DIRT CHEAP DRIVES

Tech Info

CD and DVD Writing Technology

This document explores the similarities and differences between CD and DVD technologies. Before we appreciate this comparison, we should take a look at what started the "Optical storage revolution". In the beginning there was Audio CD, then .... Data?

1) In 1983, Sony and Philips released a new form of audio player that has since transformed the comput world. This player of course, is the audio CD-ROM player. The only way to produce the CD's was by p the final cut into the CD package. Coinciding with this release, the specifications for this device were m public in the form of what is called "Yellow Book". This "Book" defines CD Read Only Memory as a standard. Included within the Yellow Book standard is an additional book called "Red Book". Red Book defines the writing and format for Digital Audio CD's. This is the standard from which all other CD sta are built, as it provides the building blocks for audio/visual CD's and CD's that contain computer data o textual information. As a result the CD-ROM has become invaluable, not only with audio systems, but f with modern PC systems.

2) In the early days of CD development, many companies applied proprietary file structures to their CD' making them difficult, at best, to use. The "High Sierra Group", an ad hoc committee, worked out a form standard which became known as the "High Sierra Format". Eventually this format was finalized with s minor changes and issued as a standard by the International Standards Organization called ISO-9660. T standard is important as it defines the file structure for almost all optical media and how it is formatted. recent years, another file format standard has been defined which allows the use of "drag 'n drop" capab as well as larger capacity discs. This new format is "Universal Disc Format - or UDF".

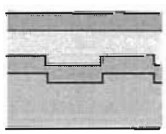
3) You may be asking at this point: why the background on file format and structure? Once the ISO-9660 standard was adopted, CD Recording for the masses became feasible, overcoming cost and usability con Keep in mind, at this stage many CD recording and duplication equipment manufacturers were charging premium for their recorders (upwards of $100,000 U.S.) and CD-R discs were also expensive at $100.0 CD mastering services were primarily available from service bureaus and also had high associated costs

4) File format and structure were not the only areas where this technology had "growing pains". The firs CD-ROM drives manufactured for the PC were extremely proprietary in nature. Many had their own dri interface, were difficult to setup and had slow data transfer and access time. The CD-ROM for the PC st its climb when software manufacturers realized that the CD was cheaper per MB than the continued use floppy disk. This also meant that the end user would no longer have to do the "floppy shuffle" to install software. This was extremely beneficial, considering the number of software packages requiring upward or more compressed data floppy disks. As the need for faster CD-ROM access and data transfer grew, d

manufacturers started to collaborate to ensure the success of the format. This collaboration resulted in fa more reliable drives and media, not to mention migration to industry standard drive interfaces such as S(and ATAPI.

5) For a number of years, writing audio or data to a CD was still beyond the majority, as the CD recorde required more than a hardware installation to work. Two primary deficiencies that existed for a long tim the lack of host systems powerful enough to handle the write process, and the lack of user-friendly "CD-Mastering" programs. CD-Mastering programs enable the user to set-up an "Image" of the disc to b written. This process is called pre-mastering. The creation of the pre-mastered image required large harc space and RAM. Robust hard drive interfaces were required to supply a steady data stream when writing "burning" the disc. Because of the deficiencies of these earlier systems, many users invariably wound ur a buffer underrun condition that created "coasters" or miniature Frisbee's! With the advent of faster har and CD drive interfaces (Ultra SCSI and Ultra ATA technologies) buffer underrun's, while not eliminat have been largely tamed.

6) To understand how CD-R & CD-RW discs work, we first need to look at the disc structure itself. Kee mind that the CD disc is read from the bottom up.



CD-R Cross Section

a) Mass produced CD discs are created by means of a stamping process where a polycarbonate plastic blank is stamped with millions of tiny indentations called pits - molded in a spiral from the center of the disc outwards. The blank is then coated with a thin layer of aluminum, giving the disc its characteristic silver color. The pits are typically 0.5 microns wide, 0.83 to 3 microns long and 0.15 microns deep. The space between the tracks - the pitch - is just 1.6 microns. Track density is over 16,000tpi, compared to 96tpi density of a floppy disk. The illustration to the right

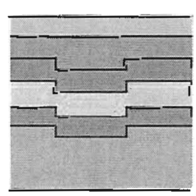
Protective Layer

shows the architecture of a typical disc.

