Rounding Out a New Way to Make an Artificial Eye

CHAMPAIGN, Ill. – A collaboration between researchers at Northwestern University in Evanston and at the University of Illinois at Urbana-Champaign (UIUC) has led to a novel technology that not only can make a camera shaped like an eyeball but also likely will lead to the successful design of visual sensors that can take on a wide assortment of nonplanar forms.

Natural vision sensors – human and animal eyes, for example – are decidedly not flat. The key to making artificial eyes, therefore, would be the development of hemispherical or otherwise nonplanar sensor arrays.

Building a sensor chip for a CMOS or CCD device, however, is a restrictive process; the resulting chip must be flat because the crystalline materials used are very much inelastic. Silicon, for example, cannot be deformed by more than 1 percent; thus it cannot be bent into useful shapes.

The Illinois teams, led by Yonggang Huang of Northwestern and by John A. Rogers of UIUC, approached the problem by devising a stretchable set of pixels linked by tiny chromium and gold connectors.

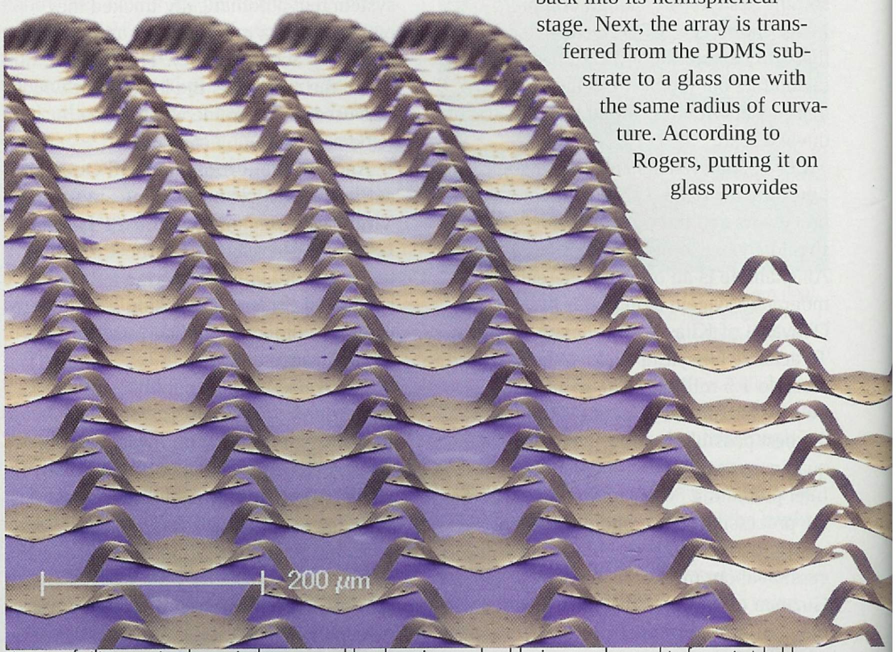
The investigators started by casting the plastic polydimethylsiloxane (PDMS) into a hemispherical lens shape with a radius of approximately 1 cm. They placed the cured polymer into a jig that held it while 10 independent mechanical arms pulled on the lens's rim until it was stretched as tight as a drumhead.

This formed the substrate upon which the researchers would build their electronic eye.

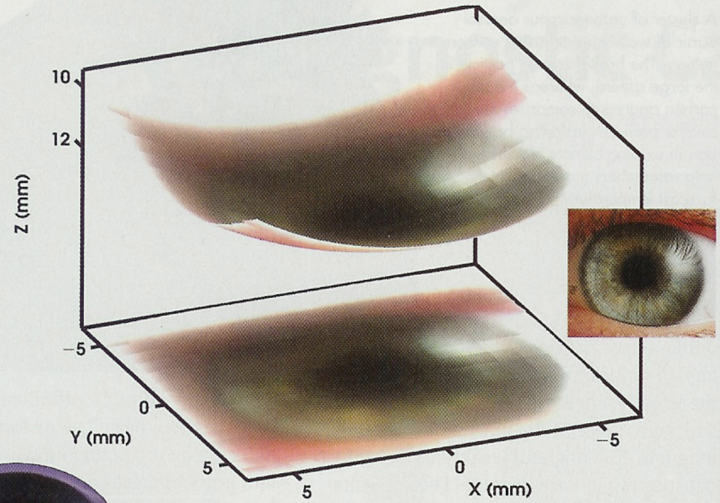
In a separate operation, using conventional flat-plane techniques, the group constructed a 16 × 16 array of silicon-on-insulator photodetectors. Each pair of these 500-μm^2 pixels was connected by a three-part band of metal 360 μm long by 50 μm wide. These bands consisted of a 3-nm-thick layer of chromium covered by a 150-nm-thick layer of gold and then by another 3-nm-thick coating of chromium.

"That sandwich design," Rogers said, "places the metal at the neutral mechanical plane, thereby providing very robust bending properties."

The overall structure must be robust because the next step is to release the grip on the drumhead substrate, letting it relax back into its hemispherical stage. Next, the array is transferred from the PDMS substrate to a glass one with the same radius of curvature. According to Rogers, putting it on glass provides



Arrays of silicon-on-insulator pixels connected by chromium and gold wires can be used to form stretchable and compressible sensors, such as eyeball-shaped cameras. Images courtesy of John A. Rogers, University of Illinois at Urbana-Champaign.



Formed into a shape reminiscent of a retina (inset), and mounted onto a rotatable stage, the flexible focal plane array acquires curvilinear images that can be flattened by software.

the rigidity and stability required for reliable interconnection with external control electronics.

"The PDMS [substrate] might provide, at some point in the future, improved interfacing with biological systems," he said.

As reported in the Aug. 7, 2008 issue of *Nature*, the investigators tested the sensor by mounting it onto a computer-controlled rotation stage and interfacing it with a PC loaded with custom-coded image-acquisition software. They took pictures of several 2-D and 3-D objects, such as printed text and faces. They found that, although the small number of pixels limited clarity, overall image quality could be improved by rotating the rounded lens incrementally in two directions.

Rogers says that the teams are looking into getting more fine details out of the camera's performance, starting, obviously, by increasing the number of pixels.

"We are implementing systems with higher pixel counts and [with] more optimized curved surfaces (for example, paraboloids instead of hemispheres)," he said. "We think that these approaches enable conformal integration of electronics and optoelectronics onto complex curvilinear surfaces in ways that could be compelling for biomedical devices with nonoptical functionality."

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New global warming element

TEMPE, Ariz. – Researchers at Arizona State University have found yet another culprit in the onslaught of global warming – and it's called brown carbon.

Taking brown carbon into account in global circulation models, which previously were based only on estimated amounts of black carbon (soot) and other aerosol pollutants, may offer a more sensitive model for forecasting increases in the Earth's temperature. The findings were published in the Aug. 8, 2008 issue of Science.

The brown carbon, which consists of carbonaceous aerosol particles, typically transpires from man-made sources such as fossil fuel combustion. Unlike greenhouse gases, which spread throughout the Earth's troposphere (lower level of the atmosphere) and last for several years, aerosols have a short life span and remain only over regions where they are produced.

Identifying carbons

The investigators discovered the brown carbon by studying the optical absorption of ambient aerosols from East Asia using a transmission electron microscopy tech-