Specialized switch that controls light can regulate flow of optical data at speed suitable to accelerate computers

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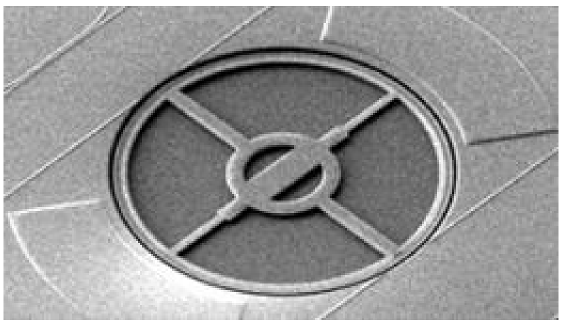

The silicon ring is a fast and effective switch for a beam of light skimming close to its edge. Credit: 2013 A*STAR Institute of Microelectronics

Long-distance communication increasingly relies on networks of fiber-optic cables that carry data encoded in nimble beams of light. Conventional computer circuits, however, still use relatively sluggish electronic circuits to process this data.

Hong Cai of the A*STAR Institute of Microelectronics in Singapore and her co-workers have now developed a device that could help computers reach light speed. Their tiny mechanical system can switch a light signal on or off extremely quickly, potentially enabling all-optical computing and simplifying the interface between electronic and optical networks. "All-optical devices could enable a large number of components to be housed on a single chip," says Cai.

Various optical switching technologies already exist, including microelectromechanical systems (MEMS). These switches, however, take microseconds to flip from one state to another, far too slow for a computer application. Cai's device is a much smaller nanoelectromechanical system (NEMS) that can switch in billionths of a second, with virtually no data loss.

"NEMS optical switches offer the potential for fast switching speed, low optical loss and low power consumption. And, they are easily integrated in large-scale arrays without complex packaging techniques," says Cai.

The researchers etched their device from a thin sheet of silicon, forming a flexible ring 60 micrometers wide that is connected to a central pillar by four thin spokes. Two channels running through the underlying silicon skim past opposite edges of the ring; they act as waveguides for two beams of light. These channels pass no closer than 200 nanometers from the ring (see image).

When light carrying a signal passes through one of the channels, the light's electromagnetic field establishes resonant oscillations around the ring. This draws energy from the beam and prevents the data from travelling any further—the switch is effectively 'off'.

To flip the switch, a low-power beam of 10 milliwatts traveling along the other channel establishes a similar resonance that slightly warps the ring, bending its edges downwards by just a few nanometers. This warping motion changes the resonant frequency of the ring, preventing it from coupling to the signal beam and allowing the data to continue unimpeded. Switching the signal on took just 43.5 nanoseconds, and the researchers observed a large difference in signal light output between the 'on' and 'off' states.

"As such, a low-power optical signal can be used to modulate a high-power optical signal at high speed," says Cai. Her team is now working on integrating the devices into circuits.

More information: Cai, H., et al. A nanoelectromechanical systems optical switch driven by optical gradient force, *Applied Physics Letters* 102, 023103 (2013). dx.doi.org/10.1063/1.4775674

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