



HIGH-RESOLUTION-DISC FORMATS
FIGHT EACH OTHER,
CONSUMERS PUSH BACK

SUBPAR WARS

WITH BLUE-LASER COMPETITORS BLU-RAY AND HD DVD BOTH GEARING UP FOR HIGH-VOLUME PRODUCTION, A CLEAR PICTURE OF THE FORMAT WINNER HASN'T YET EMERGED. RED-LASER FORMATS REMAIN CREDIBLE ALTERNATIVES IN SOME APPLICATIONS, BUT BOTH USAGE-RIGHTS RESTRICTIONS AND DISPLAY-AND-VISION LIMITATIONS PUT ALL THEIR FUTURES IN DOUBT.

Notable progress and pending production plans of the vigorously competing Blu-ray Disc and HD DVD camps were, in many observers' eyes, *the* key story of January's CES (Consumer Electronics Show) and therefore warranted an update of a topic *EDN* covered less than a year ago (**references 1 and 2**). By mid-January, Toshiba and its partners were gearing up to begin shipping HD DVD PC drives, living-room players, and media in March, with the earliest planned Blu-ray drives and players at significantly higher prices following shortly thereafter. Meanwhile, although the Blu-ray-inclusive PlayStation 3 made no meaningful appearance at CES, a press event, rumored to be taking place just before this article's publication date, may clear up at least some of the lingering format questions (**Figure 1 and Reference 3**).

Prerecorded video constitutes a dominant percentage of the total market opportunity for today's red-laser-based DVDs. Presumably, therefore, it will have a similar influence on next-generation blue-laser media; the Blu-ray and HD DVD camps' intensive courting of movie studios' mind share and endorsement reflects this supposition. Other applications, such as user-archived video, game consoles, and PC-file storage and backup, have a tangible role to play, too. They will help define which, if any, of the next-generation optical-disc formats will break out of the low-volume niches that perpetually plagued their underperforming audio precedes-

sors, SACD (Super Audio Compact Disc) and DVD-Audio (**Reference 4**). But the format that wins in the home-movie-viewing room stands a solid chance of also winning elsewhere.

Unfortunately for next-generation-format promoters, this battleground pits Blu-ray and HD DVD not only against each other, but also against more modest, evolutionary, high-definition red-laser-DVD alternatives. And, most important, it pits them *all* against consumers' market-stalling potential none-of-the-above vote, if they don't discern a benefit from any of the contenders. The consumers' backlash, if it happens, doesn't necessarily mean that, by 2010, they'll

all still be buying the same MPEG-2-based red-laser DVD movies they're watching now. After all, consumers' regular upgrades of their possessions ensure the continued viability of the tech industry. However, without another compelling reason for replacement, suppliers' only motivating weapon is cutting prices, a scenario that would be fiscally unpalatable to all stages of the optical-disc food chain.

THE PHANTOM MENACE?

The fundamental tenet of Blu-ray backers' arguments for their preferred format is the medium's higher per-layer capacity of 25 Gbytes, versus 15 Gbytes for HD DVD and 4.7 Gbytes for DVD. At January's Storage Visions conference, for example, Pioneer Electronics' Sandra Benedetto positioned Blu-ray's five-times-greater per-layer capacity over DVD as the logical next step in the optical-disc progression that began with the six-times-greater-capacity jump from CD to single-layer DVD. The futureproofing more-bits-is-better pitch is perhaps most relevant for users that are employing optical discs as backup media for their computer hard drives, thereby in part explaining Dell's strong support for the format. The capacities of modern hard-disk drives dwarf those of single-layer, 4.7-Gbyte DVDs or, for that matter, even the much more expensive, 9-Gbyte, dual-layer variants. Dell's Web site reveals that even the lowest priced desktop PC in the company's suite of product offerings contains a 40-Gbyte hard-disk

AT A GLANCE

▶ Blu-ray's fortunes hinge on capacity needs, studio enthusiasm, and the PlayStation 3.

▶ HD DVD needs to secure more extensive hardware support to sustain its momentum.

▶ Red-laser alternatives make blue laser's success uncertain.

▶ Consumer backlash and downloadable-media-delivery alternatives may doom all format options.

drive; multiple suppliers are now shipping 500-Gbyte, 3.5-in. hard disks, with even larger capacities soon to arrive, courtesy of perpendicular-magnetic-recording technology. However, hard-disk-drive backup to an external hard-disk drive or network-attached storage is in many scenarios a compelling alternative to optical-disc backup for cost, performance, and other reasons.