Reflective Layer

Recording Layer

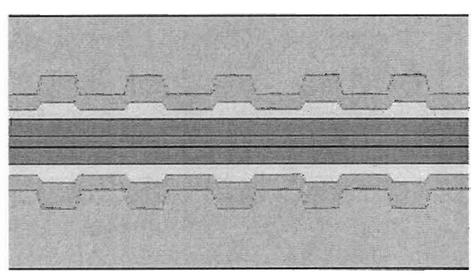
Polycarbonate Substrate Layer



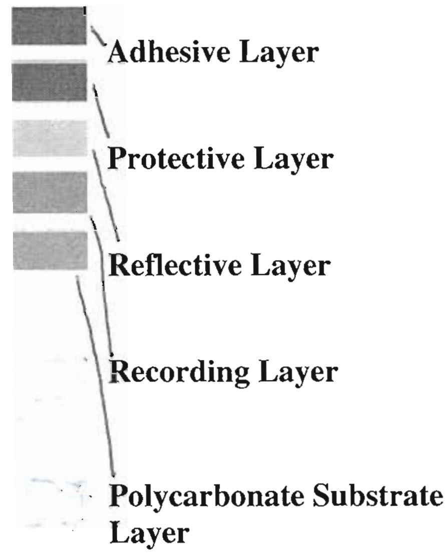
CD-RW Cross Section

b) Adding a recording layer creates recordable discs. This sounds simple enough on paper, but in reality there is, of course, more to it. The aforementioned polycarbonate plastic blank is now smooth, with the reflective coating (now made of gold or silver alloy) containing the spiral tracks. Coated directly to the reflective layer is an organic dye, which is reactive to the color or wavelength of the laser; and then another polycarbonate layer. Higher quality CD-R and CD-RW discs have an additional protective layer on the top of the disc to keep ink out of the reflective layer as well as to help prevent scratching the top of the disc. (If you scratch the top of the disc, chances are very good that you have destroyed the usability of the CD). The illustration to the right shows the architecture of a typical disc.

c) The DVD disc structure is basically the same as that of the CD disc. One difference is in the make up of the organic dye layer which allows changes in laser wavelength, track width and, consequently, in the size of the land areas where the marks or pits will be written. Also different from the CD disc, is that the DVD disc has an adhesive layer in addition to the other layers. This enables reading and writing to both sides of the disc. The illustration to the right shows the architecture of a typical disc.



Writable DVD Cross Section



7) In order to maintain "backward" compatibility with the installed base of CD-ROM drives and standar consumer audio CD players, as well as the millions of discs in the real world, manufacturers had to dupl the "Pits and Lands" environment that the data area of a pressed CD uses. This was accomplished by cre recording layer that interacts directly with the reflective layer. CD recorders and Re-writers use a laser tl a wavelength of approximately 780nm. (Laser generated light is measured by wavelength expressed in nano-meters). DVD on the other hand uses a wavelength of approximately 650nm. The resultant discs, although manufactured completely differently, achieve the same ultimate outcome.

8) CD and CD-R reading uses a laser, as indicated previously, to "Read" the information stored on the C this level it does not matter what type of data is stored - hence the reason for format standards!). The las tracks a CD from the inside going outward. As the low power laser light (the light wavelength emanated

the laser on any CD drive is in the infrared spectrum not viewable to the human eye) is focused on the tr photoreceptors receive a series of high and low reflections from the reflective layer. These reflections ar turn, converted to a data stream of 1's and 0's. The transition from high or low light actually determines 0 and is contained in the edge of the pit on the disc.

9) Even though the information on CD-R and CD-RW discs are interpreted the same way (conversion o series of high and low reflected bits of light), the actual recording method differs. A CD-R drive creates and land environment, much the same as the structure of a mass produced CD. The resulting "burned" C disc is compatible with virtually all of the installed base of CD drives (format specific, of course) and commercial CD players (for CD-I, audio, Karaoke and others). CD-RW presented the additional challen not only writing to a disc, but also erasing or overwriting the data written. This is accomplished by using is called "Phase change technology". Instead of using pits and lands to show a transition, the laser chang phase or physical orientation of the recording layer from horizontal to vertical for the area being written. vertical portion has higher reflectivity than the horizontally positioned bit which is read as a transition o should be noted here that a high reflective bit on CD-R is determined by an approximate 65% light retur the reflective layer, whereas with CD-RW the returned reflective state is approximately 15-25%. What t means to the end user is that older CD-ROM drives (typically 16x or older) will not read CD-RW discs. also applies to commercial CD players as well. This incompatibility is because the photoreceptors were sensitive enough to read the data.

10) The actual writing process is the origin of the term "burning" a CD. The laser inside the drive actual heats the area to be written on the disc, creating the data bit. The laser in the CD-R and DVD-R drive ty uses between 4 and 11mW of power, which cycles as needed to establish and maintains a heat of approximately 250° C. The laser heats the recording layer above the melting point, reducing the volume polycrystalline substrate, which also melts, fills in the area where a pit forms, thus sealing any microsco pockets of air or other gasses. In comparison, CD-RW and DVD-RAM drives use 8 to 14mW of power heats the writable area to temperatures of 500-700°C, which then melts the crystalline structure to an amorphous non-crystalline state (read by the laser as a low-reflective state). In both cases, the end result provides patterns of high/low light reflections, which can then be read by the read process.

