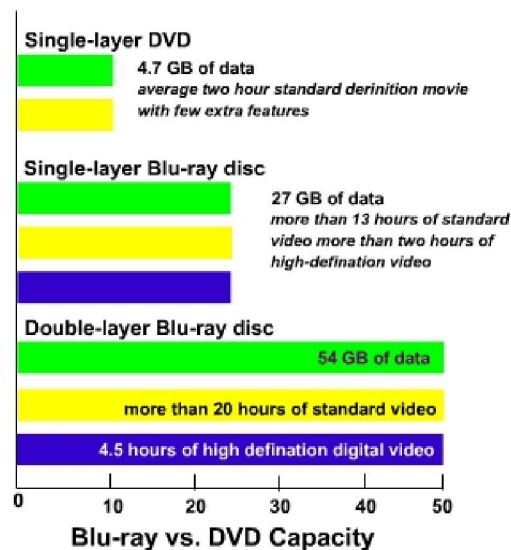


BLU-RAY : THE NEXT GENERATION DIGITAL VIDEO DISK

Introduction

1. The Blu-ray name is a combination of "blue," for the color of the laser that is used, and "ray," for optical ray. The "e" in "blue" was purposefully left off, according to the manufacturers, because an everyday word cannot be trademarked. With their high storage capacity, Blu-ray discs can hold and play back large quantities of high-definition video and audio, as well as photos, data and other digital content. A current, single-sided, standard DVD can hold 4.7 GB (gigabytes) of information. That's about the size of an average two-hour, standard-definition movie with a few extra features. But a high-definition movie, which has a much clearer image, takes up about five times more bandwidth and therefore requires a disc with about five times more storage. As TV sets and movie studios make the move to high definition, consumers are going to need playback systems with a lot more storage capacity.



2. Blu-ray is the next-generation digital video disc. It can record, store and play back high-definition video and digital audio, as well as computer data. The advantage to Blu-ray is the sheer amount of information it can hold: A single-layer Blu-ray disc, which is roughly the same size as a DVD, can hold up to 27 GB of data that's more than two hours of high-definition video or about 13 hours of standard video. A double-layer Blu-ray disc can store up to 50 GB, enough to hold about 4.5 hours of high-definition video or more than 20 hours of standard video. And there are even plans in the works to develop a disc with twice that amount of storage.

Origins

3. Philips and Sony started two projects applying the new diodes: UDO (Ultra Density Optical) and DVR Blue (together with Pioneer), a format of rewritable discs which would eventually become Blu-ray Disc (more specifically, BD-RE). The core technologies of the formats are essentially similar. The first DVR Blue prototypes were unveiled at the CEATEC exhibition in October 2000. Because the Blu-ray Disc standard places the data recording layer close to the surface of the disc, early discs were susceptible to contamination and scratches and had to be enclosed in plastic cartridges for protection. In February 2002, the project was officially announced as Blu-ray, and the Blu-ray Disc Association was founded by the nine initial members.

4. The first consumer devices were in stores on April 10, 2003. This device was the Sony BDZ-S77; a BD-RE recorder that was made available only in Japan. The recommended price was US\$3800; however, there was no standard for pre-recorded video and no movies were released for this player. The Blu-ray Disc standard was still years away as a newer, more secure DRM system was needed before Hollywood studios would accept it, not wanting to repeat the failure of the Content Scramble System used on DVDs.

Blu-ray Disc format finalized

5. The Blu-ray Disc physical specifications were finished in 2004. In January 2005, TDK announced that they had developed a hard coating polymer for Blu-ray Discs. The cartridges, no longer necessary, were scrapped. The BD-ROM specifications were finalized in early 2006. AACS LA (Advance Access Content System Licensing Administrator), a consortium founded in 2004, had been developing the DRM platform that could be used to securely distribute movies to consumers. However, the final AACS standard was delayed, and then delayed again when an important member of the Blu-ray Disc group voiced concerns. At the request of the initial hardware manufacturers, including Toshiba, Pioneer and Samsung, an interim standard was published which did not include some features, like managed copy.

