Intersubband Quantum Box Stack Lasers

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WARF: P06395US

Inventors: Dan Botez

The Wisconsin Alumni Research Foundation (WARF) is seeking commercial partners interested in developing an intersubband-transition semiconductor laser with a structure that allows—for the first time—watt-range powers to be achieved at room temperature with greater than 50 percent wallplug efficiency from semiconductor lasers operating in mid- and far-infrared wavelengths.

Overview

Intersubband semiconductor lasers represent a new type of laser that emits photons when electrons within a quantum-well structure release their energy during transit from high- to low-energy states. One type of intersubband laser, the Intersubband Quantum Box (IQB), offers the potential for greater than 50 percent electrical-to-optical power conversion efficiency, otherwise known as “wallplug efficiency,” at room temperature in the mid- and far-infrared wavelength ranges. In contrast, Quantum Cascade (QC) devices can achieve room temperature wallplug efficiencies of about four percent at best. However, due to relatively low gain, IQB lasers can only provide low power (approximately 30 mW) from conventional single-element devices.

The Invention

A UW-Madison researcher has developed an intersubband-transition semiconductor laser with an Active-Photonic-Crystal (APC) structure that allows the coherent power of the laser to be scaled to at least 1 W while maintaining high (greater than 50 percent) wallplug efficiency. The semiconductor laser consists of an array of laterally-spaced ministacks of quantum boxes separated by a matrix of current-blocking material. Coupling a few quantum boxes in each ministack allows the laser to provide higher gain and more power than a semiconductor laser composed of an array of individual quantum boxes.

To increase the output power, the optically active core of the laser is enclosed in a laterally periodic dielectric stucture that creates an APC-type structure. The APC structure selects operation in a single spatial mode from large-aperture devices.

Applications

- Defense applications, including detection of heat-seeking missiles, toxic chemical agents or explosives; laser-based radar; free-space optical communication links; infrared imaging; multi-spectral sensing of remote objects or deceptive radar jamming
- Optoelectronic devices, such as amplifiers or edge- and surface-emitting lasers
- Compact chemical-sensing systems
- Other applications in aerospace, astronomy, medical imaging, spectrometry and gas sensing

Key Benefits

- Allows—for the first time—watt-range powers to be achieved at room temperature with greater than 50 percent wallplug efficiency from semiconductor lasers operating in mid- and far-infrared wavelengths
- Provides a compact, efficient semiconductor laser with the low threshold current density and high wallplug efficiency required for a commercially practical laser

- APC structure preferentially enhances gain in the low index regions, thereby providing single-spatial mode operation to high drive levels and high continuous wave power, while maintaining high wallplug efficiency.
- Makes possible the realization of Terahertz lasers capable of operating at room temperature
- Potentially capable of revolutionizing methods for detecting many types of national security threats
- May be formed on substrates, such as GaAs, which are compatible with further semiconductor processing
- Other material systems, such as InP, may be used
- May be produced using high throughput crystal growth techniques, such as metal-organic chemical vapor deposition (MOCVD)

Additional Information

For More Information About the Inventors

- Dan Botez

Tech Fields

- Analytical Instrumentation, Methods & Materials : Lasers

For current licensing status, please contact Michael Carey at mcarey@warf.org or 608-960-9867