Optical Carriers

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Optical Carriers

Typology and history

Optical media are used for storing digital sounds, images and data. There are three main families :

— the commercially issued, mass produced, CD family including the digital audio CD – both 12 cm and the "single" 8 cm disc – CD-ROM, CD-I and CD-V and the analogue Video Disc,

— optical discs and tapes that can be recorded on once,

— re-recordable discs.

Jukeboxes are available for most types of disc allowing automated access to a number of discs.

Mass Produced Discs

The mass-produced discs of the CD family have the digital information in the form of microscopic pits pressed into a polycarbonate base which is coated with a light reflective layer. This reflective layer is usually of aluminium, but gold and silver are also used. A transparent lacquer is then placed over the reflective surface to protect it. This surface also carries any label information. As the data are impressed, they cannot be altered or rewritten.

Because of the high costs to setup the production of a pressed disc, the discs are only used when large numbers of copies are required (over about 100), for example, encyclopaedia or sound recordings. The higher the number of discs issued, the lower is the unit price. The storage capacity of a 12 cm CD is about 650 MB or 74 mn of audio. The average access time is about 300 ms with a double speed player, 250 ms with quadruple speed and 130 ms with sextuple speed.

The first disc in the family to be developed was the 30 cm analogue LV (Laser Vision) Disc for video. This usually consisted of two discs stuck back-to-back to form a double sided disc with one hour of video per side. A sub-format was developed which could store up to 54,000 still video images per side. The LV disc was the most successful of several attempts to generate market acceptance but is expected to be superseded by the DVD (Digital Versatile Disc or Digital Video Disc) that was launched in 1997.

The DVD is the same diameter as the CD (12 cm) but, by using a laser with a shorter wave length of light, the storage capacity of one layer is increased by a factor of 7 to 4.7 GB. Additionally, a dual layer structure will be possible, read by two different laser wave lengths, thus doubling the capacity to 9 GB. In principle, by glueing two such double layer discs together like the LV video discs, a total capacity of 18 GB can be achieved. The disc is intended for the storage of data-reduced video-films or, like CD-ROMs, texts and multimedia data with, however, considerably higher storage capacities.

Write-Once Recordable Media

There are several types of write-once recordable discs. The format that is becoming the most widely used is the recordable CD (CD-R or CD-WO) which has been available since 1993. Having the same format and storage capacity as the audio CD and the CD-ROM, the CD-R can be played on the appropriate standard CD drives. The polycarbonate body of the disc has a dye layer placed on it which is then coated with a metallic reflective layer. The dye layer carries the data in place of the pits of pressed discs. When recording, high-intensity laser pulses change the dye shape so optical properties. The low-intensity read laser reads the changes in reflected light as a digital bit stream. Once written, the data cannot be altered. CD writing drives are available on different speed levels. The CD-R is a well established and standardized format. Different standardized software protocols are available for

recording Audio CDs and CD-ROMs. The Photo-CD is a CD-R with a proprietary software protocol to record photographs as electronic still images.

A recordable version of the DVD in not yet available, but is expected in the near future.

CD-Rs are but the latest and most prominent examples of so-called WORM (Write Once, Read Many) discs which have been in use as computer storage media for quite some time. The biggest problem with WORMs is the great variety of systems and formats. A number of producers offer WORMs with a continuous helical recording format similar to a sound LP disc ; others offer discs with ring-shaped tracks as on computer floppy and hard discs. Some can use both formats. The proprietary software of WORMs poses a problem, too. Not even the physical dimensions are standardized.

One writing method used by a number of manufacturers including LMS, Toshiba and Sony burns pits in the metallic surface of the disc with a laser beam. Another system supported by ATG and Optimen creates bubbles by the heat of the laser beam. In both cases the reflectance of the metallic layer is changed and the data can be read by a low power laser beam.

Optical Tape

Optical tape is made by ICI and packaged in a cassette for use as a WORM format data storage tape. The tape drives are made by EMASS in the USA and supplied in Europe by GRAU Storage Systems. Kodak are about to launch a competing system.