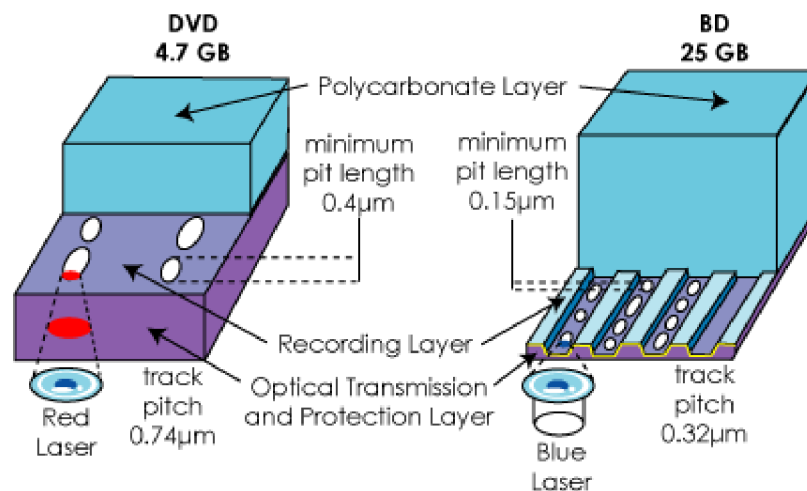
Building a Blu-ray Disc

6. Blu-ray discs not only have more storage capacity than traditional DVDs, but they also offer a new level of interactivity. Users will be able to connect to the Internet and instantly download subtitles and other interactive movie features. With Blu-ray, one can:

- record high-definition television (HDTV) without any quality loss
- instantly skip to any spot on the disc
- record one program while watching another on the disc
- create playlists
- edit or reorder programs recorded on the disc
- automatically search for an empty space on the disc to avoid recording over a program
- access the Web to download subtitles and other extra features

Discs store digitally encoded video and audio information in pits spiral grooves that run from the center of the disc to its edges. A laser reads the other side of these pits the bumps to play the movie or program that is stored on the DVD. The more data that is contained on a disc, the smaller and more closely packed the pits must be. The smaller the pits (and therefore the bumps), the more precise the reading laser must be.

7. Unlike current DVDs, which use a red laser to read and write data, Blu-ray uses a blue laser (which is where the format gets its name). A blue laser has a shorter wavelength (405 nanometers) than a red laser (650 nanometers). The smaller beam focuses more precisely, enabling it to read information recorded in pits that are only 0.15 microns (μm) long -- this is more than twice as small as the pits on a DVD. Plus, Blu-ray has reduced the track pitch from 0.74 microns to 0.32 microns. The smaller pits, smaller beam and shorter track pitch together enable a single-layer Blu-ray disc to hold more than 25 GB of information about five times the amount of information that can be stored on a DVD.



DVD Vs. Blu-Ray Construction

Each Blu-ray disc is about the same thickness (1.2 millimeters) as a DVD. But the two types of discs store data differently. In a DVD, the data is sandwiched between two polycarbonate layers, each 0.6-mm thick. Having a polycarbonate layer on top of the data can cause a problem called birefringence, in which the substrate layer refracts the laser light into two separate beams. If the beam is split too widely, the disc cannot be read. Also, if the DVD surface is not exactly flat, and is therefore not exactly perpendicular to the beam, it can lead to a problem known as disc tilt, in which the laser beam is distorted. All of these issues lead to a very involved manufacturing process.

