Upward spiral

OPTICAL STORAGE (R)EVOLVES TO HIGHER CAPACITIES, ENHANCED CAPABILITIES.

The publication of this article marks an anniversary of sorts: 20 years (and a few months) ago, Sony publicly unveiled the CD in the United States on the heels of introductions in Europe and Japan the previous fall. Philips and Sony had begun CD development in 1979; their technology harked back to ideas that Dutch physicist Klass Compaan had come up with a decade before. The Reed-Solomon EDAC scheme, a keystone of all modern optical-storage technologies, was first published even earlier, in 1960 (see "Laser-lit marvels," this issue, pg 28).

I'm old enough to vaguely remember the early days of CD, the multithousand-dollar prices of first-generation players and recorders and the hotly contested audio-CD-versus-LP debates that simmer to this day. I more clearly remember the early, more recent days of DVD (digital versatile disc) and the long and convoluted standardization road that finally led to the DVD-Video format. With this twisted and initially expensive path still fresh in my memory, I was amazed when I walked into the *grocery store* yesterday and found for sale, at $99, an all-in-one DVD-Video player plus AM/FM tuner plus six-channel (150W-total-power) amplifier, along with six matching speakers. DVD rentals just recently for the first time exceeded VHS rentals. And Sunday newspaper ads regularly tout less-than-$20, 52×24×52× CD burners and less-than-$200, multiformat DVD burners.

Observing the colossal success that the CD and its DVD follow-on have achieved in recent years, you might find it hard to believe that in the early days of optical storage, plenty of naysayers predicted a far more pessimistic fate for the formats. Contradicting the skeptics' prophecies, events of the past two decades reveal that there's *plenty* of money for companies to make in optical storage. Examples of companies that can profit from this technology are drive and media manufacturers, system suppliers whose designs integrate those drives and employ

that media, and technology developers whose patents form optical storage's foundations (**Figure 1**). Success, though, has led to no shortage of controversy; I doubt there's a segment of the technology industry that's plagued by *more* format pitches and standards tugs of war. A desire for high volumes and, consequently, lucrative royalty incomes power all this squabbling.

REVISITING THE PAST

It seems strange to associate the word "past" with CD technology, because it's such a pervasive part of modern society, but the focus of industry innovation has clearly shifted to the DVD successor. Music companies are desperate to migrate consumers off easily duplicated and ripped audio CDs and onto copy-protected DVD-Audio discs, SACDs (Super Audio CDs), and music-downloading services. For many applications, 700 Mbytes of storage capacity is insufficient in this era of 100-Gbyte and larger hard drives and multihour, high-resolution video- and surround-sound-inclusive, and extra-feature-rich movies. And it's hard to imagine *anyone* making much profit margin on $20 CD burners and $5 100 packs of CD-Rs, even assuming that a low percentage of purchasers remember to fill out those rebate forms.

Those vendors remaining active in the CD recording and playback business are attempting to differentiate their products in the primary areas of performance, density, and superset features. Anyone who remembers the first 1×-speed CD-ROM and CD-R drives may feel a twinge of nostalgia when they observe the latest generation units (see **sidebar** "Interface evolutions and revolutions"). At 52× read and write speeds, however, CD technology may have finally reached the end of the performance road for both technical and business—that is, lack of sufficient return to justify added investment—reasons. Beyond this speed threshold, the industry is seriously concerned that the rapidly spinning discs may self-destruct in the drive trays, not only obliterating stored data, but also causing serious harm to the drive and perhaps also to the user. To reliably hit these speeds, drives employ exotic approaches, such as Plextor's use of matte, black trays, which the vendor claims better absorb stray reflected laser light. And continued increases in claimed speed produce diminishing returns in real-life read and write performance; to understand why requires more information on how computer CD drives work.