The more-bits-is-better pitch is also compelling when you're considering archiving HDTV material to optical storage. Over-the-air HDTV's 19.39-Mbps peak bit rate corresponds to roughly 17 Mbps of audio-plus-video information, which translates to approximately 8 Gbytes per hour of required

storage capacity. Recently announced high-definition PVR (personal-video-recorder) chip sets from companies such as LSI Logic and Magnum Semiconductor store the incoming, unaltered Dolby Digital audio and MPEG-2 video bit streams on the system's hard-disk drive (**Reference 5**). However, to ensure that they can archive a consumer-acceptable amount of content to DVD—that is, more than a half hour's worth per layer—they must downscale the video to standard-definition resolution, and some of them also transcode the video to a more efficient format, such as an MPEG-4 variant. Blue-laser media would obviate the need for downscaling and transcoding; each layer of a Blu-ray disc, for example, could hold roughly three hours' worth of MPEG-2-formatted HDTV.

PlayStation 3 promoters claim that a single dual-layer DVD's 9-Gbyte capacity is insufficient to house the ornate high-resolution games that modern consoles can render and that consumers expect. Microsoft disputes that contention, and a recently published independent analysis backs the company's stance (**Reference 6**). The Xbox 360 team points to mechanisms that extend the relevance of low-cost, "pressed," dual-layer DVD media (**Reference 7**). These mechanisms include a robust game-development environment, which ensures the elimination of textures and other content that designers create during development but don't use in the final title. Another mechanism, the use of advanced techniques for dynamic-content rendering, includes procedural synthesis, which more efficiently uses the available disc capacity. A third mechanism relies on Xbox Live online to deliver demos; bit-gobbling, cut-scene cinematics; and additional material that might otherwise need to reside on the disc.

Despite abundant rumors to the contrary, no shipped or announced Xbox 360 title so far requires more than one DVD-9 disc. Skeptics point out that, with less than six months' worth of titles from which to draw data, it's too early to come to a definitive conclusion. However, although second- and subsequent-generation titles will be more elaborate than

their launch-targeted predecessors, the successors' less intense development cycles will combine with developers' increased experience on the console and its tool sets and lead to more efficient use of disc capacity.

Will blue-laser-based media be necessary for high-resolution prerecorded-movie content on pressed discs, and, if so, will Blu-ray's per-layer capacity edge over HD DVD be advantageous in this application? The answer to both questions is "it depends on the codec." Sony Pictures recently announced that it will master its Blu-ray titles using the more-than-10-year-old MPEG-2 video codec (**Reference 8**). This decision enables Sony to employ mature encoding tools and to avoid paying incremental royalties to companies holding patents on the more bit-efficient MPEG-4 AVC and VC-1 codecs that Blu-ray also supports. At least one more motivation probably exists: If you have the extra capacity and if you're trying to justify it, why not employ a video codec that best fills up that capacity?

Last fall, Warner Brothers Studios announced its nonexclusive backing of Blu-ray. A historically staunch DVD Forum and Toshiba ally, Warner Brothers insisted on the addition of a relaxed-pitch variant of Blu-ray in the standard as a condition of its endorsement. In effect, Warner Brothers successfully lobbied for the inclusion of low-cost, red-laser-compatible media in a Blu-ray form factor. This media would employ a more advanced video codec, such as VC-1, reflecting the company's longstanding relationship with Microsoft, to deliver a single-disc full version of a high-resolution title. Multiple industry insiders intimate, off the record, that Warner Brothers is currently devoting all of its development energy to HD DVD and backed Blu-ray only as a hedge. Another notable endorsement oddity is the fact that, although Apple is a member of the Blu-ray Disc Association, the currently shipping version of Apple's DVD Studio Pro media-development application supports HD DVD. Finally, Fox Studios successfully lobbied for Blu-ray to recognize additional DRM (digital-rights-management) mecha-

A NEW HOPE

How low an average bit rate can you losslessly compress a high-resolution video stream down to, and with what video codec, and still retain a high-quality result on red-laser-DVD media? I'll spend the next few months attempting to answer these questions with a suite of test clips; a plethora of software on Macs and PCs; an I-O Data player; and CRTs, LCDs, and plasma displays. Watch for the answers, both in the Brian's Brain blog (www.edn.com/briansbrain) and in future print write-ups.

nisms beyond AAC (advanced access-content system) as a condition of its endorsement (Reference 9).