Signal to Noise Limitations

8. Both drive and media can limit the achievable read channel signal to noise. As the density is increased additional constraints will come into play. Of particular concern are the following:

- Smaller laser spot sizes associated with higher NA optics or shorter wavelengths will necessitate lower read powers to prevent the possibility of thermal damage to the media. This plus the lower responsivity of the signal detectors at shorter wavelengths reduces the available signal.
- As the optical resolution of the pick-up increases, the read beam is able to resolve smaller noise sources and in principle may be able to resolve the grain structure of phase change materials. In the case of re-writable phase change materials jitter associated with growth of the crystalline phase into the amorphised marks is an issue for system performance even at current densities.
- Higher data rates requiring high bandwidth electronics in both the write and read channels impose more severe problems for the analogue electronics at the optical pick-up. More sophisticated data coding (such as the use of multi-level recording) would require even higher signal to noise.

Laser and optics

9. Blu-ray Disc uses a "blue" (technically violet) laser operating at a wavelength of 405 nm to read and write data. Conventional DVDs and CDs use red and near infrared lasers at 650 nm and 780 nm respectively. The blue-violet laser's shorter wavelength makes it possible to store more information on a 12 cm CD/DVD sized disc. The minimum "spot size" on which a laser can be focused is limited by diffraction, and depends on the wavelength of the light and the numerical aperture of the lens used to focus it. By decreasing the wavelength, increasing the numerical aperture from 0.60 to 0.85 and making the cover layer thinner to avoid unwanted optical effects, the laser beam can be focused to a smaller spot. This allows more information to be stored in the same area. For Blu-ray Disc, the spot size is 580 nm. In addition to the optical improvements, Blu-ray Discs feature improvements in data encoding that further increase the capacity.

Hard-coating technology

10. Because the Blu-ray Disc data layer is closer to the surface of the disc, compared to the DVD standard, it was at first more vulnerable to scratches. The first discs were housed in cartridges for protection. TDK was the first company to develop a working scratch protection coating for Blu-ray Discs. It was named Durabis. In addition, both Sony and Panasonic's replication methods include proprietary hard-coat technologies. Sony's rewritable media are spin-coated with a scratch-resistant and antistatic coating. Verbatim's recordable and rewritable Blu-ray Disc discs use their own proprietary hard-coat technology called ScratchGuard.