Early CD-ROM drives, like their audio-CD player counterparts, were of the CLV (constant-linear-velocity) variety, meaning that data streamed off the disc at an unvarying rate. To accomplish this goal, the drive would rotate the disc more slowly as the read head moved toward the disc's outer edge. This approach works well for sequentially stored and accessed audio and video information, but it hindered sustained performance with the more randomly accessed data files in most computer applications. Beginning at the 10× drive generation, CD-ROM drives employed partial CAV (constant-angular-velocity) techniques, using a constant rotational speed when reading close to the center of the disc and CLV mode for reads close to the

disc's outer edge.

Modern CD drives employ pure CAV accesses for data file reads and writes, and the "×" terminology now references the drive's peak data-transfer rate. The data throughput is highest, though, only at the disc's outer edge, so the drive can achieve the full effect of a performance increment from, say, 48× to a 52× over a small portion of the disc's total contents (and doesn't achieve this effect at all unless the disc is full, because the data spiral begins at the center of the disc and winds its way outward). Note that, regardless of the drive-access technique, the data pattern stored on the disc is still CLV with consistent pit and land sizes (see "Optical fundamentals," on pg 28). The drive's DSP, when the drive is in CAV mode, compensates for the much higher data read and write throughput at the disc's outer perimeter. Kenwood and Zen Research's TrueX drives attempted to achieve high data rates at lower, more disc-tolerant rotation speeds via a seven-laser configuration that read multiple portions of the disc track in parallel. Successive generations of Kenwood's drives achieved as much as 72× claimed speeds but were plagued by numerous reliability complaints. No other drive manufacturer widely implemented Zen's technology, and the company eventually went out of business.

If speed boosts are increasingly ineffective, perhaps storage-capacity improvements will keep the CD treadmill rolling (see **sidebar** "Bits and bytes"). Manufacturers employ a variety of approaches to address this aspiration. Whereas a first-generation 12-cm CD stored 550 Mbytes of data or 63 minutes of audio, the 650-Mbyte, 74-minute CD quickly replaced it, and the 700-Mbyte, 80-minute CD has subsequently reigned. In each of these generational jumps, the disc manufacturers tightened the track pitch. In fact, some suppliers are shipping 790-Mbyte, 90-minute and 870-Mbyte, 99-minute CDs, but interoperability concerns motivate standards bodies, such as OSTA (the Optical Storage Technology Association), not to recommend them. For similar reasons, OSTA doesn't advocate that you employ "overburning," or "oversizing," which involves writing data to the portion of the disc normally reserved for lead-out information.

In addition to reducing the track-to-track angular dimension, you might think that manufacturers could decrease the track's linear dimension—that is, the spacing between consecutive pits and lands. Plextor's GigaRec and Sanyo's HD-Burn technologies provide the means to test this theory; the concept behind them harks back to similar ideas in Sony's Double Density CD and in early-1990s DVD prototypes from Nimbus CD International, Optical Disc Corp, and Toshiba. Plextor claims that GigaRec, as its name implies, can squeeze as much as 1 Gbyte of data onto a CD-R, but using it requires disabling buffer underrun protection and that you tolerate 4× write speeds (**Reference 1**). HD-Burn doubles the normal capacity of CD-Rs, supports buffer underrun, and writes data at 24× speeds. Plextor and Sanyo freely admit that their techniques violate Orange Book specifications, but both companies claim that the precise optics in today's CD players guarantee a high degree of compatibility. Independent reviews paint a far more pessimistic interoperability picture (**Reference 2**).

If performance and capacity improvements deliver nebulous returns on investment, are there other features that suppliers can more effectively use to differentiate their products? Plextor officials think so; the company's latest generation CD burners expand beyond GigaRec to support a plethora of enhancements. VariRec, previously known as PoweRec, allows users to control the laser power to fine-tune the burning process and broaden disc compatibility at the trade-off of slower writes. Silent Mode permits users to throttle back read and write speeds to reduce the amount of noise the drive emits. SecuRec password-protects CD-Rs; a SecuViewer driver is available on the Plextor Web site for use with systems that lack an installation of the vendor's PlexTools suite.

