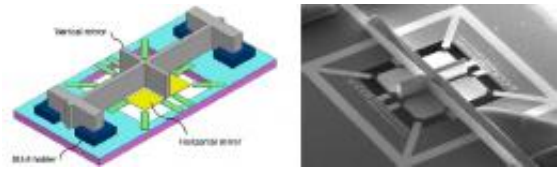
Retroreflector transmits light with negligible power consumption

April 17 2012, by Lisa Zyga



(Left) An illustration and (right) an SEM image of the piezoelectrically actuated CCR. Image credit: J. Park, et al. © 2012 IOP Publishing Ltd

(Phys.org) -- In free-space optical communications (FSO), data is wirelessly transmitted by light propagating through open space. Among their applications, FSO systems are used for communications between spacecraft and have the potential to serve as the “last mile” for fiber optics broadband services. However, one challenge they face is that the light sources used to encode the data require power, and a power supply is often limited. Devices that reflect light, called corner cube retroreflectors (CCRs), can overcome this problem because they can transmit data without their own light source, simply by reflecting incident light from a base station.

Although CCRs were introduced more than 10 years ago as a solution for FSO systems, they face their own challenges, most notably the need for a high voltage. In a new study, a team of researchers from Seoul, South Korea, has improved the CCR design so that it operates with an ultra-low voltage and negligible power consumption. The new design,

which is based on MEMS technology, could make the devices more attractive for FSO systems.

As the researchers explain in their study, CCRs work by digitally modulating incident laser light. The device reflects laser light coming from the base station back toward the source in the “on” state, and scatters the light away from the source in the “off” state. By quickly switching between states, the CCR can transmit data at high speeds.

The CCR device itself consists of three mirrors: two vertical mirrors form a cross on top of a horizontal mirror, resulting in four concave corners. The alignment of the mirrors is essential, since perfect alignment constitutes the “on” state to reflect light. Misalignment occurs when a piezoelectric cantilever causes the horizontal mirror to lift a few micrometers above the substrate like a seesaw, which causes incident light to scatter.

The difference between the CCR's “on” and “off” states. Image credit: J. Park, et al. © 2012 IOP Publishing Ltd

In previous designs, the piezoelectric cantilever required high voltages to move the mirror, but the new design can work with ultra-low voltages due to improved mirror alignment. To do this, the researchers added two

supporting cantilevers in addition to the actuating cantilever, which helps improve the initial alignment of the horizontal mirror. A simplified fabrication process also improves the alignment and flatness of the mirrors.

"The developed CCR is the first device fabricated by combining a cross-shaped vertical silicon mirror and a piezoelectrically actuated horizontal mirror," Jae Park, Professor of Electrical Engineering at Kwangwoon University, told *Phys.org*. "There are two significant advantages in its fabrication. Firstly, the cross-shaped vertical mirror was simply fabricated by using a double-SOI wafer and anisotropic KOH etching technique. This method provides good surface roughness and accurate angular alignment of reflective surfaces in the vertical mirror with mass productivity. Secondly, microfabricated piezoelectric cantilever actuator was applied to actuate the horizontal mirror. The piezoelectric cantilever provides larger angular displacement at a lower induced voltage than a conventional electrostatic actuator without power consumption."

In addition to their ability to operate with a negligible power consumption, the new CCRs can also be produced with low-cost methods and can be integrated with sensors and CMOS circuits. The researchers noted that the communication distance is still limited, since the horizontal mirror has some curvature that leads to some misalignment. They hope to improve the flatness of the horizontal mirror in the future.

"One of the most promising applications is optical sensor networks (OSN) using direct optical links," Park said. "Use of direct optical links improves network security of OSNs significantly over RFSNs (radio frequency sensor networks). The improved network security is one of the critical elements that make OSNs ideal, for example, to military applications. We can also consider the applications of broadcast and scanning networks. A light ray from the base station is directly scanned

using a galvanometer scanner, and a CMOS imager is utilized for space-division multiple access (SDMA) with CCR sensor nodes distributed in the broadcast area. The SDMA-based broadcast and scanning network can also be considerable."

More information: J. Park, et al. "Piezoelectrically operated MEMS corner cube retroreflector for optical communications." *J. Micromech. Microeng.* 22 (2012) 055007 (8pp). DOI: 10.1088/0960-1317/22/5/055007