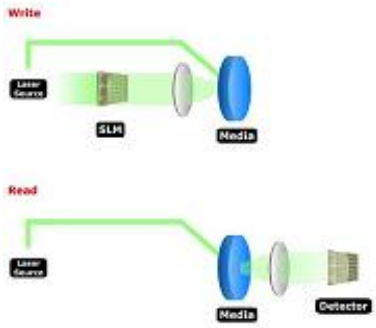
process in the second half of the year. "The media is available today," Berg said. "We are producing samples now and are doing pilot production on our first generation equipment now. Our second generation production equipment is currently being assembled at Aprilis and we will start exercising that before the end of the year. Our production rate is less than 4 minutes per disk in low volume."

Aprilis will also deliver its media in a card format, although Berg said he didn't believe that form factor would be popular enough to turn into a product.

Conventional CDs and DVDs store data on read-only tracks, which reflect light from a laser onto a sensor, which interprets the reflected image as data. Rewriteable DVDs, such as the DVD+RW format used by Philips, sandwiches a polycrystalline layer between dielectric material. When a high-intensity laser shines on the media, the polycrystalline layer melts in a controlled manner, "writing" data onto it. A lower-powered laser, paired with an optical sensor, then reads back the data.



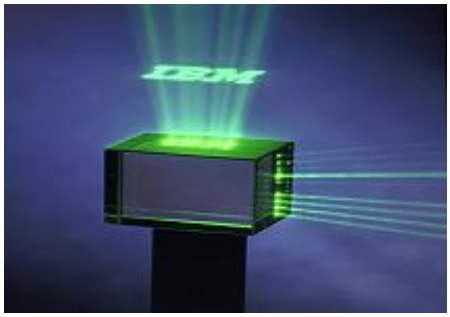
click on image for full view

In three dimensions, writing to holographic storage requires two beams: a reference and a data beam. Data is actually stored as a two-dimensional matrix of information in the medium in a polymer, Berg said. According to reports, rival Optware has been able to place the data and reference beam on the same optical axis.

When reading the data, a single laser is aimed at the target matrix, projecting the matrix onto a sensor, where it is read as data. The orientation of the matrix allows the origin of the reference beam to be deduced from the data beam. In the real world, this means that data can be read back from a single reference beam at about 200 Mbytes per second.

The kicker, Berg said, is that matrices can also be angled, storing a completely different matrix using a reference beam at a different angle. The angles allow the data to be multiplexed, creating holographic storage's remarkable capacity points.

Holographic storage also has a nice side effect: it almost seems designed for databases. Since stored holograms diffract incoming light out the side of the crystal, the brightest spots identify the data that most closely resembles the input pattern, making searches easy and efficient, Berg said.



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Unfortunately, when a device writes data to the polymer, Berg said, the media "shrinks," or compacts, limiting the amount of data per cubic centimeter. Adding additional polymer layers can mitigate the effect, however, Berg said. Berg did not disclose the data density the Aprilis technology has been able to achieve.

In the lab, IBM has been able to achieve 254 Gbits/ sq. inch, according to a spokesman—about 1 percent of the theoretical limit in volumetric density for holographic storage, which is one bit per cubic wavelength. IBM has also worked on the technology since the late 1960's.

Currently, rewritability stands as the Holy Grail of the technology, requiring a breakthrough to achieve if holographic storage is ever to replace magnetic hard drives. Pushing holographic storage into the mainstream will require low-cost manufacturing.

'We believe our technology will be comparable to CD in manufacturing cost in volume," Berg said. "The key here is 'in volume'."

Aprilis will manufacture its media itself with a Japanese partner until the company feels it has refined the process to the point where it can turn out 10,000 pieces per month. At that point, the

company will "offload" it, Berg said.

IBM, which invented the magnetic "Winchester" disk drive in use today, has too much invested in the technology to commercialize holographic storage, Berg charged. Not so, said a spokesman for IBM, who said the company feels the technology is not ready for mass deployment.

"We think it's unlikely that holographic data storage will become a reasonable storage solution for consumers in the foreseeable future," said Hans Coufal, manager of science and technology at IBM's Almaden Research Center in San Jose, in a statement. "The invention of some ideal materia could change the forecast, of course. But as we mentioned earlier, there is no known holographic storage material that is suitable for products ...and especially not something ready for the price-competitive nature of the consumer marketplace. If a material is discovered, holographic storage would surely first find success in a niche market rather than for general consumers."

For its part, Berg said there's no way the company would try to usurp the hard disk drive. While companies like TeraStor loudly promised to rewrite the history of disk drives, the pace of magnetic technology eventually buried them. Meanwhile, companies like Quinta, later bought by Seagate, are working on multi-terabit technology of their own.

"We're absolutely not going head-to-head with the magnetic storage industry," Berg said. "What you really have to focus on are attributes that the other guys can't achieve."