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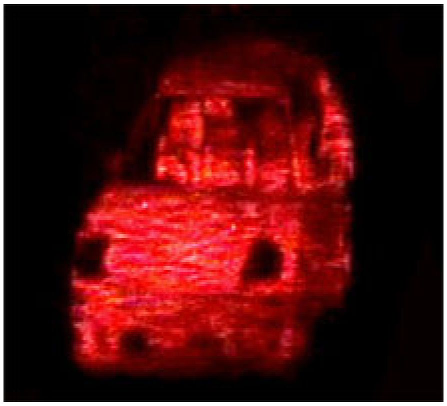
Large-Scale Rewritable Holograms

A new material allows researchers to write and erase 3-D images for displays.

By Kevin Bullis



Holographic car: A new material could make possible very large holographic displays that can be erased and rewritten. Eventually, the displays could be as big as cars. The car pictured here is on a prototype display that's 10 centimeters on a side.
Credit: Savas Tay, University of Arizona
Multimedia
- See a video of a hologram.
- Listen to a description of the technology.

A holographic display based on a new material can be repeatedly written to and erased. Rewritable holograms have been possible at small sizes, such as for holographic memory devices. But it's been difficult to make these materials at a scale large enough for displays. The new material, developed by researchers at the University of Arizona and at Nitto Denko Technical Corporation, in Oceanside, CA, could eventually allow for life-sized displays of people and objects the size of cars that could be refreshed every few minutes.

Existing high-end holographic images can be full-color and extremely detailed, but they've been restricted to still images that can't be rewritten. Stereoscopic displays, in which a different two-dimensional image is shown to each eye, are the basis of 3-D movies, but they lack some of the realism of holograms. The new display can produce holographic images, which are easier to view than stereoscopic images and can be of higher quality. But the display is better than typical holographic images in that it can be updated.

The University of Arizona researchers developed a new polymer-based material that encodes information using electric fields. The material contains two components. When light strikes the film, one of these components, a polymer, absorbs photons and generates electrons and their positive counterparts, called holes. The polymer is also a good conductor of holes, but not of electrons. As a result, the holes can easily move away from the illuminated areas where they were generated, whereas the electrons stay put. This separation of charges creates patterns of tiny electric fields within the material. These electric fields change the way that light moves through the different parts of the film.

The second component of the material, a dye, responds to the electric fields in two ways. The dye molecules change their polarization and physically rotate depending on the nature of the fields in each part of the film. These changes locally affect the index of refraction, which has to do with how a material bends and reflects light. When the researchers shine a laser through the film, the dye alters the path of the light, projecting a pattern that the eye interprets as a three-dimensional image. "It comes out of thin air--you feel like you could touch it," says Nasser Peyghambarian, a professor of materials science and engineering at the University of Arizona, who led the work.

To erase the image, the researchers expose the film to uniform light, which redistributes the electrons and holes, removing the electric fields and the changes in the material that they had produced.

Researchers have tried making rewritable holographic displays in the past, but they faced a number of problems. Materials failed to produce bright images, for example, or the images faded quickly. Peyghambarian's new materials can preserve an image for hours and produce very bright images. The materials can also be easily made in large areas. The prototype holographic film created with the new material is 10 centimeters on a side, but because it was made using well-known polymer processing techniques, it should be relatively easy to scale it up to much larger sizes, says Joseph Perry, a professor of chemistry and biochemistry at Georgia Tech.

The process currently takes a few minutes to write and erase an image--much too long for video. But it might be possible to significantly increase the write and erase speed, says Perry. There are two key limitations right now. One is how fast the electric fields can be established, which is determined by how fast the holes can move. Next, once the fields are in place, it takes some time for the dye molecules to rotate. One way to improve the speeds is to amplify the other property of the dye that changes the behavior of light--the change in polarization. Right now, this is a small effect, but the polarization changes very quickly--fast enough to change the image in real time, Perry says.

For many applications, the new approach will face stiff competition from a growing number of 3-D technologies that can already display video and, like the new approach, do not require that the viewer wear special equipment. That could limit the applications of the new display to those that don't require fast updates, such as maps, says Brian Schowengerdt, a research scientist at the

Human Interface Technology Laboratory at the University of Washington. Peyghambarian's approach could also have an advantage for very large displays, since the other technologies are difficult to make that size. These could be used for high-end marketing displays, says Neil Dodgson, the director of studies in computer science at Emmanuel College, part of the University of Cambridge.

"People already spend a lot of money on holograms," Dodgson says. "An updatable one would be a fantastic advertising medium."