The tape contains a dye layer which changes its state when a high power laser beam is applied and can be read by a lower power laser - the same basic method as for CD-Rs. Because the tape is a sequential carrier, the access time can be quite long. In compensation, the storage capacity of one tape is considerably greater than a disc (up to 100 GB).

Rewritable Optical Media

In contrast to the preceding optical media, data on rewritable optical discs ("Erasable"), Magneto-Optical (M/O) and Phase-change, can be altered or deleted many times. There are rewritable optical discs in the 5.25 inch format and, more recently, in the 3.5 inch format. The most common still are the magneto-optical discs, where a laser beam in the write mode heats the inner layer of the optical disc and thus changes the polarity of a magnetic coating. The resulting microscopic magnetic marks of different polarity can be read as a bit stream by a low-energy laser beam in the read mode. A more recent recording technology is the Phase-change where the carrier layer is coated with a thin semi-metal film, which can be both in an amorphous and in a crystalline state. A laser beam in the write mode can change single spots to either an amorphous or a crystalline state so that, again, a digital bit stream is created. The Phase-change may replace M/O in the future.

Rewritable optical discs have a short access-time (600 milliseconds). The storage capacity has steadily increased up to the current 2.6 GB.

Typology of optical carriers - synopsis

carrier	date of manuf.	media	type of recording	recording method	replay method	composition
LV Laser Vision	1982-	video / still image	analogue	mechanically pressed	optically read by laser	base : polycarbonate, reflective layer : aluminium varnish
CD - replicated	1981-	all media	digital (except CD-V : video analogue)	mechanically pressed	optically read by laser	base : polycarbonate, reflective layer : aluminium varnish, inks
CD recordable	1992-	all media	digital	thermically written by laser	optically read by laser	base : polycarbonate, organic dyes : cyanine, phtalocyanine reflective layer : gold, silver varnish, inks
CD rewritable	1996-	all media	digital	phase change written by laser	optically read by laser	base : polycarbonate, phase change layer reflective layer varnish, inks
DVD replicated	1997-	all media	digital	mechanically pressed	optically read by laser	base : polycarbonate, semi-reflective layer, fully reflective layer : aluminium coating glue double face
DVD recordable	1997-	all media	digital	thermically written by laser	optically read by laser	base : polycarbonate, organic dye, reflective layer : gold coating glue, inks single face
DVD rewritable	1998-	all media	digital	phase change written by laser	optically read by laser	base : polycarbonate phase change layer reflective layer single face disc in caddy
MD MiniDisc replicated	1992-	sound	digital	mechanically pressed	optically read by laser	base : polycarbonate reflective layer : aluminium varnish disc in caddy
MD MiniDisc recordable	1992	sound	digital	magnetic written by laser	optically read by laser	base : polycarbonate MO layer reflective layer : aluminium disc in caddy

Causes of deterioration and Preventive Measures

The Stability of Optical Carriers

The main factors that affect the stability of carriers and the retrieval of information can be summarised as :

- humidity and temperature,
- mechanical deformation,
- dust and dirt of all kind.

For some carriers there are additional factors :

- light,
- stray magnetic fields.

Humidity and Temperature

Humidity is, as with other data carriers, a most dangerous factor. In the case of optical media it has a hydrolytic action on components such as the protection layer of CDs and a corrosive influence on all metal components including metallic reflective layers. As a secondary effect, high humidity levels (above 65 % RH) encourages the growth of moulds and fungi which can obstruct the reading of optical information.

Temperature, as with all other data carriers, determines the speed of (deteriorating) chemical reactions. More importantly, it is responsible for dimensional changes which may be of concern, especially in the case of multi-layer media.