THE EMPIRE STRIKES BACK

Don't prematurely conclude that Blu-ray's on the ropes and HD DVD is the pending champion. Granted, Toshiba announced at CES that it would begin shipping its entry-level HD-A1 HD DVD player at \$499 in March (Figure 2). The least expensive Blu-ray player, Samsung's BD-P1000, will enter the market in April at \$1000, according to the company. Depending on which company's CES quote you prefer, Pioneer's BDP-HD1 will enter production in April, May, or June, with a target price of \$1800. However, it is unclear whether Blu-ray drives' higher prices reflect increased bill-of-materials costs or an attempt to extract high profits from overenthusiastic early adopters of the technology. In December, Pioneer also announced that shipments of its first-generation PC-targeted BDR-101A drive would begin in the first quarter of this year. The full-sized unit supports only single-layer Blu-ray media and can't read or write CDs.

HD DVD's hardware presence at this year's CES was understated compared with that of Blu-ray. Although leading computer and consumer-electronics supplier Toshiba can carry its championed format forward to a point, the DVD

ALTHOUGH TOSHIBA CAN CARRY ITS CHAMPIONED FORMAT FORWARD TO A POINT, THE DVD FORUM NEEDS BROADER INDUSTRY BACKING TO LEAD HD DVD TO THE FINISH LINE.

Forum needs broader and deeper industry backing to lead HD DVD to the finish line. The organization has, however, picked up several key endorsements in recent months. Intel and Microsoft late last year both threw their substantial weight behind HD DVD, citing the format's support for MMC (Mandatory Managed Copy), a DRM mechanism that allows consumers to make legal copies of discs they purchase. Microsoft followed up its endorsement with the CES unveiling of an Xbox 360 HD DVD drive, likely in a slim notebook-PC-like form factor, that will enter production later this year. The company points out that it intends the drive only for movie playback, not for games.

Hewlett-Packard, formerly a staunch

Blu-ray advocate, also backpedaled late last year and announced that it would bless both formats. The company's reversal of position occurred after the Blu-ray Disc Association indicated that, although it intended to eventually support MMC, HP's request for inclusion of the Microsoft-developed iHD (interactive-high-definition) layer was still under review. According to Blu-ray spokesman Andy Parsons, although the association is considering HP's request for interactivity, the group is still leaning toward the use of Java. "We are taking their request seriously but are not willing to delay the launch. I'm not saying we would not implement what they've requested, but it's not going to stop the format at this time," he told Reuters (Reference 10). Pragmatically, although Microsoft didn't indicate a preference for iHD when it backed HD DVD, the company's long-time anti-Java bias was probably also a factor in its decision. Dependence on Sun's Java runs counter both to Microsoft's ambitions for the PC-in-the-living-room Windows XP Media Center Edition and to partner Intel's VIIV efforts.

Although the press has paid much attention to Blu-ray's exclusive endorsement by movie studios Lions Gate, Sony Pictures, and Fox Studios, HD DVD also has an "exclusive" feather in its cap: Universal Studios. More generally, at CES, HD DVD-format backers claimed that



(a)



(b)

Figure 1 The PlayStation 3 may look like a game console, and it is, but it's also a key platform by which Blu-ray supporters plan to advance their media ambitions (a). Stand-alone players, for the moment at premium prices, will also play a key role in the format's prospects for success (b).



(a)



(b)



(c)



(d)

Figure 2 Toshiba and other HD DVD promoters plan to begin shipping players (a), full-sized computer drives (b), slim-sized computer drives (c), and drive-inclusive computers (d) near press time (a, c, and d: courtesy Toshiba; b courtesy NEC).

they would release nearly 200 titles by the year-end, with close to 50 of those available by May. The studios at the CES event represented more than half of the movies ever made. However, besides Warner Brothers, two other HD DVD advocates are also hedging their format bets. Last November, HD DVD-promoter NEC merged its PC-optical-disc-drive operations with Blu-ray developer Sony, following in the footsteps of HD DVD-backer Toshiba and Blu-ray-backer Samsung, which had in September 2003 combined their optical-disc-drive programs.

