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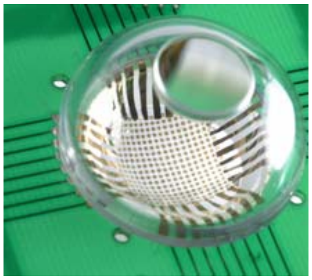
Wednesday, August 06, 2008

A Spherical Camera Sensor

A stretchable circuit allows researchers to make simple, high-quality camera sensors.

By Kate Greene



The eyes have it: This camera consists of a hemisphere-shaped array of photodetectors (white square with gold-colored dots) and a single lens atop a transparent globe. The curved shape of the photodetector array provides a wide field of view and high-quality images in a compact package.
Credit: Beckman Institute, University of Illinois

Today's digital cameras are remarkable devices, but even the most advanced cameras lack the simplicity and quality of the human eye. Now, researchers at the University of Illinois at Urbana-Champaign have built a spherical camera that follows the form and function of a human eye by building a circuit onto a curved surface.

The curved sensor has properties that are found in eyes, such as a wide field of view, that can't be produced in digital cameras without a lot of complexity, says John Rogers, lead researcher on the project. "One of the most prominent [features of the human eye] is that the detector surface of the retina is not planar like the digital chip in a camera," he says. "The consequence of that is [that] the optics are well suited to forming high-quality images even with simple imaging elements, such as the single lens of the cornea."

Electronic devices have been, for the most part, built on rigid, flat chips. But over the past decade, engineers have moved beyond stiff chips and built circuits on bendable sheets. More recently, researchers have gone a step beyond simple bendable electronics and put high-quality silicon circuits on stretchable, rubberlike surfaces. The advantage of a stretchable circuit, says Rogers, is that it can conform over curvy surfaces, whereas bendable devices can't.

The key to the spherical camera is a sensor array that can withstand a curve of about 50 percent of its original shape without breaking, allowing it to be removed from the stiff wafer on which it was originally fabricated and transferred to a rubberlike surface. "Doing that requires more than just making the detector flexible," says Rogers. "You can't just wrap a sphere with a sheet of paper. You need stretchability in order to do a geometry transformation."

The array, which consists of a collection of tiny squares of silicon photodetectors connected by thin ribbons of polymer and metal, is initially fabricated on a silicon wafer. It is then removed from the wafer with a chemical process and transferred to a piece of rubberlike material that was previously formed into a hemisphere shape. At the time of transfer, the rubber hemisphere is stretched out flat. Once the array has been successfully adhered to the rubber, the hemisphere is relaxed into its natural curved shape.

Because the ribbons that connect the tiny islands of silicon are so thin, they are able to bend easily without breaking, Rogers says. If two of the silicon squares are pressed closer together, the ribbons buckle, forming a bridge. "They can accommodate strain without inducing any stretching in the silicon," he says.

To complete the camera, the sensor array is connected to a circuit board that connects to a computer that controls the camera. The array is capped with a globelike cover fitted with a lens. In this setup, the sensor array mimics the retina of a human eye while the lens mimics the cornea.

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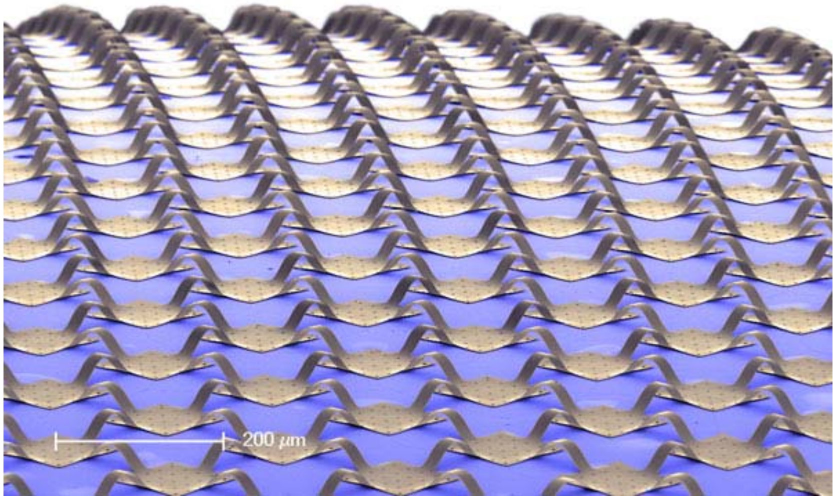

Stretchable mesh: The square silicon photodetectors, connected by thin ribbons of metal and polymer, are mounted on a hemisphere-shaped rubber surface. The entire device is able to conform to any curvilinear shape due to the flexibility of the ribbons that connect the silicon islands.
Credit: Beckman Institute, University of Illinois

"This technology heralds the advent of a new class of imaging devices with wide-angle fields of view, low distortion, and compact size," says Takao Someya, a professor of engineering at the University of Tokyo, who was not involved in the research. "I believe this work is a real breakthrough in the field of stretchable electronics."

Rogers isn't the first to use the concept of a stretchable electronic mesh, but this work distinguishes itself in that it is not constrained to stretching in limited directions, like other stretchable electronic meshes. And importantly, his is the first stretchable mesh to be implemented in an artificial eye camera.

The camera's resolution is 256 pixels. At the moment, it's difficult to improve resolution due to the limitations of the fabrication facilities at the University of Illinois, says Rogers. "At some level, it's a little frustrating because you have this neat electronic eye and everything's pixelated," he says. But his team has sidestepped the problem by taking another cue from biology. The human eye dithers from side to side, constantly capturing snippets of images; the brain pieces the snippets together to form a complete picture. In the same way, Rogers's team runs a computer program that makes the images crisper by interpolating multiple images taken from different angles.

The most immediate application for these eyeball cameras, says Rogers, is most likely with the military. The simple, compact design could be used in imaging technology in the field, he suggests. And while the concept of an electronic eye conjures up images of eye implants, Rogers says that at this time he is not collaborating with other researchers to make these devices biocompatible. However, he's not ruling out the possibility in the future.

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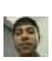

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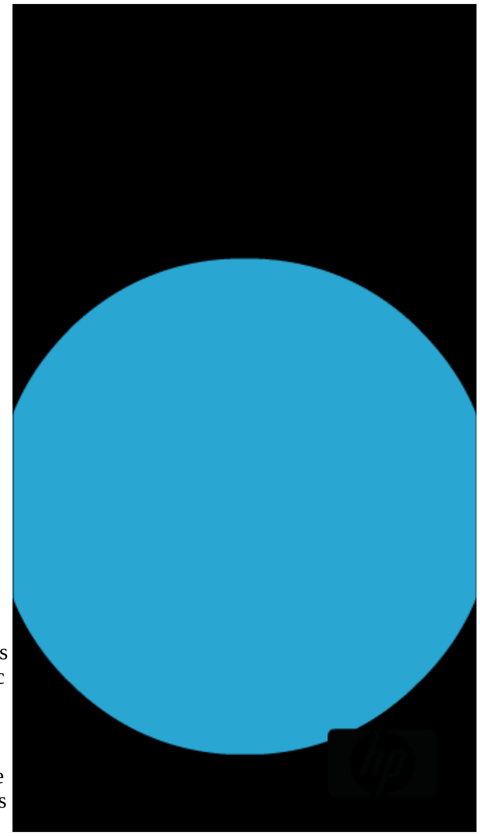

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