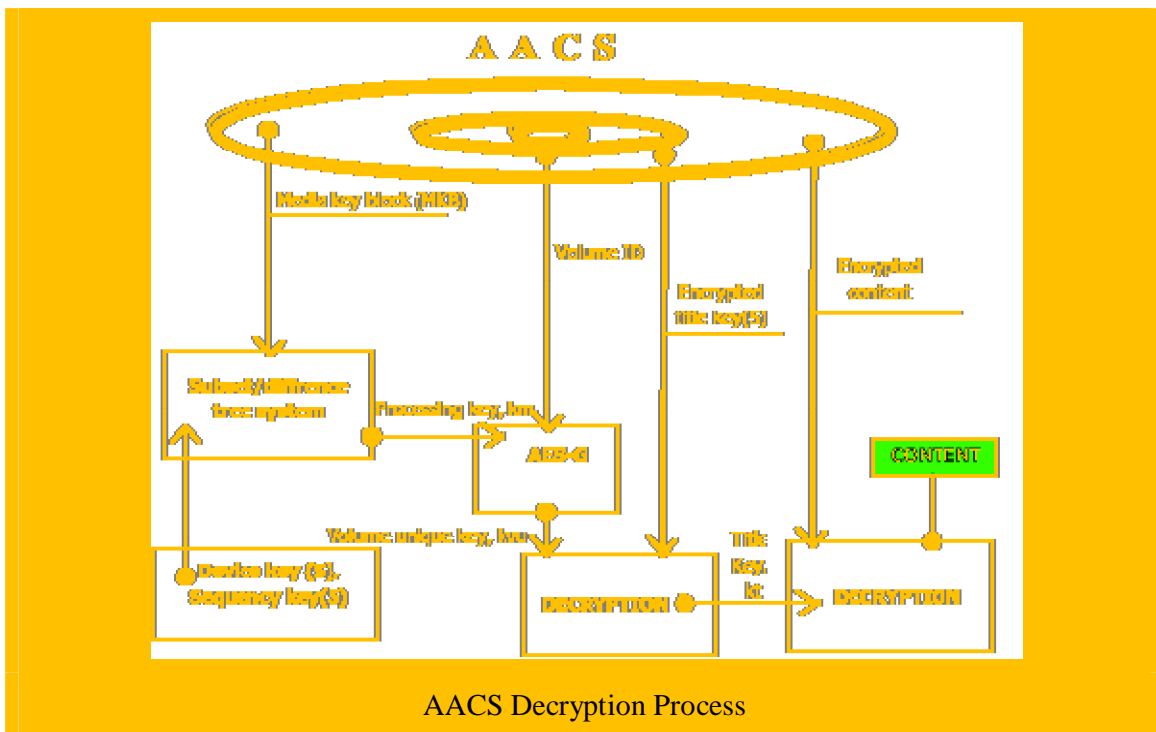
Software Standards : Codecs

11. Codecs are compression schemes that store audio and video more efficiently, optimizing for either low space usage or quality per megabyte. There are both lossy and lossless compression techniques. The BD-ROM specification mandates certain codec compatibilities for both hardware decoders (players) and the movie-software (content). For video, all players are required to support MPEG-2, H.264/MPEG-4 AVC, and SMPTE VC-1. MPEG-2 is the codec used on regular DVDs, which allows backwards compatibility. MPEG-4 AVC was

developed by MPEG and VCEG. VC-1 is a codec that was mainly developed by Microsoft. BD-ROM titles with video must store video using one of the three mandatory codecs. Multiple codecs on a single title are allowed.

12. The choice of codecs affects the producer's licensing/royalty costs, as well as the title's maximum runtime, due to differences in compression efficiency. Discs encoded in MPEG-2 video typically limit content producers to around two hours of high-definition content on a single-layer (25 GB) BD-ROM. The more advanced video codecs (VC-1 and MPEG-4 AVC) typically achieve a video runtime twice that of MPEG-2, with comparable quality. Modern releases are now often encoded in either MPEG-4 AVC or VC-1, allowing film studios to place all content on one disc, reducing costs and improving ease of use. For users recording digital television programming, the recordable Blu-ray Disc standard's initial data rate of 36 Mbit/s is more than adequate to record high-definition broadcasts from any source (IPTV, cable/satellite, or terrestrial).

13. At the 2005 JavaOne trade show, it was announced that Sun Microsystems' Java cross-platform software environment would be included in all Blu-ray Disc players as a mandatory part of the standard. Java is used to implement interactive menus on Blu-ray Discs, as opposed to the method used on DVD video discs, which uses pre-rendered MPEG segments and selectable subtitle pictures, which is considerably more primitive and rarely seamless. The inclusion of a Java Virtual Machine as well as network connectivity in some BD devices will allow updates to Blu-ray Discs via the Internet, adding content such as additional subtitle languages and promotional features that are not included on the disc at pressing time. This Java Version is called BD-J and is a subset of the Globally Executable MHP (GEM) standard. GEM is the worldwide version of the Multimedia Home Platform standard.



Digital rights management

14. The Blu-ray Disc format employs several layers of digital rights management. Advanced Access Content System (AACS) is a standard for content distribution and digital rights management. It is developed by AS Licensing Administrator, LLC (AACS LA), a consortium that includes Disney, Intel, Microsoft, Matsushita (Panasonic), Warner Bros., IBM, Toshiba and Sony. Since appearing in devices in 2006, several successful attacks have been made on the format. The first known attack relied on the trusted client problem. In addition, decryption keys have been extracted from a weakly protected player (WinDVD). Since keys can be revoked in newer releases, this is only a temporary attack and new keys must continually be discovered in order to decrypt the latest discs. This cat-and-mouse game has gone through several cycles and as of August 2008 all current AACS decryption keys are available on the Internet.

