Nested Waveguides for Generating or Detecting Radiation, Including Terahertz Radiation

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The Wisconsin Alumni Research Foundation (WARF) is seeking commercial partners interested in developing a device capable of penetrating a wide variety of non-conducting materials for applications such as medical imaging, wireless communications and the detection of chemical and biological molecules.

Overview

Systems based on terahertz (THz) radiation technology show promise for communication and imaging applications. These systems can penetrate through many materials and are sensitive enough to resonate with biological molecules, making them well suited for the detection of biological and chemical agents like those found in biological weapons, bioaerosols and trace explosives. Other applications include time-domain spectroscopy, medical imaging and ultra-wideband wireless communications.

Although methods have been developed to produce THz-based systems, the existing sources for these systems, free electron laser (FEL) and the quantum cascade laser (QCL), have numerous limitations. FEL and QCL have an inefficient linear input to output power relationship. In addition, FEL has a large footprint, and QCL has a substantial cooling requirement. A smaller, more efficient THz-based system is needed.

The Invention

UW Madison researchers have recently demonstrated a room temperature, tunable THz source operating at 1.3 THz with an extremely narrow linewidth (< 200 kHz; < 7 x 10-6 cm-1) and record conversion efficiency. This source takes advantage of a new nested waveguide structure to produce continuously phase-matched difference frequency mixing between spectrally pure, amplified diode laser pumps. The thin film active medium for this source ($LiNbO_3$) is interchangeable with other nonlinear materials operating at other frequency ranges (e.g., AlGaAs for 3.5 THz). It can be designed to generate ultra-narrow band radiation across a range of frequencies. The device also may be designed to detect THz radiation.

The nested waveguides are fabricated using well established lithography and semiconductor fabrication techniques, such as chemical vapor deposition. A smaller waveguide can be embedded within a larger waveguide. The smaller waveguide provides guidance for radiation of a shorter wavelength, while the larger waveguide provides a transition to radiation of a longer wavelength. The waveguides enhance the efficiency at which the nonlinear process converts the radiation to the desired frequency by providing strong optical confinement of the input and output radiation, reducing diffraction and improving phase matching. Nested waveguides also have a small footprint, making them ideal for creating small THz-based systems.

Applications

- Imaging applications from spectroscopy to medical imaging
- Security devices for detecting biological or chemical agents
- Wireless communications
- Manufacturing monitoring systems

Key Benefits

- Increases efficiency by 10^4 over bulk THz generation
- Enables the use of different construction material to modify power conversion efficiency by orders of magnitude
- Reduces footprint of THz-based systems
- Uses low cost materials
- Uses well established lithography fabrication techniques
- Enables large scale production with resulting reductions in manufacturing costs
- Uses readily available light sources
- Requires no cooling

Additional Information

For More Information About the Inventors

- Thomas Kuech

Publications

- Staus C., Kuech T., and McCaughan L. 2008. Continuously Phase-Matched Terahertz Difference Frequency Generation in an Embedded-Waveguide Structure Supporting Only Fundamental Modes. Opt. Express 16, 13296-13303.

Tech Fields

- Analytical Instrumentation, Methods & Materials : Optics
- Information Technology : Networking & telecommunications
- Medical Imaging : Other diagnostic imaging

For current licensing status, please contact Jeanine Burmania at jeanine@warf.org or 608-960-9846