

## ERASING DATA AND RECYCLING OF OPTICAL DISKS

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### ABSTRACT

*Optical disks, DVDs and CDs, are convenient recording media on which to safely store data for a long period of time. However, the complete data erasure from recorded media is also important for the security of the data. After erasure of data from optical disks, recycling the material is needed in order to recover the valuable components of the optical disks. Here, data erasure methods for optical disks are discussed in the view of material recycling. The main finding of the study is that the explosion of optical disks in water is a very suitable method for complete erasure of data on the disks as well as recycling of their materials.*

**Keywords:** Optical disk, DVD, CD, Data erasure, Recycling, Security, Explosion, Polycarbonate, Silver, Collection

### 1 INTRODUCTION

Nowadays saving and protecting data are necessary; however, erasing data from the recording media and recycling of their materials should also be considered in the view of security, privacy, and environmental protection. Table 1 shows many kinds of recording media. CD-Rs and DVD-Rs constitute the largest world production of recording media with 20 billion units, followed by floppy disks (4 billion units), VHSs (3 billion units), CD-ROMs (2.5 billion units) and cassette tapes (2 billion units). In this work, data erasure methods and recycling systems for some types of recordable and rewritable optical disks (i.e. CD-Rs, CD-RWs, DVD-Rs, and DVD-RWs) will be discussed. Table 2 shows the Japanese and world production of optical disks in 2003. It can be seen that the world production of CD-Rs is 20 times larger than that of CD-RWs, whereas the production of DVD-Rs is 4 times than that of RWs. It can also be seen that the Japanese production of CD-Rs and RWs is 6% of the world (Table 2), while the production of DVD-Rs and RWs is much larger, i.e. ca. 36%. The breakdown of world production of CD-Rs by country is shown in Figure 1. It can be seen that Taiwan produces the largest number of CD-Rs, about 90 % of the production in Asia. Figure 2 shows the world production of CD-Rs and DVD-Rs in various years. Showing that CD-R and DVD-R production in 2006 was more than 20 billion units, indicating that there is a sharp increase in DVD-R production when compared with

that of CD-Rs.

Cross section views of CD-R & DVD-R are shown in Figure 3. The recorded layer of a CD-R is one surface on the polycarbonate disk (thickness 1.2 mm); however, the recorded layer of a DVD-R is sandwiched in between two polycarbonate disks of 0.6 mm thickness. Therefore, data erasure from DVD-Rs is more difficult than for CD-Rs. In both cases the thickness of the disk is 1.2 mm. Each is made of 15g of polycarbonate and a thin layer of silver, 70 to 90 nm thick, weighing 15mg, which is used as the reflection layer in both disks. If 2 billion optical disks are made in Japan, the polycarbonate used is about 30 thousand tons per year (6 billion yen per year), and silver used is 30 tons per year (1.5 billion yen per year). Therefore, it is not only important to erase the data on used optical disks but also to recycle their materials.

**Table 1.** Recorded media

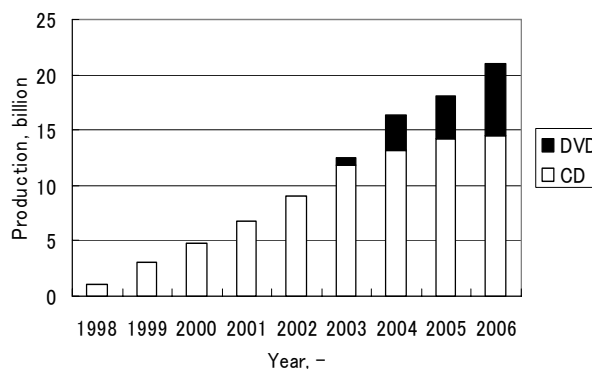
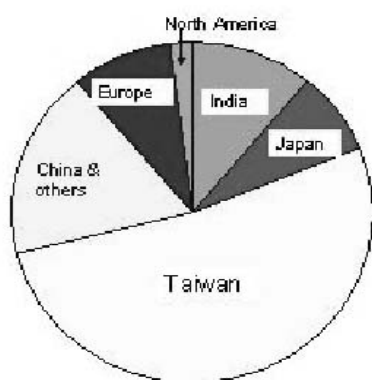
- Floppy disk
- Video tape (VHS), Cassette tape
- Hard disk
- MO(Magneto Optical Disk)
- Memory card, Memory stick etc.
- **CD-R(Compact Disk Recordable)**
- **CD-RW(Compact Disk ReWritable)**
- **CD-ROM(Compact Disk Read Only Memory)**
- **DVD-R(Digital Versatile Disk Recordable)**
- **DVD-RW(Digital Versatile Disk ReWritable)**
- **DVD-ROM(Digital Versatile Read Only Memory)**
- **DVD-RAM(Digital Versatile Disk Random Access Memory)**