ATTACK OF THE NEAR-CLONES

The development of players that handled both DVD-Audio and SACD provided the resolution to that format war. However, only a small percentage of DVD players today support either format, probably at least partially because of the

format standoff. Meanwhile, no PC optical drives can play back SACD. Could a dual-format, high-resolution DVD player effect a similar détente on the Blu-ray-versus-HD DVD battle, and at what cost for adoption? The recent unveiling of dual-format-controller ICs from companies such as Atmel and Broadcom may indicate that such a player could emerge. But, unlike past multifORMAT challenges, the situation is more complex this time around; its closest parallel is the mid-1990s appearance of drives supporting both CD and DVD media.

Those drives needed to handle both infrared, 780-nm, CD- and red, 650-nm, DVD-laser wavelengths and to focus that laser at both the 1.2-mm-CD and 0.6-mm-DVD levels within the optical media. Expand that format plethora to comprehend HD DVD, and you need to encompass the 405-nm, blue-violet-laser

wavelength. However, HD DVD retains a common disc structure with DVD, enabling the use of a single-lens optical head for both. Further expanding the format list to include Blu-ray or substituting Blu-ray for HD DVD, however, complicates the lens arrangement, because you now also need to focus the laser at a 0.1-mm level.

HD DVD's evolutionary affiliation with DVD has long been the fundamental tenet of its advocates' arguments, much as Blu-ray's promoters have stayed "on message" with their preferred format's higher per-layer capacity. The DVD/HD DVD similarity is a plus for drive and media manufacturers, which would prefer to leverage investments they've already made into the DVD infrastructure. Media-content rights-holders, on the other hand, don't necessarily view this similarity as a benefit, thereby partially

explaining the strong studio backing of Blu-ray. The widespread piracy of both CDs and DVDs has stung these rights-holders, who don't relish the thought of those mass-production lines quickly and cheaply migrating to pirated HD DVDs.

With neither Blu-ray nor HD DVD an obvious winner at this point, and with the standoff showing no signs of a near-term resolution, might another high-resolution video format seize the spotlight? In fact, a third contender *already* exists. Using a more modern video-codec alternative to MPEG-2, such as MPEG-4 AVC, also known as MPEG-4 Part 10 and as H.264, or VC-1, also known as WMV9, you can shoehorn a high-quality, high-resolution, long-playing movie onto a conventional single- or dual-layer red-laser DVD. For example, you can buy WMV9-encoded DVDs, such as *Standing in the Shadows of Motown*, *Step Into Liquid*, *Terminator 2: Judgment Day*, and a series of films from Imax. DRM issues currently restrict their playback to PCs, including living-room-based units, but manufacturers could add appropriate DRM support to the next generation of DVD players.

WMV9 is the codec choice of HDNet, which has begun offering its high-resolution, DRM-free content for sale on red-laser DVDs. Disc players based on the Taiwanese, red-DVD-based FVD (forward-versatile-disc) format are now ramping into initial production, and the porn industry is reportedly also beginning to ship high-resolution video content on red-laser DVDs. Pornography (no matter what you might think of its morality) has had a significant effect on driving the development and direction of technology over the years. Examples include its influence on the VHS-versus-Beta-format wars of the early 1980s, on DVD's multiangle feature, and on the streaming-media industry. Meanwhile, the China-based EVD (Enhanced Versatile Disc) Consortium soldiers on with the development of its formerly VP6-based, now high-resolution MPEG-2-based red-laser DVD format, with increased capacity courtesy of VMD (versatile-multilayer-disc) technology.

Buffalo Technology bases its Link-Theater DVD player on Sigma Designs' EM8620L decoder chip, and I-O Data's



Figure 3 I-O Data's SRDVD-100U is a pivotal piece of my video-codec-testing suite.

AVLP2/DVDLA and SRDVD-100U also employ this video processor (Figure 3). These players support DRM-free high-definition WMV9 and DivX playback, both from red-laser DVDs and over a network connection; DivX is a "kissing cousin" of MPEG-4 Advanced Simple Profile. Equator Technologies, now part of Pixelworks, has also for several years demonstrated prototype DVD players that support high-definition WMV and MPEG-4 content. A much larger group of DVD players today supports standard-definition DivX, primarily to serve people who download movies from file-sharing services and other Internet sites and people who rip and transcode dual-layer, pressed DVDs, in both cases burning the resultant material onto single-layer, recordable DVDs. And manufacturers are now shipping the next generation of chips supporting MPEG-4 AVC in decoding, encoding, and decoding-plus-encoding flavors. Ambarella, for example, claims that MPEG-4 AVC generally has higher quality than WMV9 at equivalent bit rates and that MPEG-4 AVC has 2.5 times the coding efficiency of MPEG-2 at equivalent resolutions, frame rates, and delivered quality.

