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How to Build a Bionic Eye

Researchers have created an electronic contact lens that could be used as a display or a medical sensor.

By Kate Greene

People don't think twice about wearing a Bluetooth headset to have conversations on their cell phones. Well, one day it might not be unusual to wear a contact lens that projects the phone's display directly onto the eye. Researchers at the University of Washington have taken an important first step toward building contact lenses that could do just that. By incorporating metal circuitry and light-emitting diodes (LEDs) into a polymer-based lens, they have created a functional circuit that is biologically compatible with the eye.

"If you look at the structure of a lens, it's just a simple polymer," says Babak Parviz (http://www.ee.washington.edu/faculty/parviz_babak/) , professor of electrical engineering at the University of Washington. A number of researchers are putting electronics into polymers to build flexible circuits or displays, for instance. "What we realized was, we can make a lot of functional devices that are really tiny, and they can be incorporated into a contact lens to do a lot more than just improve vision," Parviz says.

The team created the electronic lens with two main purposes in mind, he says. One of the goals was to see if it would be possible to build a heads-up display that could superimpose images onto a person's field of view, while still allowing her to see the real world. It would be a sort of augmented reality, explains Parviz. (See "TR10: Augmented Reality (http://www.technologyreview.com/Infotech/18291/) .") Soldiers could use the technology to see information about their environment, collected from sensors. Or civilians could use the electronic lens as a cell-phone display, to see who is calling and to watch videos during a commute, although these goals are long term, he says.

Another possible application is to use the lens as a sensor that could monitor chemical levels in the body and notify the user if they indicate signs of disease. Although Parviz won't go into details about the specific sensors that his team is making, he explains that many indicators of health can be monitored from the surface of the eye. The live cells on the eye, he says, are in indirect contact with blood serum, which contains biomarkers for diseases. If a sensor designed to pick up these biomarkers was built into a lens, then doctors could have a completely new, noninvasive tool for disease tests. In addition, the lens could continually monitor changes over time, providing a more complete view of a person's health.

Admittedly, these applications are years away. But Parviz and his team have laid the foundation for the work. In a paper presented at the International Conference of Micro Electric Mechanical Systems (http://www.mems2008.org/) in Tucson, AZ, last week, the researchers describe how they created a lens with 16 working LEDs. The lens was made from a polyethylene tetraphthalate substrate--the kind of plastic used in beverage bottles--which was covered with metal wires for connecting the LEDs.

In addition to wires, the researchers used chemicals to carve out circular indentations in which the LEDs would be placed. Parviz notes that one challenge in building working electronics and opto-electronics into plastic is that these devices must be made with high heat that would melt the plastic. To get around this problem, his team fabricated LEDs on a separate substrate, ensuring that the devices could easily be removed and transferred onto the plastic lens.

Next, the researchers coated the fully assembled electronic lenses with polymethyl methacrylate (PMMA), a biocompatible material. PMMA is also used to coat hard contact lenses, says Parviz, making his lenses more similar to hard contacts than the soft contacts worn by most people today. In the final step, the researchers molded the plastic into the shape of a lens.

When the team tested the lenses, the circuit was viable and the LEDs lit up. The researchers also placed the lens in a rabbit's eye for 20 minutes and found no adverse effects. However, they did not turn on the electronics while the lens was in the rabbit's eye. "I think we have to be careful about what happens to the eye when it turns on," says Parviz. "It's a functioning circuit. It could generate some heat. We need to take all the possible precautions to make sure this is safe." While it's true that the human body can withstand a range of temperatures, ultimately the circuits must be designed to consume ultralow amounts of power.

"The idea of building a circuit into a contact lens is interesting--it catches the attention," says George Whitesides (http://gmwgroup.harvard.edu/people_biography.html) , a professor of chemistry at Harvard who is not affiliated with the project. "It has been something that others have certainly talked about, but I, at least, have never seen any kind of implementation." Whitesides adds that this is an early step, and there is still the issue of providing power to the lens while it is in the eye. In addition, the University of Washington prototype does not have a clear function.

One of the next steps for the team will be to increase the number of LEDs on the lens to a couple hundred, in the hope of making a viable display. Right now, the LEDs are about 300 micrometers in diameter, which obviously limits the number of them that can be put on a lens. In addition, LEDs this size tend to break in the lens-shaping process. Parviz's team will try to shrink the LEDs to 30 micrometers in future experiments, which could enable the lens to display a few hundred pixels, he says.