Recommended Climatic Access Storage Parameters						
	temperature	±/24h	±/year	RH	±/24h	±/year
optical media	about 20°C	±1°C	±3°C	40%	±5°C	±5°C

Fluctuations of chosen parameters should be kept to a minimum. Operation areas (studios) should, therefore, have the same climatic conditions as storage areas. As with magnetic carriers, tighter parameters would be favourable for long term preservation. Such suggestions have, however, to be offset against the availability of hard- and software, which seems to be of greater concern than the stability of the carriers themselves.

Mechanical Deformation

Mechanical integrity is of utmost, and underrated, importance. Even microscopic scratches can hinder the reading laser beam, as do fingerprints and other foreign matter. Mechanical bending of discs cause microscopic cracks which again divert the laser. While the WORM and MO-discs developed as computer storage media are housed in cartridges which only open when inserted into the respective players, the representatives of the CD-family must be handled with utmost care, keeping mechanical integrity in mind. Some professional CD players will handle CDs kept in special storage cartridge shells that prevent the disc being touched or deformed when loading and unloading. These add to the expense but can help preserve frequently used or particularly valuable discs.

Dust and Dirt

Dust and dirt prevent the proper reading of the recorded information. Cigarette smoke will accumulate on the disc surfaces and may hide information. The CD-family is again more exposed to this danger than those discs that are protected by cartridges.

Light

Light may affect the dye layers used in recordable and erasable discs.

Magnetic Stray Fields

Magnetic stray fields must be kept away from magneto-optical discs.

Standards

ISO/DIS 9171-1.2. ISO/IEC 9171-1:1989	Information Processing – Information Interchange on 130 mm Optical Disc Cartridge – Write Once (5.25 inch-WORM, 297-327 MB on each Side), Part 1 : Unrecorded Optical Disc Cartridge (Technical concept, conditions for handling and storing, measures, mechanical and physical properties, optical properties or information, physical interchangeability between systems)
ISO/DIS 9171-2.2. ISO/IEC 9171-1:1990	Information Processing - Information Interchange on 130 mm Optical Disc Cartridge - Write Once (5.25 inch-WORM, 297-327 MB on each Side), Part 2 : format of recording (tracks and sector, correction of mistakes, methods of modulation of recording, sequence of recording, data capture)
ISO DP 10090- Draft Proposal	Standards for Information Interchange on 86 mm Optical Disc Cartridges (3.5 inch Rewritable M/O, 120 MB on each Side) are still under preparation.
AES28-1997	AES Standard for Audio Preservation and Restoration - Method for Estimating the Life Expectancy of compact discs (CD-ROM), based on the effects of temperature and relative humidity.
AES35-xxxx	Draft AES Standard - Method for estimating the Life Expectancy of magneto-optical (M-O) discs, based on the effects of temperature and relative humidity.
AES36-xxxx	Draft AES Standard - Procedures for the storage of optical discs including read only, write once and rewritable.
AES38-xxxx	Draft AES Standard - Life Expectancy of information stored in recordable compact disc systems. Methods for estimating, based on the effects of temperature and relative humidity.

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TROCK, Jacob. Bevaring av elektroniske dokument pa CD-R (The keeping of electronical documents on CD-R). Thesis presented at Konservatorskolen, Det Kongelige Danske Kunstakademi, Denmark
e-mail :jtrock@post3.tele.dk

WILLIAMS, E.W. The CD-ROM and Optical Disc Recording System. - Oxford : Oxford Science Publications, 1996.

Website Directory

Records and information management resource list
Links to Records and Information Management (RIM) and other related websites.
A list of resources created by Alan S. Zaben.
http://home.earthlink.net/~survivoraz/infomgmt/medstr_f.htm

Electronic Storage Media
A list of information resources on the CoOL website.
http://palimpsest.stanford.edu/bytopic/electronic-records/electronic-storage-media/

Audio/Video Glossary
Searchable alphabetically and by subject.
http://www.soundsite.com/glossary/glossary.html

European audiovisual Conference
Speeches, papers and reports from the Conference. Birmingham, 6-8th of April 1998.
http://europa.eu.int/eac/bg-intro_en.html

Websites last visited : 2nd August 1999