11) From the beginning, DVD drives have been intended as a replacement for the CD-ROM drive. This why, on first glance, the DVD disc appears to be the same as a CD-ROM disc. There are certain similari and some big differences as well. With the almost certain demise of the CD drive, DVD was designed w compatibility as part of the overall design. As a result, DVD is more of a companion, rather than a comp technology. As indicated earlier, DVD, DVD-R and DVD-RAM disks utilize the same physical structur their CD counterparts. Where they differ is in the chemical make up of the organic dye substrate, and in overall capacity of the disc. The rest of the differences are in the actual disc layout and presentation forn the information stored on the disc. To achieve the higher disc density required to write 6-7 times the cap of a CD disc, the laser wavelength was changed to 635-650nm (red) vs. the 775-795nm (infrared) for CI other major change was made to the optics to reduce the track width on the disc. To do this the aperture the laser beam is focused on the disc area) was changed to a value of 0.60 vs. 0.5, which resulted in a 0. mark size. This is compared to the minimum mark size of 0.834um for CD's. With the reduction of the r size, the track width was reduced by half that of a 74 minute CD disc. With the reduction of the track wi the number of tracks per inch goes up exponentially, as does the amount of data that can be stored.

12) In summary ... As you can see, the optical disc is an ingenious storage medium that has come into it right. With its ability to read CD media, as the prices come down and the need for higher capacity storag increases, the DVD drive will become the predominant optical storage device. The CD drive will eventu phased out. This does not mean that CD disc technology will also go away, because the need for relative small capacity media will remain.

13) This document covers the basics of how optical media is read and written to. Other technologies, wh
have not been covered here also contribute to the success and capability of the CD and DVD.

Return to Technical Index
Return to Dirt Cheap Drives homepage.

DIRT CHEAP DRIVES

Tech Info

DVD FAQs

1. **What are regional codes and how are they used?**
2. **How much video or information can a DVD hold?**
3. **Can I make a backup copy of my new digital movie?**
4. **What do I need to play DVD on my computer?**

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1. What are region codes and how are they used?

The DVD standard includes codes that can be used to prevent playback of Digital Video Discs in certain geographical regions. Each DVD player is given a code for the region in which it is sold. The DVD player will refuse to play discs that are not allowed in that region. This means that discs bought in one country may not play on players bought in another country. Some players allow you to change the region code on a player, usually limited to 9 times or less. Once the limit has been reached, the region code can be changed only by the manufacturer. A few "code free" players have been manufactured, but some studios are now including a program on each DVD release that checks for the code and will not play if the player has not been coded. If the code is somehow successfully removed or altered, the warranty is voided on the player.

DVD releases may contain codes ranging from "no code" to all codes from all regions on a disc. Each code on a disc is a byte of information and is permanent. It does not become inactive after a period of time, and it cannot be reset or changed. Regional codes are optional for each maker of a disc. Discs without codes will play in any player in any country.

The purpose of the code is to protect the motion picture studios' distribution rights and theatre release dates. Motion pictures are not released world wide simultaneously, nor shown in all theatres simultaneously. A movie can be in home release in the United States at the same time it is being shown for the first time in theatres in Europe. Studios also sell distribution rights to different foreign distributors and need to guarantee an exclusive market to their distributors.

There are 6 regions (also called "country codes" or "zone locks"). Players and discs are identified by the region number superimposed on a world globe. If a disc plays in more than one region it will have more than one number on the globe.
1: Canada, U.S., U.S. Territories
2: Japan, Europe, South Africa, Middle East (including Egypt)
3: Southeast Asia, East Asia (including Hong Kong)

4: Australia, New Zealand, Pacific Islands, Central America, Mexico, South America, Caribbean
5: Former Soviet Union, Indian Subcontinent, Africa (also North Korea, Mongolia)
6: China

Regional codes do not apply to DVD-Audio, but they do apply to DVD-ROM systems when playing DVD-Video discs. Computer playback systems will check for regional codes before playing movies from a DVD-Video.

Back to Top

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2. How much video or information can a DVD hold?

The number of bytes of data that a DVD can store is dependent on the number of layers and number of sides the disc was manufactured to use. The number of hours of video is dependent upon the number of sides and layers in addition to the number of tracks of audio and the amount of compression used. A single-sided, single layer DVD can store 4.38Gb of uncompressed data and over 2 hours of **average** digital video with 3 audio tracks on a DVD-5. It should be noted that if the digital video is compressed to normal VHS quality, a single sided disc could store over 9 hours of video on a DVD-5.

