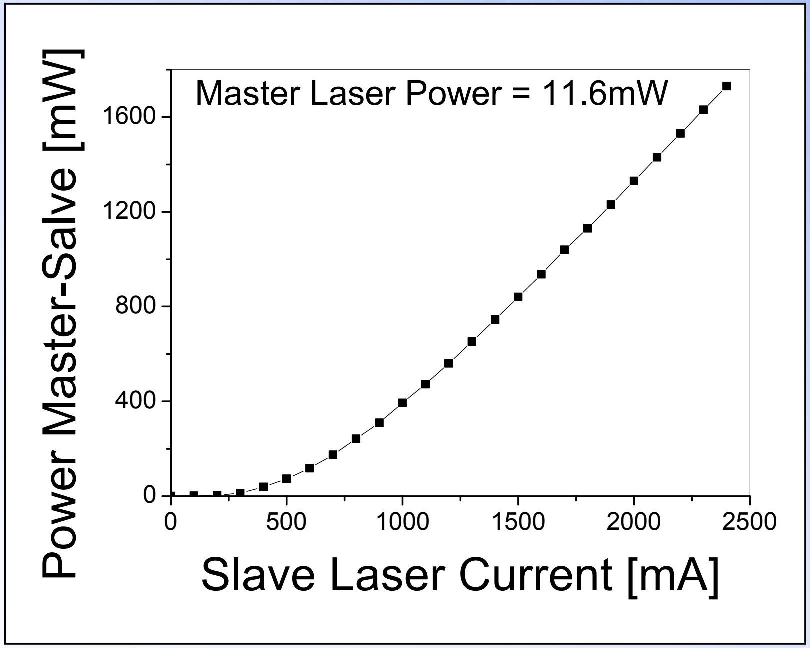


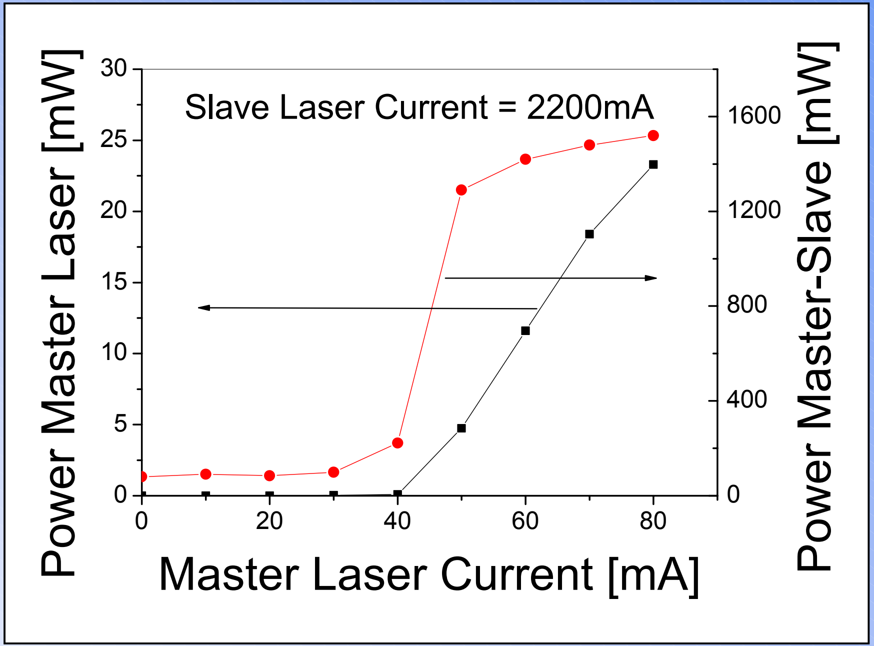
$\Delta\nu \approx$ 100 kHz in 1 ms

Characterization of Tapered Amplifier

PI Curve

Saturation Curve

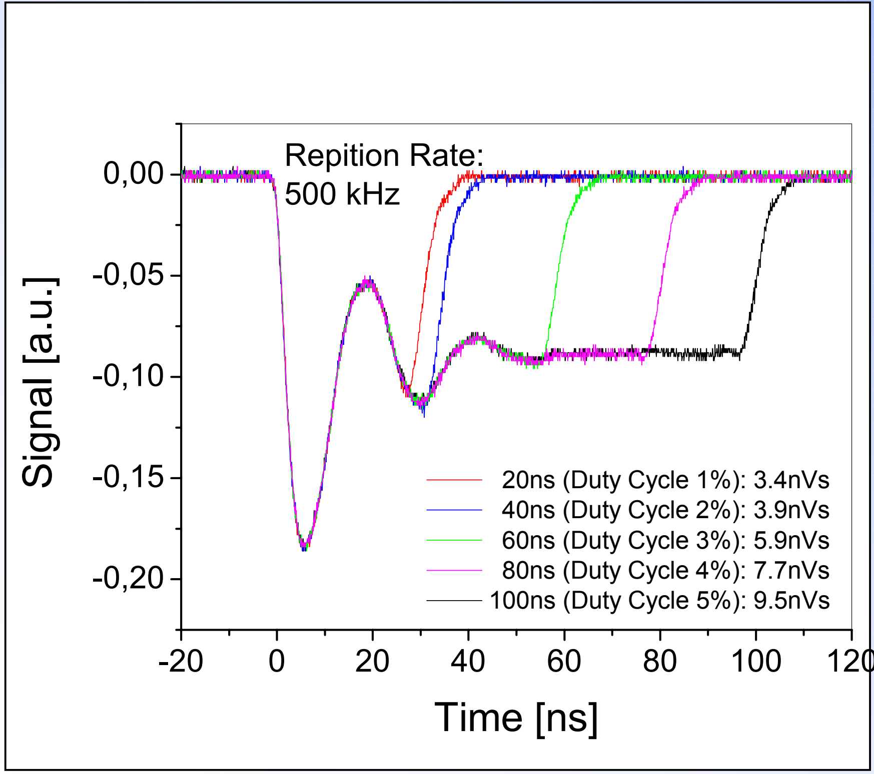