AT A GLANCE

- Boutique, unique features represent CD vendors' best chance for future success.
- Advocates of DVD+ and DVD− continue to squabble, but format-flexible drives increasingly and fortunately make the argument obsolete.
- Some next-generation, high-definition video proposals preserve portions of today's red-laser-DVD infrastructure.
- Significantly boosting the amount of on-disc storage requires a transition to a blue-laser-based system.

THE TAPE ALTERNATIVE

Tape and optical discs have a history of spec one-upmanship as they jockey for consumer attention. At a given image resolution and playback duration, tape initially holds the edge due to its lowest cost. As optical disc's volumes rise and prices consequently fall, its ruggedness and higher performance random-access characteristics swing the popularity pendulum in its direction. In response, tape advocates attempt to migrate consumers to higher resolutions and other factors that increase required storage capacity.

You saw this phenomenon, to a limited degree, with the rollout of S-VHS tape and video recorders that supported high-fidelity, two-channel audio; both were competitive responses to the unveiling of laser discs. Although laser discs didn't conquer videotape, DVD has surmounted its analog-tape challenger. In living rooms, JVC is counterattacking by unveiling the D-VHS tape format, which supports high-definition video images and the corresponding D-Theater system.

Camcorders from companies such as Matsushita/Panasonic and Sony are also beginning to support small-diameter, red-laser DVD media instead of tape, and JVC in response is rolling out its GR-HD1 high-definition camcorder. The GR-HD1 uses mini-DV-format tape, like a conventional mini-DV camcorder, but switches from the motion-JPEG-derived DV codec to more efficient MPEG-2 to squeeze the larger images onto the available storage capacity. With multiple companies already showing off high-definition camcorder prototypes that employ next-generation, blue-laser-based optical storage, though, the long-term success of the GR-HD1 is by no means assured.

PlexTools also includes read and write transfer-rate benchmarking utilities, along with Q-Check software that allows users to analyze a disc's number of C1 and C2 errors (first and second levels of correctable errors, respectively) and CU (uncorrectable) errors. These features will likely be more successful than Yamaha's DiscT@2, which enabled burning images onto CD-Rs and CD-RWs but worked only if the user sacrificed a significant amount of data-storage capacity. Yamaha exited the CD-burner business in February.

Feature enhancements aren't limited to drive manufacturers; disc suppliers can also benefit from differentiation. TDK's Armor Plated CDs incorporate a ruggedized protective layer, which, according to multiple independent reviews, dramatically improves their tolerance of rough handling; the vendor's DVDs also offer Armor Plating (**references 3** and **4**). Imation's Business Select optical-media product lines similarly deliver robust scratch resistance. Optical Disc Corp's CDR-ROM-hybrid format combines a read-only CD-ROM partition at the inner area of the disc with two writable partitions: a small one at the disc's center (for the updateable table of contents) and a much larger area toward the disc's outer edge.

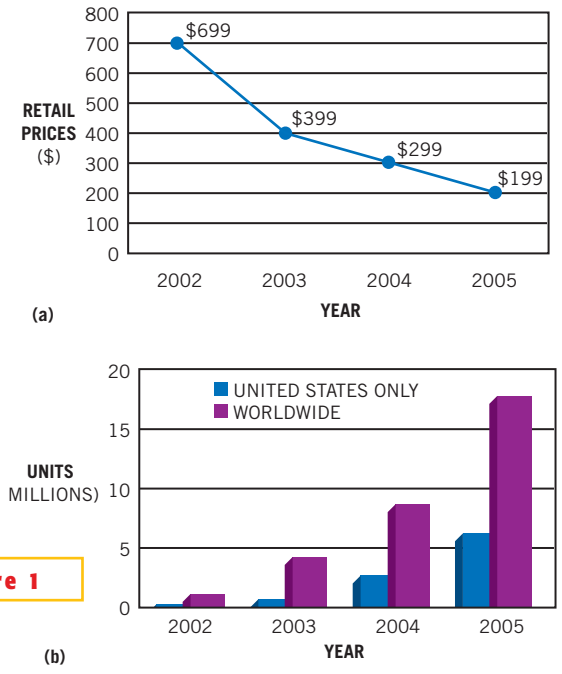


Figure 1

Industry analysts predict that, as DVD-recorder prices fall, their volumes and, therefore, optical-disc volumes will skyrocket as consumers use them to replace both DVD players and VCRs (courtesy In-Stat/MDR).

