New Technology Announcement

Widely Tunable, Semiconductor THz Laser

APPLICATIONS:

- Terahertz (THz)imaging and THz vision
- IR and far-IR optical instrumentation
- Trace gas and atmospheric monitoring
- Supramolecular chemistry
- Military applications such as radar modeling and scale-model radar THz imaging

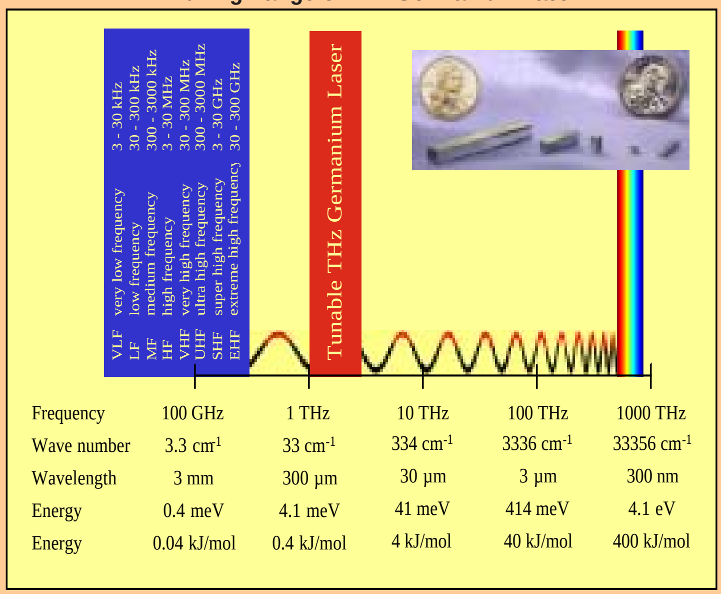
ADVANTAGES:

- Broad tuning range 1 - 4 THz, high laser power (a few µW to several Watts), and high duty cycles up to 5%
- Electrically controlled solid state lasers provide safe, maintenance-free operation, with no need for toxic gases
- Can be operated in commercially available closed-cycle refrigerators
- All solid state

ABSTRACT:

Eugene Haller and Erik Brundermann have invented a new type of semiconductor THz and far-IR laser using lightly doped p-type germanium single crystals grown at Berkeley Lab. By changing an electric and/or magnetic field the laser can generate laser pulses or radiation tens of microseconds long with frequencies in the THz frequency range (1-4 THz, corresponding to 75-300 µm, 35-130 cm^{-1} or 4-16 meV).

Tuning Range of THz Germanium Laser



The THz germanium laser covers the frequency range from 1 to 4 THz or 35 to 130 cm^{-1}. These frequencies correspond to energies. If an energy in this range exists in your specific application you might use the germanium laser to initiate transformations, e.g., if the energy corresponds to a potential barrier, or you might be able to study the absorption of your species or material in this frequency range. Inset: Various germanium THz lasers.

The laser is operated in closed-cycle refrigerators but low temperature cryostats can be used as well. The laser is safe, maintenance-free, and electrically controlled. In contrast, commercially available THz radiation generators are large (100 ft^2), sensitive gas lasers that have emission spectra covering only a limited range of frequencies. The handling of these lasers is complex and involves using hazardous gases CH_2F_2 or HCOOH to operate them and undesirable CO_2 lasers to pump them.

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The magnetic field is applied by superconducting coils or small and inexpensive permanent magnets with a volume of about 1cm^3. The maximum emission power depends on the crystal volume and can reach from a few μW to several Watts with duty cycles of up to 5%. Current research is heading for continuous wave emission (100% duty cycle).

Berkeley's versatile, widely tunable laser source is relevant to areas that can make use of low and high resolution spectroscopy with a finesse of up to 10^7 in the THz range such as: THz imaging and THz vision, environmental monitoring of trace gases (NO_x, CO, etc.), monitoring of the atmosphere, IR and far IR optical instrumentation, and measuring van der Waals bonding energies in biomolecules or organic semiconductors.

The high intensity THz pulses of a 0.4 cm^3 laser can penetrate water layers of approximately 1 mm thickness which makes the study of biomolecules or living cells in their natural environment feasible. This is a major advantage compared to Fourier Trnasform spectrometers and other low intensity sources typically used in this frequency region. Military applications might be found in radar modeling and scale-model radar THz imaging.

Berkeley Lab seeks partner(s) in the development of a computer controlled laser system based on this new germanium laser. Some assistance developing prototypes could be provided.

STATUS: This technology is covered by U. S. Patent # 6,011,810. Available for collaborative research and/or licensing.

Reference Number: IB-1161

PUBLICATIONS:

- E. Bründermann, D.R. Chamberlin, and E.E. Haller, "High duty cycle and continuous terahertz emission from germanium," *Appl. Phys. Lett.* 76, 2991-2993 (2000).
- D.R. Chamberlin, E. Bründermann, and E.E. Haller, "Planar contact geometry for far-infrared germanium lasers," *Appl. Phys. Lett.* 74, 3761-3763 (1999).
- E. Bründermann, D.R. Chamberlin, and E.E. Haller, "Novel design concepts of widely tunable germanium terahertz lasers," *Infrared Phys. Technol.* 40(3), 141-151 (1999).

For additional information, please visit:

http://www.mse.berkeley.edu/Groups/haller/brundermann/technology_transfer.html

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Berkeley Lab seeks partners for collaborative research opportunities and licensing of this new technology

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