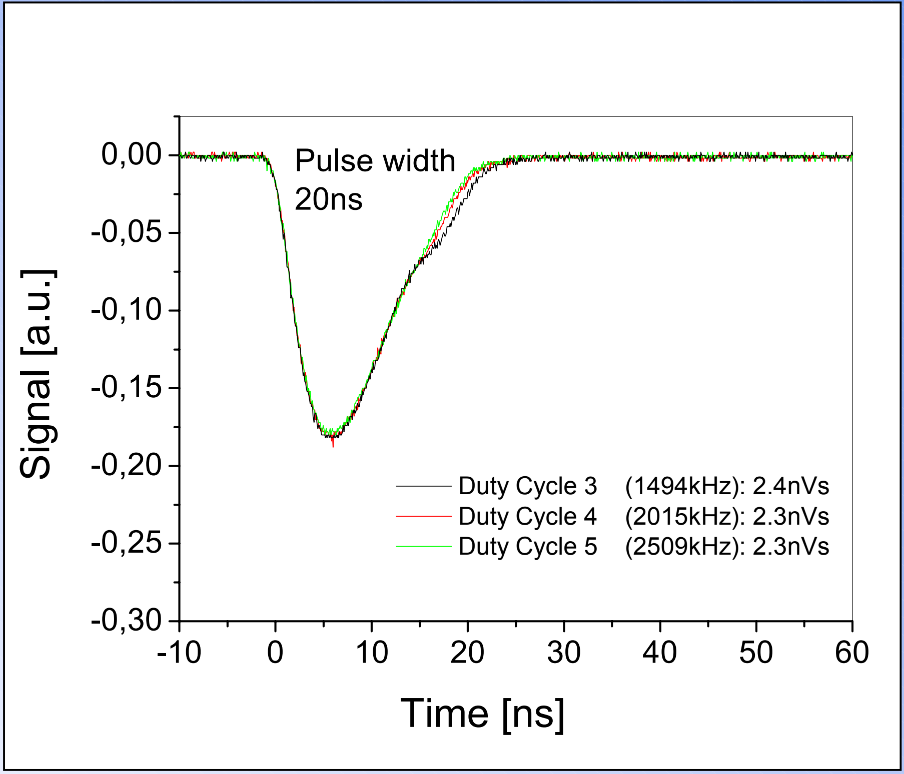


Power: 1.5W

Characterization of Tapered Amplifier

ns Optical Pulses for different operation conditions

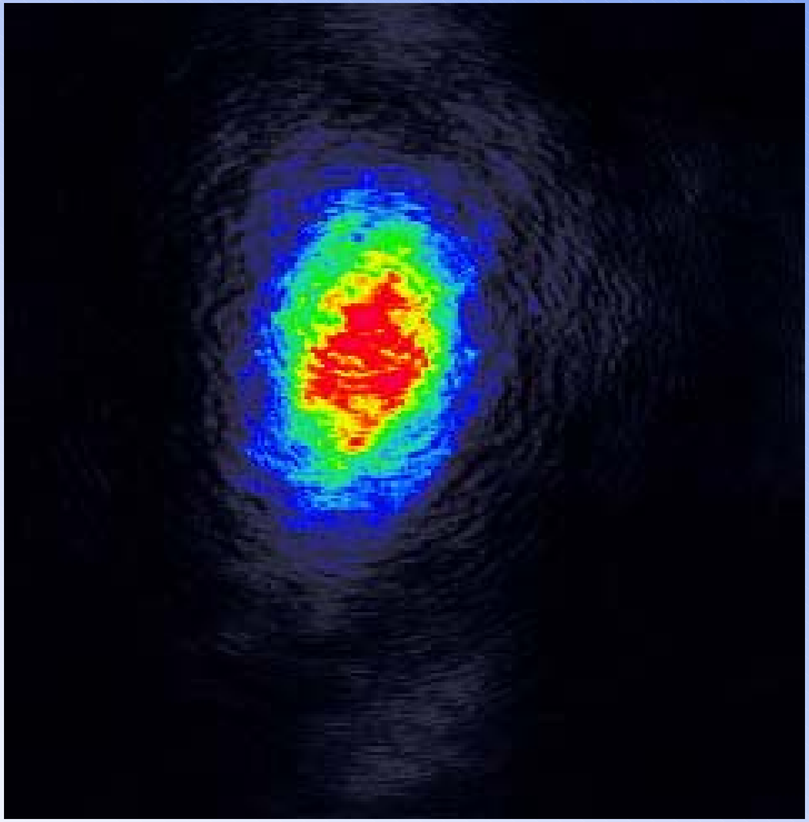




Characterization of Tapered Amplifier

Excellent Beam Quality