POLISHING THE PRESENT

Warning: Attempts to sort out the available DVD options may lead to acronym-induced head-aches! I hope the following few paragraphs will suffice to lead you through the morass; and plenty of additional materials are available for more inquisitive readers. Think of DVD-R and DVD-RW as denser variants of, respectively, CD-R and CD-RW, mimicking both the writable-CD formats' strengths (low cost) and their shortcomings (slow formatting and lack of sector-based random read/write support). They employ shorter wavelength lasers (635 nm in the DVD-R For Authoring format and 650 nm in all other formats) than do CDs, and, therefore, they can more closely pack together pits and lands within the track and consecutive spirals of the track, boosting per-side capacities to 4.7 Gbytes. Whereas CD-Rs appeared first in the CD generation, and CD-RWs followed later, the rewritable variants of DVD emerged before their write-once counterparts. Read-only pressed DVDs also support dual-layer mode; the read laser focuses "through" the first layer and, in some implementations, interlayer-transparent adhesive when accessing the second layer. Per-side capacities double with dual-layer media; writable versions, which various vendors have demonstrated, have not yet reached production status (**Table 1**).

DVD-RAM, the third format that the DVD Forum has blessed, is intended for use in random-partial-rewrite applications, such as computer mass storage and PVRs (personal video recorders) (see **sidebar** "The tape alternative"). Attempting to balance between the fast random-access needs of computer mass storage and the consistent data-throughput requirements of PVRs, data arranges on the disc in a Zoned CLV layout with constant rotational speed within each of the 35 concentric zones on a 120-mm disc or the 14 zones on an 80-mm disc. DVD-RAM media can deliver more than 100,000 rewrites per disc, thanks in part to its hardware-based defect management, but the fact that it writes information both in the track groove and in the space between grooves, as well as other format inconsistencies, renders it incompatible with most DVD-ROM drives and DVD-Video players. Windows XP and Mac OS X operating systems include support for the DVD-RAM format. (Microsoft plans to broaden its native support to encompass all other writable DVD formats in its next OS revision, now code-named Longhorn.) Manufacturers ship the discs preformatted, and they support multiple reformatting

BITS AND BYTES

Two interpretations of the prefix "kilo" find use in describing parameters such as storage densities and transmission bandwidths. The first, derived from the base-10, or decimal number system, defines a "kilo" as 1000, or 10^3. The base-2, or binary, number-system variant of kilo is 1024 (2^{10}), a number 2.4% larger than its base-10 counterpart.

As storage densities increase, the percentage error between base-2 and -10 alternatives also increases. A base-10 "mega" is 1 million (10^6), whereas the base-2 mega is 1,048,576, or 2^{20}—nearly 5% larger. Ironically, the so-called 1.44-Mbyte, 3.5-in. floppy disk uses a third variant of mega. This version blends the base-2 and -10 kilo designations and defines a megabyte as 1,024,000 bytes.

At "giga" densities, the difference between base-10 (1 billion, or 10^9) and base 2 (1,073,741,824) further expands, to 7.4%. When undertaking a hardware or software design or when exchanging data with your peers, make sure you're using a known and consistent numerical base in your terminology. Otherwise, harking back to the imperial-versus-metric-system mix-up that doomed NASA's Mars Climate Orbiter four years ago, your results may not match your predictions.

modes, several of which take only a few seconds to complete.