**Table 2.** Production of CD-R,RW and DVD-R,RW in Japan and the world in 2003.

	CD-R	CD-RW	DVD-R	DVD-RW
Japan	0.4	0.028	0.115	0.041
World	6.94	0.327	0.345	0.082

Unit: billion/year

Source: Japan recording-media industries association



**Figure 1.** Production ratio of CD-R in 2003. **Figure 2.** CD-R and DVD-R(± R) world production.

## 2 A TOTAL RECYCLING SYSTEM FOR OPTICAL DISKS

Optical disks are designed to last for 50 to 100 years. They have great mechanical and thermal strength. The life cycle of CD—Rs and DVD-Rs is shown in Figure 4. Discarded optical disks can be collected from industry and other businesses and carried to a material recycling facility. This can be done by using collection boxes equipped with Radio-Frequency Identification (RFID) and Global Positioning System (GPS). However, it is difficult to collect these wastes from private users. Optical disks used by private users make up

approximately 60% of the total use, and most of these disks, when no longer wanted, are discarded as municipal waste. The protection and erasure of recorded information on CD-Rs and DVD-Rs turned in for recycling purposes is a very important step of this process. The mechanical recycling of these disks ensures that the separated materials (i.e. polycarbonate and silver) become raw materials for other processes and further provides destruction of recorded information. For cascading recycling, it is necessary that the purity of the polycarbonate be very high in order to reduce the cost and the energy needed. The polycarbonate can then be used to produce the non-recording plastic board of other optical disks.

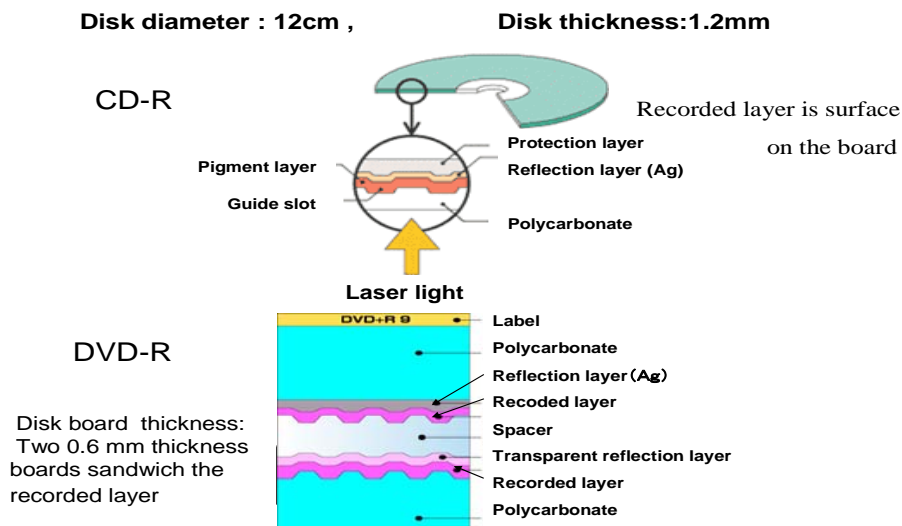


Figure 3. Cross section view of CD-R & DVD-R (Source: Rikoh HP, IT media)

