Electrically Driven Light-emitting Tunnel Junctions

Technology #18393

Applications

This invention has applications in the emerging field of optoelectronics where it can be used for on-chip optical communication and data processing. Additionally, it can also be used as a light source in the development of high-resolution displays.

Problem Addressed

On-chip optical communication and data processing has received significant interest as part of a drive to develop ever higher-performing computers. One major technological hurdle in the development of optoelectronic devices needed to bridge optical and electronic computing platforms is the lack of light sources that are simultaneously capable of ultra-fast modulation and amenable to on-chip integration. Conventional light-emitting diodes suffer from low modulation speeds while the large form factor of electrically driven lasers preclude on-chip integration. This invention proposes a novel design for an optical nanoantenna that meets both speed and on-chip integration requirements.

Technology

The optical nanoantenna described by this invention operates based on the excitation of a plasmon mode by electrons tunneling inelastically through a metal-insulator-metal (MIM) tunneling junction. Light is emitted as the excited plasmon mode subsequently decays.

The MIM tunneling junction consists of a bottom electrode, made up of two metal nanoplates separated by a 20-60 nm-wide gap, and a metal nanocube which bridges the gap. The nanocube is separated from the underlying electrode by a molecular layer with a precisely controlled thickness on the order of several nanometers, forming a tunneling gap. When an electric field is applied across the two nanoplates, a tunneling current travels from one nanoplate to the other via the bridging nanocube. The wavelength of light produced by this process is a function of the nanocube dimensions as well as the thickness and refractive index of the molecular layer.

By selecting a compressible material for the molecular layer, the width of the tunneling gap can be dynamically tuned by inducing an electrostatic force across the junction to compress the molecular layer and reduce the width of the tunneling gap, thereby altering the wavelength of light emitted.

The entire structure has a footprint on the order of several nanometers and can be fabricated using a combination of directed self-assembly (for nanoscale features) and conventional lithography (for contacting wires and pads), making it well-suited to on-chip integration.

Advantages

- Ultra-fast conversion between electrical and optical signals
- Dynamically tunable operating wavelength allows implementation of complex data processing

255 Main Street, room NE 18-501
Cambridge, MA 02142-1601
Phone: 617-253-6966 Fax: 617-258-6790
http://tlo.mit.edu
Contact the Technology Manager: tlo-inquiries@mit.edu

and multiplexing operations
- Nanoscale design compatible with on-chip integration

Categories For This Invention:

Photonics
Data Communications
Displays
Telecommunications
Sources

Intellectual Property:

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Inventors:

Jeffrey Lang
Farnaz Niroui
Thomas Mahony
Vladimir Bulovic

External Links:

Bulovic Group
http://onelab.mit.edu/
Microsystems Technology Laboratories
http://www-mtl.mit.edu/
Research Laboratory of Electronics
http://www.rle.mit.edu/

255 Main Street, room NE 18-501
Cambridge, MA 02142-1601
Phone: 617-253-6966 Fax: 617-258-6790
http://tlo.mit.edu
Contact the Technology Manager: tlo-inquiries@mit.edu