Sony, Philips, and Hewlett-Packard, the founding members of the DVD+RW Alliance, had both technical and business motivations for stepping outside the DVD Forum and developing the DVD+RW and DVD+R formats. Technically, they aspired to combine the best elements of DVD-RAM (random access and fast formatting) and DVD-RW (low cost and DVD-ROM and DVD-Video compatibility) in one set of write-once and rewritable media (**Figure 2**). From a business standpoint, they were miffed that the DVD Forum-sanctioned formats didn't incorporate more of their patents and, therefore, generate a more lucrative royalty stream. DVD+RW uses lossless linking and supports both CAV- and CLV-patterned data layouts. Note that CAV-formatted media is incompatible with standard DVD drives and players. First-generation DVD+RW drives, as it turns out, did not support DVD+R media, despite manufacturers' initial promises of future upgradability, so carefully read the fine print if you encounter a "too-good-to-be-true" bargain at your favorite computer-equipment surplus outlet.

Numerous compatibility studies on DVD+ and DVD− media have reached inconclusive and often contradictory results (**references 5** to **7**). Incompatibilities can crop up in the physical, file-system, application, and implementation levels—in other words, the physical, logical, and implementation levels. Aside from obvious incompatibilities, such as a DVD-Video player's inability to understand the DVD-Audio- or more generic DVD-ROM-file formats on a disc, many incompatibilities derive from laser-wavelength and reflectivity mismatches between what a player expects and what a disc delivers. For example, DVD-Video players usually handle CD-RW discs better than CD-R discs, although audio-CD players are more compatible with CD-Rs than they are with CD-RWs. Generally, DVD-ROM drives and DVD-Video players more successfully read DVD-R and DVD+R discs than they do DVD-RW and DVD+RW discs.

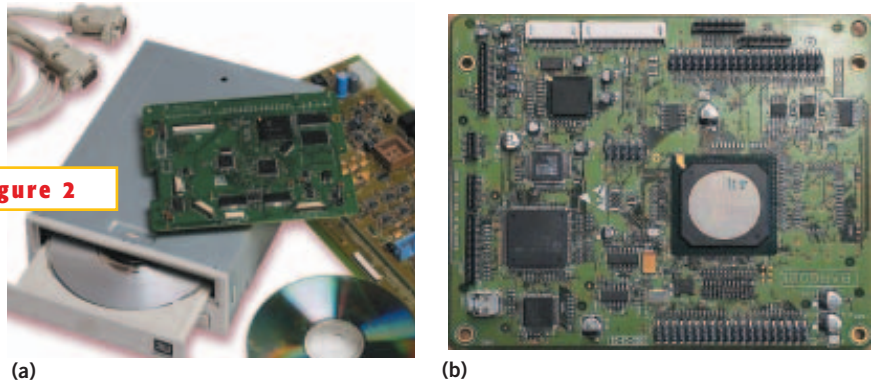
The standards battle between DVD+ and DVD− advocates shows little sign of abating, but multiformat drives supporting both formats are quickly making it an obsolete issue. Sony's DRU-500A reached production first, and the DRU-510A recently superseded the 500A. The 510A writes DVD+RW media at 4× speeds. Sony RDR-GX7 is a format-agnostic DVD-Video-recorder counterpart to the DRU-5x0A computer DVD burners. Note that 1× speed in the DVD generation is roughly equivalent to 9× speed with CDs. Pioneer's DVR-A06 similarly supports DVD±R/RW in addition to writable CDs; previous-generation drives comprehended only the DVD− formats (**Reference 8**). And Iomega's new Super DVD Drive handles *all* DVD Forum- and DVD+RW Alliance-sanctioned formats, including DVD-RAM. Manufacturers make these pragmatic moves because they are loath to experience the high customer-return rates that purchasing incompatible drives and media cause. It's uncertain, though, whether this hybridization will spread beyond computers to DVD recorders in living rooms, because bill-of-materials cost pressure is much greater in consumer-electronics applications. The consumer-electronics market segment also has less tolerance for the additional system complexity and consequent increased potential for bugs that multiformat support causes; bugs are also harder to fix there than in PCs. Then again, high return rates might force manufacturers' hands here, too.