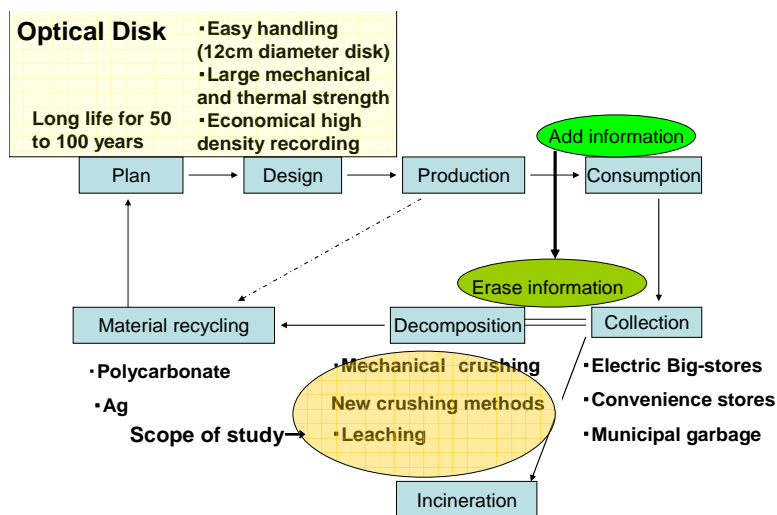


Figure 4. Life cycle of CD-R and DVD-R.

### **3 COLLECTING OPTICAL DISK S FROM INDIVIDUAL CONSUMERS**

Possible methods of collecting unwanted, used CD-Rs and DVD-Rs from individual consumers are discussed below. The selected collection sites and methods are as follows:

- Electronics stores - deposit system, points back, exchange, lottery
- Convenience stores - deposit system, exchange, lottery
- Municipal garbage collection sites - Recycling box

Each possibility has its merits and demerits, which were determined by the use of questionnaires given to companies and individuals, who use these disks. The total possible number of points for merits  $p$  and demerits  $q$  is 100. The total points  $r_t$ , used to rate each collection system, is calculated by using the following equation:

$$r_t = \sum_{k=1}^p m_{kt} - \sum_{l=1}^q d_{lt} \quad (1)$$

In other words,  $r_t$  is calculated as the difference between the merit points  $m_{kt}$  and demerit points  $d_{lt}$ . The results are given in Table 3. The scenario obtaining the most points is the following: the individual consumer brings used CDs or DVDs to an electronics store. There the consumer exchanges the used disks for new CD-Rs or DVD-Rs, using a special exchange ratio. Also, the consumer will be able to erase the information on the used CDs or DVDs using a machine installed at the store.

### **4 DATA ERASURE AND RECYCLING OF USED OPTICAL DISKS**

There are many kinds of data erasure methods; however, the number of methods used to recycle polycarbonate plate and silver are limited. Table 4 lists various data erasure methods and estimates their usefulness in recycling CD-R and DVD-R materials. As shown in Figure 3, the one sided recording layer of a CD-R is easily destroyed by scratching the recording board; however, data erasure from a DVD-R is very difficult because the recording layer is sandwiched between two polycarbonate boards. Crushing by hand or scissors or mechanical crushing can destroy the optical disk; however, the data still remains in the crushed parts. The scratch method for data crushing CD-Rs in (Fig. 5(a)) is effective for use by offices and individual consumers in destroying data. Then the board can be recycled by leaching the silver in a nitric acid solution; however it is impossible to erase the data on a DVD-R in this way. A roller press (Fig. 5(b)) can easily separate two attached DVD plates, prior to acid leaching, which erases the data and dissolves the silver at the same time. Microwave heating and electrical crushing in water shown in (Fig. 5(c)) can erase the data on a small number of optical disks. The data recorded on optical disks can be also removed by thermal heating; however, recycling bent and fixed boards is difficult. The best method for this explosion in water, shown in Figure 5(D). In this method, stainless steel boxes are filled with optical disks and water. Then, an explosive is put above the middle and set off.

