Researchers test carbon fiber to make tiny, cheap video displays

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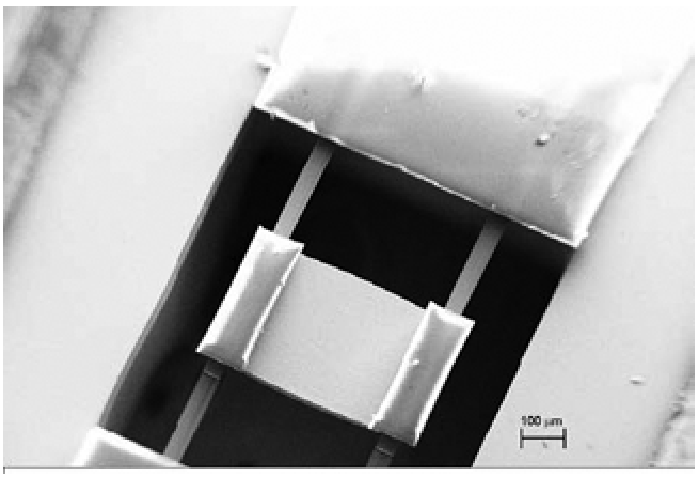


Carbon fiber rods supporting this tiny mirror can be made to bend up to 90 degrees millions of times without showing fatigue. The technology could be used to create a video projector on a chip. Credit: Thompson Lab/Cornell University

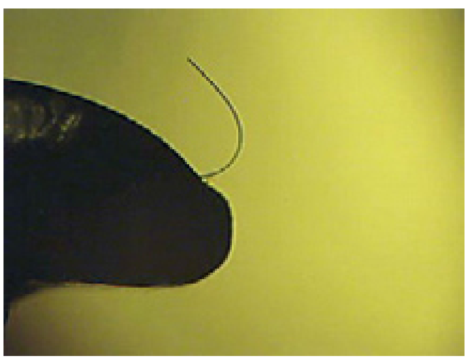
Engineers who develop microelectromechanical systems (MEMS) like to make their tiny machines out of silicon because it is cheap, plentiful and can be worked on with the tools already developed for making microelectronic circuits. There is just one problem: Silicon breaks too easily.

For decades, researchers have been trying to make video displays using tiny mirrors mounted on silicon oscillators. But silicon won't oscillate fast enough and bend far enough.

"You need something incredibly stiff to oscillate at a resonant frequency of 60,000 times a second (the line-scanning rate of most video displays), but it also needs to bend a lot for adequate image size," explained Shahyaan Desai, a Cornell graduate student who has been working for more than three years to create a practical MEMS video display device.

So Desai and his Cornell colleagues have turned to carbon fiber, the same material used to reinforce auto and aircraft body parts, bicycle frames and fishing rods.

"Carbon fiber is twice as stiff as silicon but 10 times more flexible," said Desai.



Microscopic flash photography shows a carbon fiber 5 microns in diameter bending nearly 90 degrees while driven to oscillate at 33.4 kHz. The combined flexibility and durability of carbon fibers suggest many uses in microelectromechanical (MEMS) devices, including use as springs and as supports for vibrating objects. Credit: Thompson Lab/Cornell University

He is first author of a paper with Michael Thompson, Cornell associate professor of materials science and engineering, and Anil Netravali, Cornell professor of fiber science, on using carbon fibers in MEMS, published in the July issue of the *Journal of Micromechanics and*

Microengineering.

Carbon fibers are made of thin, narrow sheets of graphite that roll up and clump together to form fibers. For industrial uses the fibers are embedded in plastic to form composite materials that are stronger than steel, yet lighter. Desai's MEMS are made with the raw fibers.

Desai first showed that micrometer-scale carbon fibers can bend like tiny fishing rods by more than 90 degrees and can be made to vibrate billions of times without breaking down. "This is, to our knowledge, the first material to even approach such large deformation at high frequencies without observable fatigue," the researchers wrote in their paper.

"Carbon is normally a brittle material," Desai said, "but in the fiber form it resists breakage. We have some data implying that if it lasts three and a half days it's going to last forever."

Desai then built an optical scanner consisting of a tiny rectangular mirror measuring 400 by 500 microns, supported by two carbon-fiber hinges about 55 microns across. Made to oscillate at 2.5 kHz, the tiny mirror caused a laser beam to scan across a range of up to 180 degrees, corresponding to a 90-degree bend by the carbon fibers.

An oscillating mirror could be used to scan a laser beam across a screen, and an array of mirrors, one for each horizontal line, could produce an image in the same way that a moving electron beam creates an image on a television screen.

"It would be an incredibly cheap display," Desai said. And the entire device would be small enough to build into a cell phone to project an image on a wall.

Besides serving as oscillators, the researchers said, carbon fibers could be made into clock springs that either unwind slowly to power a micromachine over a period of time or unwind rapidly to provide a sudden burst of power, or used as micro-sized pendulums that could harvest energy from motion like a mechanical self-winding watch to make cell phones, PDAs and even watches that are powered by the user's movement.

Source: Cornell University