Manufacturers build both DVD-Audio discs and SACDs on a common DVD foundation, but their potential incompatibilities stem from dissimilar causes. Conventional SACDs store information only in the DSD (direct-stream-digital) format, which neither CD nor DVD players can interpret. Some SACDs come in a hybrid format, which, similar to a dual-layer, pressed DVD, contains both DSD and Red Book CD-formatted music variants. Audio-CD players can read the Red Book layer, but some DVD players that correctly access conventional audio CDs lock onto the DSD layer, interpret it as an incorrectly formatted DVD layer, and won't proceed. DVD-Audio discs' high-resolution and, often, MLP-encoded audio isn't directly compatible with either CD or DVD-Video players, but most DVD-Audio discs also contain a DVD-Video partition holding a PCM (pulse-code-modulation)-, Dolby Digital-, or DTS-encoded variant of the music. Another approach to broadening disc compatibility comes from Sonopress, which, employing technology licensed from DVD Plus International, claims to have figured out how to cost-effectively create a dual-sided disc containing DVD material on one side and CD content on the other.

As the DVD format matures, suppliers are seeking defensible, profitable, differentiated niches much as they previously have done with CDs. Toshiba's SD-R6012, for example, is the world's first slim DVD burner that notebook CDs can use. Because multimedia is such a dominant piece of the DVD pie, it's received much of the format-differentiation focus. Microsoft and Matsushita/Panasonic have developed the HighMAT format, which aspires to smooth the exchange of media between PCs and consumer-electronics devices. Sonic Solutions' OpenDVD defines a standard for creating DVD titles that users can edit and otherwise revise over time. And WebDVDs contain additional content that users can access when they play them on computers or network-connected DVD players.

FlexPlay's EZ-D fades to black (more accurately, dark purple) and becomes unusable in a manufacturer-adjustable

Figure 2



(a) (b)

Ready-for-production 8× write-speed designs for computer drives (a) and video recorders (b) will, DVD+RW Alliance members hope, lead to widespread format success (courtesy Philips).

time of eight to 60 hours after a user opens its sealed packaging and exposes it to air. Movie studios like EZ-D for several reasons: They believe they can charge more for it than a normal rental fee due to the convenience factor, because consumers need not return it or pay late fees. Also, because users can purchase it wherever they can buy movies, EZ-D puts more money into the studios' pockets and less into those of Blockbuster and Hollywood Video. Environmentalists are unhappy with the prospect of all those discs clogging landfills, and anyone who remembers the controversial and now-defunct Divx program that Circuit City bankrolled will likely see plenty of parallels in EZ-D.

FORECASTING THE FUTURE

Video is also a key application focus area for next-generation optical-storage formats, and the numerous contenders exhibit varying degrees of backward compatibility with today's disc-manufacturing lines and playback hardware and software. Targeting high-definition video, the Pixonics pHD DVD system supplements a conventional 6-Mbps DVD data stream with a separate 1.5-Mbps stream that holds the incremental data you need to transform the 480-line video images into a 1080-line presentation. Pixonics claims that pHD DVD is fully backward-compatible with today's DVD-Video and supports 2.5 hours of movie playback on a DVD-9 disc. Conventional DVD players ignore the enhanced disc's superset data, which pHD-aware devices process. Conceptually, Pixonics' approach is similar to the one that delivers greater-than-six-channel and high-resolution audio in the Digital Theater Systems DTS-ES algorithm (**Reference 9**).

A next-generation HD-DVD format that Warner Brothers proposes would also employ a conventional DVD but would migrate from MPEG-2 toward a more advanced video codec, such as MPEG-4 AVC (also known as MPEG-4 Part 10, H.264, and other names); Microsoft's Windows Media Video 9; or On2 Technologies' VP6 (**Reference 10**). This codec would allow content creators to squeeze a high-definition video presentation into roughly the same space that a standard-definition presentation employs on DVD-Video. It would require no changes to DVD-manufacturing facilities but would necessitate upgrades to consumers' DVD-playback equipment. HD-DVD is reminiscent—in both name and implementation—of Sonic Solutions' hDVD pitch of a few years ago, which the company later withdrew, claiming that it was premature for the market need.