15. BD+ was developed by Cryptography Research Inc. and is based on their concept of Self-Protecting Digital Content. BD+ is effectively a small virtual machine embedded in authorized players. It allows content providers to include executable programs on Blu-ray Discs. Such programs can:

- Examine the host environment, to see if the player has been tampered with. Every licensed playback device manufacturer must provide the BD+ licensing authority with memory footprints that identify their devices.
- Verify that the player's keys have not been changed.
- Execute native code, possibly to patch an otherwise insecure system.
- Transform the audio and video output. Parts of the content will not be viewable without letting the BD+-program unscramble it.

If a playback device manufacturer finds that its devices have been hacked, it can potentially release BD+-code that detects and circumvents the vulnerability. These programs can then be included in all new content releases. The specifications of the BD+ virtual machine are available only to licensed device manufacturers. A list of licensed commercial adopters is available from the BD+ website. The first titles using BD+ were released in October 2007. BD-ROM Mark is a small amount of cryptographic data that is stored separately from normal Blu-ray Disc data. A specially licensed piece of hardware is required to insert the ROM-mark into the media during replication. Through licensing of the special hardware element, the BDA believes that it can eliminate the possibility of mass producing BD-ROMs without authorization.

Player profiles

16. The BD-ROM specification defines four Blu-ray Disc player profiles which include an audio only player profile (BD-Audio) that does not require video decoding or BD-J. All three of the video based player profiles (BD-Video) are required to have a full implementation of BD-J, but with varying levels of hardware support. When Blu-ray software authored with interactive features dependent on Bonus View or BD-Live hardware capabilities are played on Profile 1.0 players, they will be able to play the main feature of the disc but some extra features may not be available or may offer limited capability.

17. The biggest difference between Blu-Ray Video profiles 1.1 and 2.0 is that Profile 2.0 requires a high-speed Internet connection (usually via a standard Ethernet RJ-45 network port) to access downloadable content. While some Profile 1.1 players may have an Ethernet port, these are used for firmware updates and are not used for getting downloadable content. In addition, to handle this content, Profile 2.0 also requires more storage. Currently, the most "future-proof" players, and thus the most sought players on the market are those that meet the Profile 2.0 standard. With the exception of the LG-BH100, the LG-BH200, the PlayStation 3, and the Samsung BD-UP5000, Profile 1.0 players can not be upgraded to be Bonus View or BD-Live compliant.

Backward Compatibility

18. Though not compulsory, the Blu-ray Disc Association recommends that Blu-ray Disc drives should be capable of reading standard DVDs and CDs for backward compatibility. A few early Blu-ray Disc players released in 2006 could play DVDs but not CDs.



An experimental 200GB rewritable Blu-ray Disc

Although the Blu-ray Disc specification has been finalized, engineers continue working to advance the technology. Quad-layer (100 GB) discs have been demonstrated on a drive with modified optics (TDK version) and standard unaltered optics ("Hitachi used a standard drive."). Hitachi stated that such a disc could be used to store 7 hours of 32 Mbit/s video (HDTV) or 3.5 hours of 64 Mbit/s video (Cinema 4K). In August 2006, TDK announced that they have created a working experimental Blu-ray Disc capable of holding 200 GB of data on a single side, using six 33 GB data layers. Also behind closed doors at CES 2007, Ritek revealed that they had successfully developed a High Definition optical disc process that extends the disc capacity to 10 layers. That increases the capacity of the discs to 250 GB. However, they noted that the major obstacle is that current reader and writer technology does not support the additional layers. JVC has developed a three-layer technology that allows putting both standard-definition DVD data and HD data on a BD/DVD combo. If successfully commercialized, this would enable the consumer to purchase a disc which could

be played on current DVD players, and reveal its HD version when played on a new BD player.

