OPTICAL MEMORIES

OPTICAL MEMORIES

New material may facilitate holographic data storage

Sunny Bains

Two new developments in the field of holographic data storage were reported recently at the Conference on Lasers and Electro-Optics (CLEO; San Francisco, CA). Researchers from the California Institute of Technology (CalTech; Pasadena, CA) presented their first results with a promising new holographic storage medium based on phenanthrenequinone (PQ) doped PMMA. And researchers from IBM Almaden research center (San Jose, CA) described a method for allowing more digital data to be stored in any holographic medium given a target bit-error rate.

First invented in the former Soviet Union and currently also under development at the Massachusetts Institute of Technology (MIT: Cambridge, MA), PMMA has major advantages over some of its competitors because it is inexpensive, unlike LiNbO3 (lithium niobate), does not suffer from shrinkage, unlike commercially available photopolymers, and exhibits high diffraction efficiency.

Phenanthrenequinone (PQ) doped PMMA 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 PQ molecules that are free from the long-chain PMMA molecules, while the other is based on the PQ becoming attached to the PMMA. Over time, or when exposed to enough heat, the free molecules will diffuse through the material, destroying the grating of which they had been a part. This has the effect of increasing the diffraction efficiency of the other grating with its molecules anchored to the PMMA such that they cannot move. Scientists at the S. I. Vavilov State Optical Institute (Leningrad, Russia) dubbed this property diffusion amplification. With it, they claimed to be able to make holograms with almost 100% diffraction efficiency.

Northeast Photosciences, (Hollis, NH), collaborated with Vavilov researchers to transfer the technology to the USA. The company entered into a collaboration with MIT, Laser Photonics Technology (Buffalo, NY), and the US Air Force Research Laboratory (Hanscom Field, Bedford, MA) to develop the material further. Through this effort, researchers at CalTech learned about the material and started a separate project to develop the material.

Interestingly, though they come from the same root, the CalTech and MIT materials are very different. According to Demetri Psaltis at CalTech, their PQ-doped PMMA has relatively poor sensitivity--no better than lithium niobate--but a very high M number of 5--the M number indicates how much holographic data can be recorded in a given volume of material. Selim Shahriar of MIT, however, finds that his material has a sensitivity a hundred times better than lithium niobate, but with a more modest M number between 1 and 2. The diffusion process, carried out by baking, seems to be much faster with the current-generation MIT material. Both groups report that it is straightforward to make thick samples (a few millimeters) of the material with arbitrary shape and good optical properties. Fabrication of the material into disks can be done by injection molding, and, because the material is mechanically strong and rigid, it can be made without using a separate substrate.

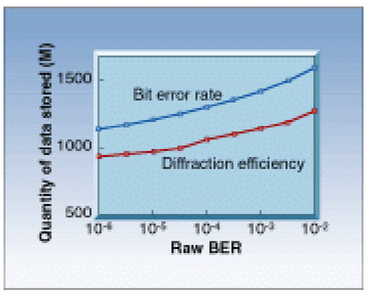
At present, the differences between the two materials make them more suitable for different applications. Because of its high sensitivity, Shahriar and his collaborators see the PQ-doped PMMA as more suitable for write-once-read many times (WORM) memories. Psaltis, however, sees his slower, denser material as better for read-only memories (ROMs). Both groups are continuing their research into improving the chemistries of the materials and developing optical architectures to exploit them.

More-efficient storage

For those working with more-conventional holographic materials, however, there is good news on how to store digital data efficiently. Most holographic storage systems require that many holograms are stored within the same volume of holographic material. Because the holograms are recorded in sequence, each one slightly erases all the preceding ones. For this reason, researchers have used a recording schedule--giving more exposure time to early holograms and less to later holograms--in order to even out the resulting diffraction efficiency. At IBM, researchers have shown that the conventional wisdom about recording schedules does not take into account the particular needs of digital data storage.

The new scheme--which assigns exposure times based on a nonlinear curve--came about from analyzing the bit error rate associated with early- and late-recorded holograms. Because the earlier holograms are more degraded than their later counterparts, they are also noisier. For this reason, they need to have a higher diffraction efficiency in order for the individual pixels to be correctly identified as "on" or "off" at the detection plane. Conversely, late-recorded holograms are much cleaner and, as a result, can be dimmer without introducing extra errors. The change to recording schedules based on bit error rate rather than diffraction efficiency should give most holographic materials an immediate boost in capacity (see figure).

SUNNY BAINS is a scientist and journalist based near San Francisco, CA; www.sunnybains.com.



7-NEWS-5 98

New holographic recording schedule developed at IBM involves maintaining the bit error rate (BER; to¥curve) rather than the diffraction efficiency (bottom curve). This allows considerably more holograms to be recorded (M) in the same volume.

Laser Focus World July, 1998

Links referenced within this article

Find this article at:
http://lfw.pennnet.com/Articles/Article_Display.cfm?Section=Archives&Subsection=Display&ARTICLE_ID=26060&KEYWORD=shahriar

Uncheck the box to remove the list of links referenced in the article.