Pixonics' and Warner Brothers' proposals alter the usage of the available storage on DVDs, but they don't increase the amount of storage (see **sidebar** "Next-generation bypasses"). Format de-

NEXT-GENERATION BYPASSES

Now that manufacturing yields are sufficiently high on pressed, dual-layer DVD-9 media, an increasing percentage of feature-rich movies come packaged in this DVD-format option instead of the DVD-5 or multisided DVD-10 alternatives, which some perceive as less consumer friendly due to their requirement for midmovie disc flipping or swapping. Writable DVDs aren't yet available in multilayer variants, though, and may never be. Instead of waiting for next-generation, higher-density optical-disc formats to appear, DVD owners who want to back up discs they've purchased have another option: software programs from companies such as 321 Studios.

The vendor's X Copy Express allows you to deselect material on the DVD-9 source disc that you don't care about, such as alternative audio tracks and special features, and, if necessary, it also transcodes the video to a lower bit rate during copying so that the resultant material will fit on one DVD-5. Alternative programs, such as InterVideo's DVD Copy and Pinnacle Systems' InstantCopy, don't directly duplicate CSS (content-scrambling-system)-encoded discs, but an easy workaround is to use a program such as the DVD Decrypter freeware to strip the CSS encoding and copy the source disc to your hard drive. Then you can use DVD Copy or InstantCopy to burn the material to the destination disc. Transcoding the video may result in perceptibly reduced image quality, but, like ripping an audio CD to lossy MP3 format, the space-slimming result may be worth the trade-off.

TABLE 1- DVD-FORMAT MAXIMUM CAPACITIES

	Characteristics	Capacity (billion bytes)
DVD-5	One side, one layer	4.7
DVD-9	One side, two layers	8.54
DVD-10	Two sides, one layer per side	9.4
DVD-14	Two sides, one layer on one side, two layers on the other side	13.24
DVD-18	Two sides, two layers per side	17.08

FOR MORE INFORMATION...

For more information on products such as those discussed in this article, contact any of the following manufacturers directly, and please let them know you read about their products in *EDN*.

Calimetrics
www.calimetrics.com

DVD Forum
www.dvdforum.org

DVD Plus International
www.dvdplusinc.com

DVD1RW Alliance
www.dvdrw.com

Flexplay Technologies
www.flexplay.com

Hewlett-Packard
www.hp.com

Imation
www.imation.com

InPhase Technologies
www.inphase-technologies.com

Iomega
www.iomega.com

JVC (Japan Victor Co)
www.jvc.com

Matsushita/Panasonic
www.matsushita.co.jp
www.panasonic.com

Microsoft
www.microsoft.com

NEC, www.nec.com

Optical Disc Corp
www.optical-disc.com

Philips,
www.philips.com

Pioneer
www.pioneerelectronics.com

Pixonics
www.pixonics.com

Plextor
www.plextor.com

Sanyo
www.sanyo.com

Sonic Solutions
www.sonic.com

Sonopress
www.sonopress.com

Sony
www.sony.com

TDK
www.tdk.com

Toshiba
www.toshiba.com

Warner Brothers
www.warnerbros.com

OTHER COMPANIES MENTIONED IN THIS ARTICLE:

Abit Computer
www.abit.com.tw

Addonics Technologies
www.addonics.com

InterVideo
www.intervideo.com

Kenwood
www.kenwood.com

Lucent Technologies
www.lucent.com

NASA, www.nasa.gov

On2 Technologies
www.on2.com

OSTA, www.osta.org

Pinnacle Systems
www.pinnaclesys.com

Silicon Image
www.siliconimage.com

321 Studios
www.321studios.com

Yamaha
www.yamaha.com

velopers can use one of two techniques to increase storage and retain the use of 650-nm wavelength lasers. Both resurrect ideas that designers first implemented on CDs. An optical-storage system could tighten the track-to-track pitch, as 700-Mbyte CDs do, or it could narrow the spacing between consecutive pits and lands, as GigaRec and HD-Burn do. (The technology that HD-Burn uses also appears on at least one manufacturer's DVD burner.) Backward-compatibility concerns may, as in the CD generation, inhibit the widespread use of either approach.