A DISTURBANCE IN THE FORCE

Or maybe *none* of the high-resolution-disc alternatives will achieve widespread

prominence, due to alternative delivery mechanisms, consumer backlash, or a combination of these two factors. Microsoft Chairman Bill Gates, during an interview with Princeton University's student newspaper last October, in which he explained Microsoft's backing of HD DVD over Blu-ray, said: "For us, it's not the physical format. Understand that this is the last physical format there will ever be. Everything's going to be streamed directly or on a hard disk. So, in this way, it's even unclear how much this one counts" (Reference 11). Reflecting his forecast, you can now rent and download high-definition Hollywood movies over the Internet from vendors such as CinemaNow and Movielink. Judging from announcements and rumors at CES, the list of sources will markedly expand in the near future, following in the footsteps of the exploding digital-audio-download market (Reference 12).

Consumer backlash could occur for any number of reasons. Several recent studies, among them one that the BBC (British Broadcasting Corp) published in September 2004, have attempted to measure just how much resolution an average viewer can discern with various display technologies, screen sizes, aspect ratios, and viewing distances. The BBC study concluded, for example, that a 720-line video presentation suffices for a viewing distance of 9 feet with a 50-in.-diagonal

display (Reference 13). As *Sound & Vision* magazine's Technical Editor David Ranada said in his summary of the BBC report, "Change either the viewing distance or the screen size, and the resolution requirement changes. Sit closer or use a bigger screen, and you need greater screen/signal resolution. Sitting at 9 feet, you start needing 1080 lines to avoid seeing the pixel structure once the screen size reaches around 56 inches" (Reference 14).

However, consider the flip side of Ranada's observation. If a consumer's screen is smaller than 50 in. or if he sits farther than 9 feet away from it, the added resolution potential of a 720-line, high-definition image will go to waste. It will be indistinguishable from today's 480-line DVDs. How many consumers own 50-in. or larger TVs, and how many of them view their TVs from closer than 9 feet, except perhaps on a consumer-electronics store's showroom floor? Not many. Therefore, how many of them will be willing to replace their DVD player with a significantly more expensive, high-definition version and all of their movies with even more expensive, high-definition versions? Again, probably not many.

One of the differentiating points the Blu-ray camp tried to make at CES, in positioning itself versus HD DVD, was that some of the announced Blu-ray players support 1080p single-link HDMI (high-definition-multimedia-interface) outputs, whereas the first crop of HD DVD players supports single-link resolutions only as high as 1080i. The term "1080i" refers to a 1080-line, 1920×1080-pixel, 60-field/sec, interlaced-scan video presentation, and "1080p" refers to 1080-line, 60-frame/sec, progressive-scan video. This difference doesn't reflect a fundamental format limitation; both Blu-ray and HD DVD can store 1080p video. It's also not a fundamental HDMI limitation; the interconnection's 165-MHz peak frame rate supports 1080p.

Although the HDMI specification supports frame rates as high as 165 MHz,

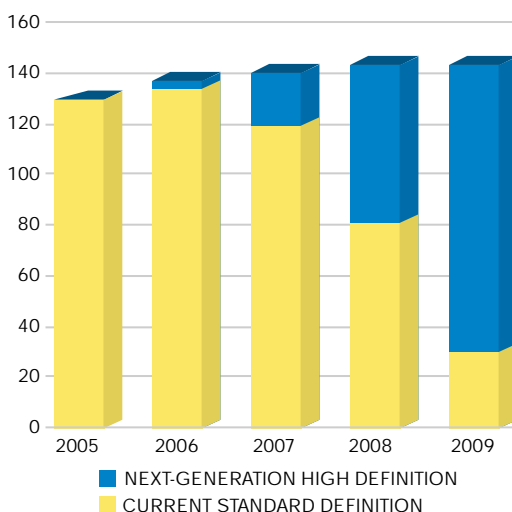


Figure 4 This forecast shows minimal total market growth, and it doesn't comprehend standard-definition DVD recorders and DVD-playback-capable game consoles (courtesy iSuppli).

that peak rate isn't a requirement for certification. HDMI transmitters and receivers synchronize up at a compatible speed when you first connect them, based on the receiver's EDID (extended-display-identification data). If a receiver supports rates only as high as 100 MHz, for example, the HDMI certification lab confirms that rate as the upper limit. TVs from many suppliers can't currently handle 1080p HDMI inputs, so a 1080p-capable Blu-ray player would need to down-throttle to 1080i to work with them. And, even if a display accepts 1080p, the video processor might immediately discard half of the information to simplify its job, effectively transforming the signal into 1080i. Future HD DVD players will likely be 1080p-capable; the fact that they're not now is negligible.