Variants

19. The types of Blu-ray discs are as follows:-

- The "*Mini Blu-ray Disc*" (also, Mini-BD and Mini Blu-ray) is a compact 8cm (~3in) diameter variant of the Blu-ray Disc that can store approximately 7.5GB of data. It is similar in concept to the MiniDVD. Recordable (BD-R) and rewritable (BD-RE) versions of Mini Blu-ray Disc have been developed specifically for compact camcorders and other compact recording devices.
- BD9 and BD5 are lower capacity variants of the Blu-ray Disc that contain Blu-ray compatible video and audio streams contained on a conventional DVD (650 nm wavelength / red laser) optical disc. Such discs offer the use of the same advanced compression technologies available to Blu-ray discs (including H.264/MPEG-4 AVC, VC-1 and MPEG-2) while using lower cost legacy media.
- AVCREC is an official lower capacity variant of the Blu-ray Disc used for storing Blu-ray Disc compatible content on conventional DVD discs. It is being promoted for use in camcorders, distribution of short HD broadcast content and other cost-sensitive distribution needs.
- Blu-ray Disc recordable refers to two optical disc formats that can be recorded with an optical disc recorder. BD-R discs can be written to once, whereas BD-RE can be erased and re-recorded multiple times.

Launch and sales developments

20. The first BD-ROM players were shipped in the middle of June 2006, though HD DVD players beat them in the race to the market by a few months. The first Blu-ray Disc titles were released on June 20, 2006. The earliest releases used MPEG-2 video compression, the same method used on DVDs. The first releases using the newer VC-1 and AVC codecs were introduced in September 2006. The first movies using dual layer discs (50 GB) were introduced in October 2006. The first audio-only release was made in March 2008. The first mass-market Blu-ray Disc rewritable drive for the PC was the BWU-100A, released by [Sony](#) on July 18, 2006. It recorded both single and dual layer BD-R as well as BD-RE discs and had a suggested retail price of US \$699.

Blu-ray Competitors

19. The other big player is HD-DVD, also called AOD (Advanced Optical Disc), which was developed by electronics giants Toshiba and NEC. HD-DVD was actually in the works before regular DVD, but it didn't begin real development until 2003. The advantage to HD-DVD is that it uses the same basic format as the traditional DVD and can therefore be manufactured with the same equipment, saving on costs. HD-DVD matches the storage capacity of Blu-ray. A rewritable, single-layer HD-DVD can hold 15 GB of data, a double-layer disc can hold 30 GB, and a triple-layer disc can hold 45 GB (that's compared to 27 GB and 50 GB for Blu-ray).



Samsung BD-P1000 Blu-ray player

20. Blu-ray and HD-DVD are the two major competitors in the market, but there are other contenders, as well. Warner Bros. Pictures has developed its own system, called HD-DVD-9. This system uses a higher compression rate to put more information (about two hours of high-definition video) on a standard DVD. Taiwan has created the Forward Versatile Disc (FVD), an upgraded version of today's DVDs that allows for more data storage capacity (5.4 GB on a single-sided disc and 9.8 GB on a double-sided disc). And China has introduced the Enhanced Video Disc (EVD), another high-definition video disc. There are also professional versions of the blue laser technology. Sony has developed XDCAM and ProData (Professional Disc for Data). The former is designed for use by broadcasters and AV studios. The latter is primarily for commercial data storage (for example, backing up servers).

Conclusion

21. The UDO (Ultra Density Optical) road map was designed to use proven technologies at all stages in order to ensure that products could be delivered on time and to budget. UDO takes the existing proven elements of Blu-Ray technology to deliver a family of professional data storage products with the initial generation shipping in 2003. Later generations push the technology further as the industry develops the techniques required to manufacture components required to an acceptable level. Pioneer goes beyond Blu-Ray, Pioneer is developing an optical disc that will blow away the hard disc in most of our PCs in terms storage capacity, holding 500 GB of data. How so? Pioneer's lasers are ultraviolet, which have an even shorter wavelength than the blue. It seems that the future holds a whole lot more than 25 to 54 GB on a single disc.