The other two dominant next-generation contenders, NEC and Toshiba's AOD (Advanced Optical Disc) and a multivendor Blu-ray approach (led by Sony and Philips), switch to a 405-nm, blue-laser wavelength, and they correspondingly can make the channel bit length and track-to-track spacing tighter than that of DVD. AOD, which stores as much as 36 Gbytes per side in a dual-layer structure, supports DVD-like numerical apertures and protective-layer thickness. Therefore, the companies claim that AOD represents an easy and inexpensive migration path for the DVD-manufacturing infrastructure. Blu-ray, in contrast, employs a wider numerical aperture and a much thinner protective layer. The thin protective layer necessitates the use of a protective cartridge housing that consumers have historically resisted with past disc formats, such as DVD-RAM. Blu-ray advocates, following the "might-makes-right" approach to establishing a de facto industry standard, have to date been more aggressive than their AOD counterparts in demonstrating prototype recorders and players. A Blu-ray high-definition video recorder from Sony is available for purchase in Japan, and Sony also introduced its blue-laser-based Optical Disc videocameras and decks at this year's NAB (National Association of Broadcasters) conference (**Figure 3**).

Regardless of the laser wavelength, Calimetrics designers believe they can squeeze as much as 3 bits' worth of information into each pit or land by more precisely controlling the laser-writing and read-back intensities and durations and, therefore, their effects on and interpretations of writable, phase-change, optical-disc materials. The company has demonstrated at various industry technical conferences the ability to extract as many as eight levels' worth of modulated data via a variety of techniques: variable pit depths and diameters, more efficient coding schemes, and others. Even more exotic are the holographic-storage techniques that Lucent Technologies spin-off InPhase Technologies employs (**Reference 12**). Holographic storage is poorly suited for some mass-storage applications; it reads and writes a significant amount of data in parallel, and it's currently a write-once approach. But the claimed storage densities are on the order of 200 Gbytes per disc, and InPhase Technologies indicates that it is nearing production with its first-generation architecture. Soon, we may finally get a chance to see whether holographic storage survives outside the laboratory.□

Figure 3

A Sony-developed high-definition video recorder (top) and Blu-ray media (bottom) are already available for sale in Japan.

The references for this article appear on the Web version at www.edn.com.

INTERFACE EVOLUTIONS AND REVOLUTIONS

With PCs migrating from parallel to SATA (serial-ATA) hard-drive interfaces, you might be wondering if it's necessary to make the same transition with optical drives. The narrower SATA cables *do* simplify interconnect routing and improve airflow, but optical drives don't yet deliver the level of sustained performance that begs for SATA's 150-Mbyte/sec transfer-rate capabilities. Preparing for the high-speed DVD and follow-on blue-laser future, however, the SATA standardization body recently added ATAPI (Advanced Technology Attachment Packet Interface) support to its specifications, and both host- and peripheral-side chips from Silicon Image support the SATA enhancement.

If you'd like to convert your parallel ATA-based optical drives to SATA, you can use Abit's Serillel 2, and PCI-based internal and external SATA-interface add-in cards are available from numerous suppliers (**Figure A**). Addonics Technologies even makes a CardBus-based SATA card for notebook PCs. SCSI (Small Computer Systems Interface) gets lost in this shuffle; the widespread availability of high-speed ATA buses for internal connections and both USB Version 2.0 and IEEE-1394 for externally tethered drives means that even historically staunch SCSI advocate Plextor hasn't yet bothered to introduce DVD-inclusive optical drives with the SCSI option.

Figure A

Abit's adapter turns any ATA or ATAPI peripheral into a Serial ATA equivalent (top), and Addonics Technologies' adapter enables you to use Serial ATA peripherals with systems containing CardBus slots (bottom).

AUTHOR'S BIOGRAPHY

Technical editor Brian Dipert wishes that the DVDs he rents from Netflix didn't occasionally show up with fingerprints and scratches all over them. Reach him at 1-916-454-5242; bdipert@edn.com, and www.bdipert.com.