- $M^2 < 1.2$



Summary

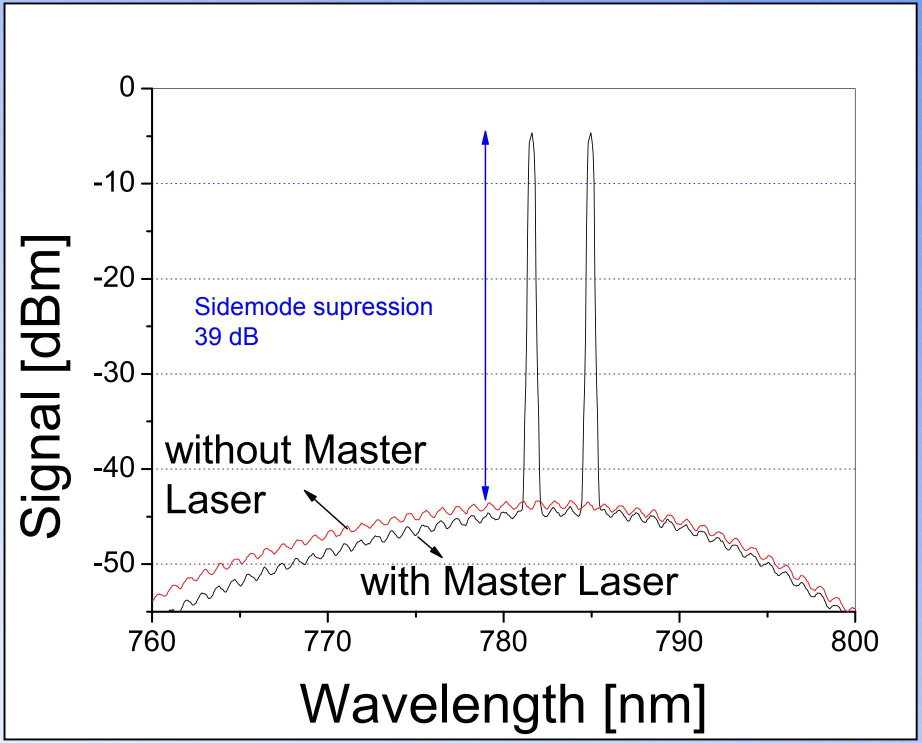
Tera Hertz Radition

- 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



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

Examples for Customized THz Systems