**Table 3.** A comparison of several methods of collecting optical disks

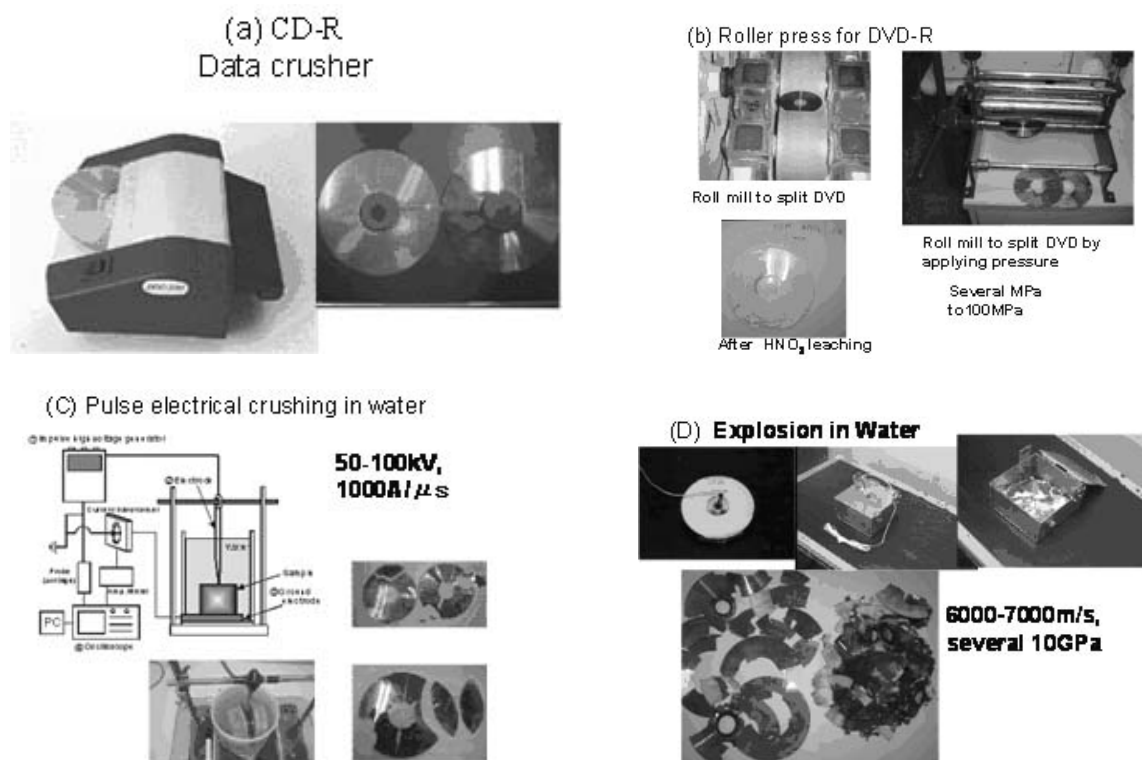
	Deposit				Point back		Exchange				Drawing				BOX
	Electric Big-stores		Convenience store		Electric Big-stores		<b>Electric Big-stores</b>		Convenience store		Electric Big-stores		Convenience store		at house
	Deposit				Point back		<b>Exchange</b>				Lottery				Box
Erasure of recorded information	by myself	Machine	by myself	Machine	by myself	Machine	by myself	<b>Machine</b>	by myself	Machine	by myself	Machine	by myself	Machine	Machine
<i>Number of collection methods</i>	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
14 Protection of private information	11.0	11.0	11.0	11.0	11.0	11.0	11.0	<b>11.0</b>	11.0	11.0	11.0	11.0	11.0	11.0	2.9
10 Benefit to consumers	2.6	2.6	2.6	2.6	5.1	5.1	10.2	<b>10.2</b>	10.2	10.2	5.1	5.1	5.1	5.1	0.0
13 Safety of mechanical crushing	0.0	12.9	0.0	12.9	0.0	12.9	0.0	<b>12.9</b>	0.0	12.9	0.0	12.9	0.0	12.9	12.9
14 Motive of consumers to recycle	11.1	11.1	11.1	11.1	8.3	8.3	11.7	<b>11.7</b>	11.7	11.7	4.4	4.4	4.4	4.4	1.7
14 Advertisement of recycling	6.9	6.9	6.9	6.9	6.9	6.9	13.9	<b>13.9</b>	13.9	13.9	13.9	13.9	13.9	13.9	6.9
8.7 Total collected amount	3.8	3.8	5.2	5.2	3.8	3.8	6.6	<b>6.6</b>	7.3	7.3	6.6	6.6	7.3	7.3	1.0
8.7 Collected amount at one place	8.7	8.7	0.4	0.4	8.7	8.7	8.7	<b>8.7</b>	0.4	0.4	8.7	8.7	0.4	0.4	0.0
17 Feasibility of recycling	13.0	17.4	13.0	17.4	13.0	17.4	13.0	<b>17.4</b>	13.0	17.4	13.0	17.4	13.0	17.4	17.4
100 Total merit points	57.1	74.3	50.2	67.4	56.9	74.1	75.0	<b>92.2</b>	67.4	84.6	62.7	79.9	55.1	72.3	42.8
10 Necessity to keep wastes	0.0	0.0	0.0	0.0	0.0	0.0	5.1	<b>5.1</b>	5.1	5.1	0.0	0.0	0.0	0.0	10.2
9.8 Payment by consumers	4.9	4.9	4.9	4.9	0.0	0.0	0.0	<b>0.0</b>	0.0	0.0	0.0	0.0	0.0	0.0	9.8
12 Cost to carry wastes	12.4	12.4	2.7	2.7	12.4	12.4	12.4	<b>12.4</b>	2.7	2.7	12.4	12.4	2.7	2.7	0.0
12 Management cost of data erasure	9.0	0.0	9.0	0.0	9.0	0.0	9.0	<b>0.0</b>	9.0	0.0	9.0	0.0	9.0	0.0	0.0
6.3 Cost to make recycling system	6.3	6.3	6.3	6.3	3.2	3.2	3.2	<b>3.2</b>	3.2	3.2	6.3	6.3	6.3	6.3	3.2
13 Cost by recycling company	6.3	6.3	6.3	6.3	8.5	8.5	12.7	<b>12.7</b>	12.7	12.7	12.7	12.7	12.7	12.7	0.0
13 Competition with cost of oversea	12.7	12.7	12.7	12.7	0.0	0.0	0.0	<b>0.0</b>	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13 Energy to collect the wastes	4.2	4.2	8.5	8.5	4.2	4.2	4.2	<b>4.2</b>	8.5	8.5	4.2	4.2	8.5	8.5	12.7
11 Cost of machine to erase data	0.0	11.1	0.0	11.1	0.0	11.1	0.0	<b>11.1</b>	0.0	11.1	0.0	11.1	0.0	11.1	11.1
100 Total demerit points	56.0	58.1	50.5	52.5	37.3	39.4	46.6	<b>48.7</b>	41.1	43.2	44.7	46.8	39.2	41.3	47.0
Total amount	1.0	16.2	-0.3	14.8	19.6	34.7	28.4	<b>43.5</b>	26.4	41.5	18.0	33.1	15.9	31.0	-4.0

