Analytical Instrumentation, Methods & Materials

New Method of Constructing a Quantum Cascade Laser with Improved Device Performance

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The Wisconsin Alumni Research Foundation (WARF) is seeking commercial partners interested in developing a method to grow a quantum cascade laser on metamorphic buffer layers to achieve shorter emission wavelength and increased continuous wave efficiency.

Overview

One type of light-emitting semiconductor laser is the Quantum Cascade Laser (QCL). Extending QCLs to short emission wavelengths (i.e., less than 4.0μm) is challenging due to strain-relaxation considerations. To accommodate the larger electron-transition energy, deeper wells and taller barriers (i.e., higher strain) are necessary to prevent excessive active-region carrier leakage. However, the barrier and well compositions that can be accessed are limited by strain-thickness considerations in order to avoid strain relaxation. As the critical thicknesses for strain relaxation are approached, it is anticipated that device reliability may deteriorate through thermally-activated relaxation processes.

Numerous layers of highly strained materials are needed for practical devices, making it challenging to control the strain in these structures that are grown on InP substrates. Other laser technologies exist that allow researchers to achieve a wavelength of three microns, but these methods employ less mature, more expensive material systems. A method for building a QCL that achieves a wavelength under four microns and uses common, low-cost materials is needed.

The Invention

UW–Madison researchers have developed a method to grow a QCL on compositionally graded metamorphic buffer layers. Unlike traditional QCLs that position the device directly on an InP or GaAs substrate, this method uses these substrates to grow the graded metamorphic buffer layers; this localizes dislocations and provides a platform with a larger lattice spacing on which to grow the QCL structures. Thus, the metamorphic buffer layers can be utilized as virtual substrates with a specified lattice spacing, opening up the palette of III/V alloys available for new device architectures and strain mitigation.

The researchers have developed a semiconductor structure comprising a GaAs substrate, a metamorphic buffer layer structure over the substrate and a quantum cascade structure over the metamorphic buffer layer structure. This QCL is characterized by its ability to emit light at 4.5 microns or less when under the influence of an applied electric field.

Applications

- Environmental monitoring
- Chemical sensing including remote sensing
- Free-space optical communications
- Health care

- Materials processing
- Laser range-finding
- Infrared countermeasure systems
- Laser marking on plastics

Key Benefits

- Improved strain control to achieve smaller wavelengths
- Improved electro-optical characteristics
- Higher continuous wave power and higher continuous wave wallplug efficiencies
- QCL achieves a wavelength under four microns.
- Can be formed on low-cost, large-area GaAs substrates
- Reduction in surface roughness of the metamorphic buffer layers provides a superior “virtual substrate” for growth of QCL structures.

Stage of Development

Simulations have been carried out for the growth of quantum cascade lasers on metamorphic buffer layers.

Additional Information

For More Information About the Inventors

- Luke Mawst
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Tech Fields

- Analytical Instrumentation, Methods & Materials : Lasers

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