Graphene-silicon optical cavity for next-generation high-speed, low power, chip-scale optoelectronic applications

Lead Inventor: Chee Wei Wong, Ph.D.

Hybrid graphene-silicon optical cavity with enhanced nonlinear optics enables high-performance, chip-scale optoelectronic applications

Graphene, a single atom thick form of carbon, possesses a variety of useful electrical and optical properties that make it highly suitable for ultrafast, low power, chip-scale optoelectronic applications. In particular, the high nonlinear optical response of graphene enables it to be used to construct ultrafast photonic logic gates and memories, generate light pulses at low energies, and amplify optical signals. The current technology takes advantage of these capabilities via hybrid graphene-silicon optical cavities for novel optoelectronic applications such as optical signal processing circuits and devices. Such technology is silicon CMOS-compatible and may have a wide range of applications towards high-speed, low power, and chip-scale optoelectronics.

Electrical and nonlinear optical properties of graphene enables superior performance compared to current compound semiconductor materials for electronic applications.

The high electrical conductivity and nonlinear optical properties that have been demonstrated in graphene allow it to achieve superior performance compared to the compounds used in current semiconductor-based electronics. The inventors of this technology reported the observation of several ultrafast, low-power operational characteristics of graphene-silicon hybrid optoelectronic devices arising from the optical nonlinearities of graphene. Graphene was grown and transferred onto a photonic crystal cavity, and the sample was used to perform optical and numerical measurements using semiconductor lasers and simulation software, respectively. Compared with control measurements on solely monolithic silicon cavities, the graphene-silicon specimen exhibited a very high linear optical response, resulting in physical phenomena that can be exploited to enable ultralow-power and high speed optical information processing. In addition, unlike currently existing non-silicon semiconductor materials, the fusion of graphene and silicon allows for easy integration with existing silicon electronic and photonic platforms.

Applications:

• The technology can be used to develop low-power optoelectronic circuits for ultrafast communication and signal processing.
• Photonic logic gates and memory circuits.
• Chip-scale optical signal switches, amplifiers and oscillators.
• Low-energy light pulse generator for laser applications such as optical imaging, microscopy, laser surgery, etc.
• Optical fibers for telecommunications.
• Low-power photodetector applications such as phototubes, charge-coupled digital imaging devices, biomedical imagers, and light-emitting diodes (LEDs).
Advantages:

- The high nonlinear optical response of graphene leads to several physical phenomena that enable graphene-silicon hybrid optoelectronic devices to achieve low-power, high speed operational capabilities.
- The ultralow-power resonant optical bistability of graphene enables construction of photonic logic gates and memories.
- The self-induced renegerative oscillations of graphene enables the generation of light pulses at low energies.
- The coherent four-wave mixing property of graphene enables the amplification of optical signals.
- Silicon CMOS-compatibility facilitates easy integration with existing silicon electronic and photonic plaforms.
- Graphene's electrical conductivity is 1000 times better than silicon, meaning it can be used to make devices that are much more sensitive than is possible now.

Patent information: Patent Pending

Licensing Status: Available for licensing and sponsored research support


Inventors

Chee Wei Wong