The discs are either manufactured as Single-Sided / Single-Layer or as Dual-Sided / Dual-Layer. The Dual-Sided / Dual-Layer variety of DVD holds about 8 hours of average digital video with 3 audio tracks and 15.9 Gb of data. All players manufactured using the DVD standard are capable of reading dual-layer discs, although double-sided discs require you to flip them over for the reader to access the second side.

The current and planned DVD uncompressed capacities for 8cm and 12cm discs are listed in the table below for your reference.

DVD Capacity Table.

- **DVD-1 (8cm, SS/SL): 1.36 gig (1.4 G), about half an hour**
- **DVD-2 (8cm, SS/DL): 2.48 gig (2.7 G), about 1.3 hours**
- **DVD-3 (8cm, DS/SL): 2.72 gig (2.9 G), about 1.4 hours**
- **DVD-4 (8cm, DS/DL): 4.95 gig (5.3 G), about 2.5 hours**
- **DVD-5 (12cm, SS/SL): 4.38 gig (4.7 G) of data, over 2 hours of video**
- **DVD-9 (12cm, SS/DL): 7.95 gig (8.5 G), about 4 hours** — MOVIE + EXTRA
- **DVD-10 (12cm, DS/SL): 8.75 gig (9.4 G), about 4.5 hours**
- **DVD-14 (12cm, DS/ML): 12.33 gig (13.24 G), about 6.5 hours**
- **DVD-18 (12cm, DS/DL): 15.90 gig (17 G), over 8 hours** — DS/DL
- **DVD-R (12cm, SS/SL): 3.68 gig (3.95 G)** → 4.7 GB IN 2002
- **DVD-R (12cm, DS/SL): 7.38 gig (7.9 G)**
- **DVD-R (8cm, SS/SL): 1.15 gig (1.23 G)**
- **DVD-R (8cm, DS/SL): 2.29 gig (2.46 G)**
- **DVD-RAM (12cm, SS/SL): 2.40 gig (2.58 G)**
- **DVD-RAM (12cm, DS/SL): 4.80 gig (5.16 G)**

NOT YET DOUBLE LAYER

Note: Two gigabytes = one hour of average digital video

Back to Top

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3. Can I make a backup copy of my new digital movie?

The answer to this question is, "probably not," but it depends on the copy protection system implemented on the disc. At the current time, there are four forms of copy protection used on DVD that cover the various analog and digital means of copying material. Several proposals under consideration will probably add several more to the list because the current copy protection schemes are only effective against casual copying. The first three schemes listed below are optional to the disc maker. Movie decryption is also optional for hardware and software playback manufacturers, although a player or computer without decryption capability will only be able to play unencrypted movies.

1. Analog Copy Protection System. (CPS)
Copying to video tape is prevented with a Macrovision 7.0, or a similar circuit in every player. The general term is APS (*Analog Protection System*). Computer video cards with composite or s-video output are required to use APS. Macrovision is not on the video output of early players, but it is required on all new players. The discs contain a trigger in the header of each sector telling the player whether or not to enable it. This allows for control over which sections are copy-protected. The producer of the disc decides what amount of copy protection to enable and then pays Macrovision royalties. Just as with videotapes, some DVDs are Macrovision-protected and some are not.

2. Copy Generation Management System (CGMS)
Each disc also contains information specifying whether or not the contents can be copied and if it is designed to prevent copies or copies of copies. The information is embedded in the outgoing video signal. For this process to work, the equipment making the copy must recognize and respect the CGMS.

3. Content Scrambling System (CSS)
Because of the potential for perfect digital copies, movie studios forced a deeper copy protection requirement into the DVD-Video standard. CSS is a form of data encryption designed to discourage reading media files directly from the disc because most players now have a decryption circuit that decodes the data before it can display it. No unscrambled digital output is allowed until work in progress for secure digital connections is finished.

On the computer side, DVD-ROM drives and video display/decoder hardware or software exchange encryption keys so that the video is decrypted just before being displayed by the encoder. Since 1999, all DVD-ROM drives are required to support regional management in conjunction with CSS.

4. Digital Copy Protection System (DCPS)
Five digital copy protection systems have been proposed to CEMA. The apparent frontrunner is **DTCP** (*digital transmission content protection*). DTCP was developed primarily for IEEE 1394/FireWire but is applicable to other protocols. In all five proposals, content is marked with CGMS-style flags of "copy freely," "copy once," "don't copy" and sometimes "no more copies." Digital devices that do nothing more than reproduce audio and video will be able to receive all data (as long as they can authenticate that they are playback- only devices). Digital recording devices are only able to receive data that is