TechWeb The Technology News Site

Technology News

Holographic Material Lends Hope For Storage

(06/09/98; 1:04 p.m. ET)

By Sunny Bains, EE Times

A new holographic material based on polymethylmethacrylate (PMMA) holds out hope for very dense read-only data-storage applications. Invented in the former Soviet Union and now being developed at both the Massachusetts Institute of Technology and CalTech, the material is said to offer low-expense, high-diffraction efficiency and no shrinkage.

It promises to solve one of the most fundamental problems in holographic data storage: lack of good recording materials. Iron-doped lithium niobate, for instance, has been the material of choice for a long time. But since it is not very sensitive to light, relatively high laser powers are needed for successful hologram-recording. It is also very difficult to "fix" -- that is, the holograms fade with time, requiring constant rerecording. This makes the material unsuitable for read-only applications.

More recently, researchers have turned to photopolymers, which are also used for the recording of holographic-display images, such as those found on some drivers' licenses. These have a major advantage for read-only memories in that they can be fixed permanently through polymerization. However, this process causes some shrinkage, which has two negative effects: It changes the replay wavelength and introduces unpredictability to the entire process. Both photopolymers and iron-doped lithium niobate also have problems in terms of form: They cannot be made easily or cheaply in arbitrary shapes.

Getting Around The Glitches
According to Demetri Psaltis, a professor of electrical engineering at CalTech, the new material gets around some of these problems. "It can be made in large samples of good optical quality, sufficient thickness -- up to 3 millimeters so far -- and does not shrink after exposure," he said. "At the same time, the M number is sufficient for most memory applications."

The M number indicates just how much holographic information can be stored within a given volume of material, and so limits the data density of the final memory system. CalTech researchers have achieved a high M number of 5.

The material in question, PMMA doped with phenanthrenequinone (PQ), is a holographic recording medium with an unusual property: two holograms, phase-shifted to approximately cancel each other out, are created during exposure. One of these holograms is based on the migration of free PQ molecules from the long-chain PMMA molecules, while the other is based on the PQ's becoming attached to the PMMA.

Over time, or when exposed to enough heat, the free molecules will diffuse through the material, destroying the grating they had been a part of. This has the effect of increasing the diffraction efficiency of the other grating, whose molecules are anchored to the PMMA, and cannot move. Scientists at the S.I. Vavilov State Optical Institute in Leningrad have dubbed this property diffusion amplification. With it, they are said to be able to make holograms with almost 100 percent diffraction efficiency.

Northeast Photosciences, in Hollis, N.H., collaborated with Vavilov researchers to transfer the technology to the United States. They entered into a collaboration with MIT, Buffalo, N.Y.-based Laser Photonics Technology, and the Air Force Research Laboratory to develop the material. Through this effort, researchers at CalTech learned about the material and started a project to develop a version of it.

At Cambridge, Mass.-based MIT, researchers refer to the material as PDA (polymer with diffusion amplification). MIT's Selim Shahriar said the material has a sensitivity 100 times better than lithium niobate, but that the M number achieved so far is between 1 and 2 -- lower than the CalTech results. This is somewhat offset by the relatively poor sensitivity of the CalTech material, which is about the same as lithium niobate.

Another difference between the two materials is in the baking that causes the diffusion. It seems to be much faster with the current generation of MIT material.

Both groups reported that the PQ-doped PMMA is straightforward to work with. According to Shahriar, "The sample can be made very thick -- 1 centimeter or greater, as compared with 200 microns for the best photopolymer." Also, he said, "It is possible to make PDA in shapes such as cubes that are compatible with compact, nonmechanically addressable architectures." Fabrication into disks can be done through injection molding.

Both groups see this material as being at an early stage of development. Because of the long baking times required, for instance, the material is not suitable for write once, read many times applications. Another problem is it is not immediately obvious how master holograms could be copied. Effectively, therefore, each set of holograms has to be recorded individually.

Next-Generation DVD?

Shahriar said he foresees a terabyte CD-ROM-type system, where companies ship 1,000 gigabytes of data to a central facility and get a single disk back. Psaltis also said he believes the material will be useful primarily for ROM applications -- perhaps as a next-generation DVD.

Psaltis and Shahriar agree that continuing research into improving the chemistries of their materials is crucial. Psaltis said researchers must "improve sensitivity as much as possible and characterize properties in large numbers of samples to ensure repeatability for commercial-grade material." The CalTech group has begun this process by characterizing the birefringent properties.

"Both groups are trying to re-create, and hopefully improve, the same Russian material," he said. "And we are talking to each other." rw

Related Stories:

New Technology Brings Low-Cost Multimedia To Set-Tops

New Blue Laser Triples DVD Capacity

Search Archives Search