Consumers will likely be able to experience high-resolution video from a Blu-ray or HD DVD player only if it connects to a display over a content-protected HDMI link. The AACCS standards body publicly admitted in mid-January that its specifications include a flag that, if content providers set it, downscales video to 540-line resolution before outputting it over analog outputs, such as RGB or component video (Reference 15). This "feature" means that anyone who owns a non-HDMI-equipped display is out of luck when it comes to viewing high-res-

olution flag-set material.

Consumer backlash may also come from the new AACCS content-protection scheme that both Blu-ray and HD DVD have embraced. A small but tangible percentage of the DVD-viewing public currently employs CSS (content-scrambling-system)-circumventing software, to back up DVDs they've legally acquired, to copy them to a laptop-computer hard-disk drive, or to illegally duplicate DVDs from friends, family, or rental services. The developers of AACCS claim that the technology will put a stop to such shenanigans. Consider, though, the following quote from Jon Johansen (also known as "DVD Jon"), who

developed the initial De-CSS (decryption-of-CSS) algorithm (Reference 16). "AACCS, like CSS, will be a success—not at preventing piracy. That's not the primary objective of any DRM system. Anyone who has read the CSS license agreement knows that the primary objective is to control the market for players. Don't you just love when your DVD player tells you 'this operation is prohibited' when you try to skip the intro?"

Fox successfully lobbied the Blu-ray group for additional content-protection mechanisms, whose details are not yet public, beyond AACCS. Also, HD DVD supporters complained off the record at CES about the fact that Blu-ray advocates on the AACCS board had, by repeatedly postponing the finalization of the specification, consumed much of the production-schedule lead that HD DVD otherwise would have had over Blu-ray. Turn-about is fair play, however: The Blu-ray content-protection enhancements that Fox demanded are reportedly among the key reasons that the PlayStation 3 is late to market.

AACCS, unlike its CSS predecessor, implements three key aspects necessary for any robust DRM scheme: authentication, revocation, and renewal/upgrade (Reference 17). But under what monitoring and delivery scheme will manufacturers implement this content protec-

tion? AACs promoters repeatedly have stated that it will be unnecessary, either occasionally or constantly, to connect a Blu-ray or HD DVD player to the Internet. An executive of a major semiconductor supplier, however, paints a different picture. Players *will* need to regularly “dial in” to confirm their conformance and to adjust their features, he says off the record. Additionally, movie studios are reportedly, for example, considering releasing a single pressing of a high-resolution DVD worldwide as a cost-savings move. In this scenario, language-specific soundtracks, titles, and other viewer-tailored content would dynamically stream down to the player over the Internet, rather than reside on disc. Reflecting this vision, Toshiba’s ad for its first-generation HD DVD players touts their “Internet connectivity for downloading soundtracks and bonus content.”

FOR MORE INFORMATION

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Blu-ray- and HD DVD-specific media could end up being dead on arrival, as was their D-VHS high-resolution video predecessor. Eventually, in this worst-case scenario, studios will release double-sided discs with high-resolution video on one side and standard-definition DVD content on the other, much as music labels are migrating from CDs to DualDisc at little to no price premium over CDs; this strategy is probably a far less lucrative one than the music labels originally envisioned. And consumers will most likely underwhelmingly embrace Blu-ray and HD DVD players. Consumers will probably buy them only when their DVD players break down, and then only when the price difference between them and a less-than-\$100 replacement DVD player is minimal to nonexistent. This forecast is admittedly gloomy, and, for the continued vibrancy of the semiconductor industry, I hope it's too skeptical (**Figure 4**). But I find it difficult to conclude otherwise, particularly without detailed information on PlayStation 3 and Xbox 360 HD DVD drive costs, prices, production schedules, and volume ramps.EDN

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