The bubbles in the water detach the DVD boards. For example, 1g of explosive can be used to explode 100 DVD-R disks. When the crushed parts are then immersed in nitric acid, silver and dye are leached. Finally, the clean polycarbonate is recovered and recycled. Silver ions are precipitated as silver chloride, then reduced, and sent on to an electro wining process in order to obtain extremely pure silver.

**Table 4.** Estimation of various methods for data erasure, prior to material recycling of CD-Rs and DVD-Rs

	CD-R		DVD-R	
	Data erasure	Material Recycling	Data erasure	Material Recycling
Crushing by hand or scissors	△	△	△	△
Mechanical crushing by cutter or mill	△	△	△	△
Data crusher	○	○	X	X
Microwave heating	△	△	△	△
Electrical crushing in water	△	△	△	△
Thermal heating	○	X	○	X
Roller press	X	X	○	○
Explosion crushing in water	○	○	○	○

○ : good, △ : poor, X: impossible



**Figure 5.** Methods of erasing the data from and recycling optical disks

## **5 CONCLUSIONS**

This research discusses complete and safe methods of erasing data from various type of optical disks, CD-Rs, CD-RWs, DVD-Rs, and DVD-RWs, prior to their recycling. Various collection systems and data erasure methods are investigated for their suitability.

It has been suggested that for security reasons industrial consumers can track their discarded disks by RFIDs attached to the recycle boxes. After being collected, the data stored in the optical disks are erased by explosion in water treatment, an effective method also considering the material recycling.

It also has been suggested that the private users can bring their used optical disks to electronics stores to exchange them for new ones. At the store, the user can erase the data from the disk by means of a roll mill or a data crusher installed at the store. The recycling company can recover silver by leaching the disks in nitric acid and producing pellets from the recovered polycarbonate. Optical disk producers can then reuse the recycled polycarbonate and recovered silver in the manufacturing process of new disks, completing the cycle of the so-called cascade recycling.

## **6 REFERENCES**

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