

Data Erasing and Recycling of Optical Disks

Toyohisa Fujita^a, Gjergj Dodbiba^a,
Kenji Murata^b and Takao Ihashi^c

*a: The University of Tokyo, Geosystem
Engineering, 7-3-1 Hongo, Bunkyo-ku,
Tokyo 113-8656, Japan*

*b: Nippon Koki co., Ltd., Fukushima, 961-
8686 Japan*

c: Bifrostec Inc., Tokyo 101-0051, Japan

Recorded media

- Floppy 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)**

Relationship between C D, D V D material recycling and information data erasing

- Data erasing mechanically in private
 - Mechanically crushing by scissors and hand easy but difficult to material recycling and unsafe for person and data erasing
- Data erasing in office and general consumer
 - Utilization of recycle box to carry recycle company
 1. Observation of box by GPS and RFID
 2. Importance of complete data erasing and new material recycling method

1. Current Situation

Optical disk

World Production of Optical Disk (FY 2005):
ca. **20 billion disks**, of which CD-R represented more than 50 %.

Production in 2003, November, (unit: 1 million/year)

	CD-R	CD-RW	DVD-R	DVD-RW
Japan	400	28	115	41
World	6940	327	345	82

(Source: Japan recording-media industries association)

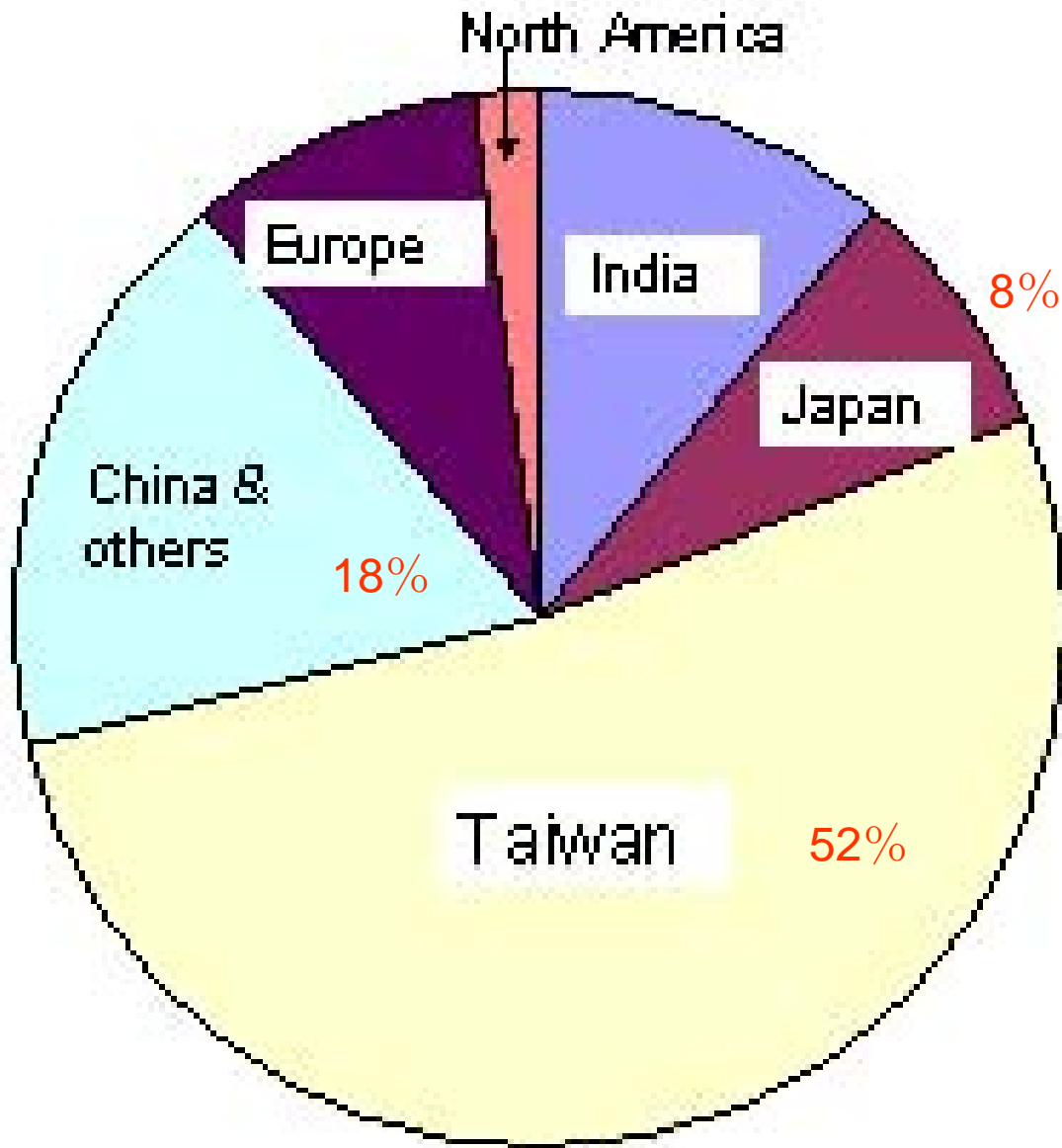


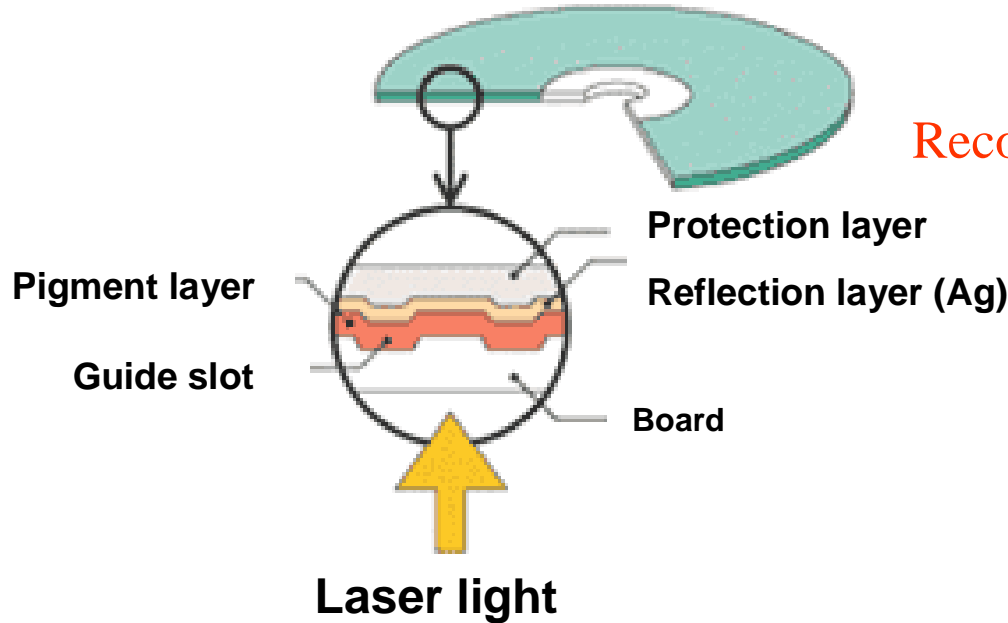
Fig.2 Production ratio of CD-R in 2003.

Cross section view of CD-R & DVD-R (Source: Rikoh HP)

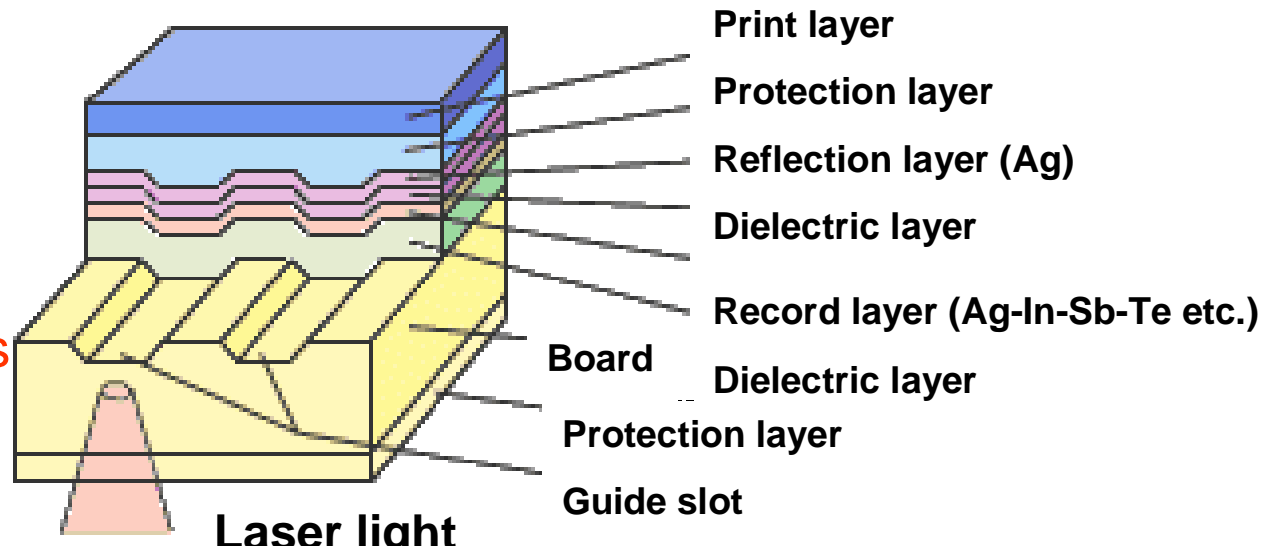
Disk diameter : 12cm ,

Disk thickness:1.2mm

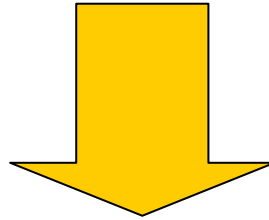
CD-R



DVD-R



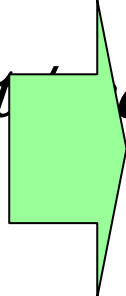
Disk board thickness:
Two 0.6 mm thickness
boards sandwich the
recorded layer



Optical disk demand in Japan is 600 million disks

One disk (both CD,DVD) contain:

15g polycarbonate
and 15 mg silver (layer thickness 70-90nm)

polycarbonate	9 0 0 0 t/year		1.8 billion/year
Silver		(\200/kg)
.	9 t/year		0.5 billion/year
			(\50/g) in 2007 October

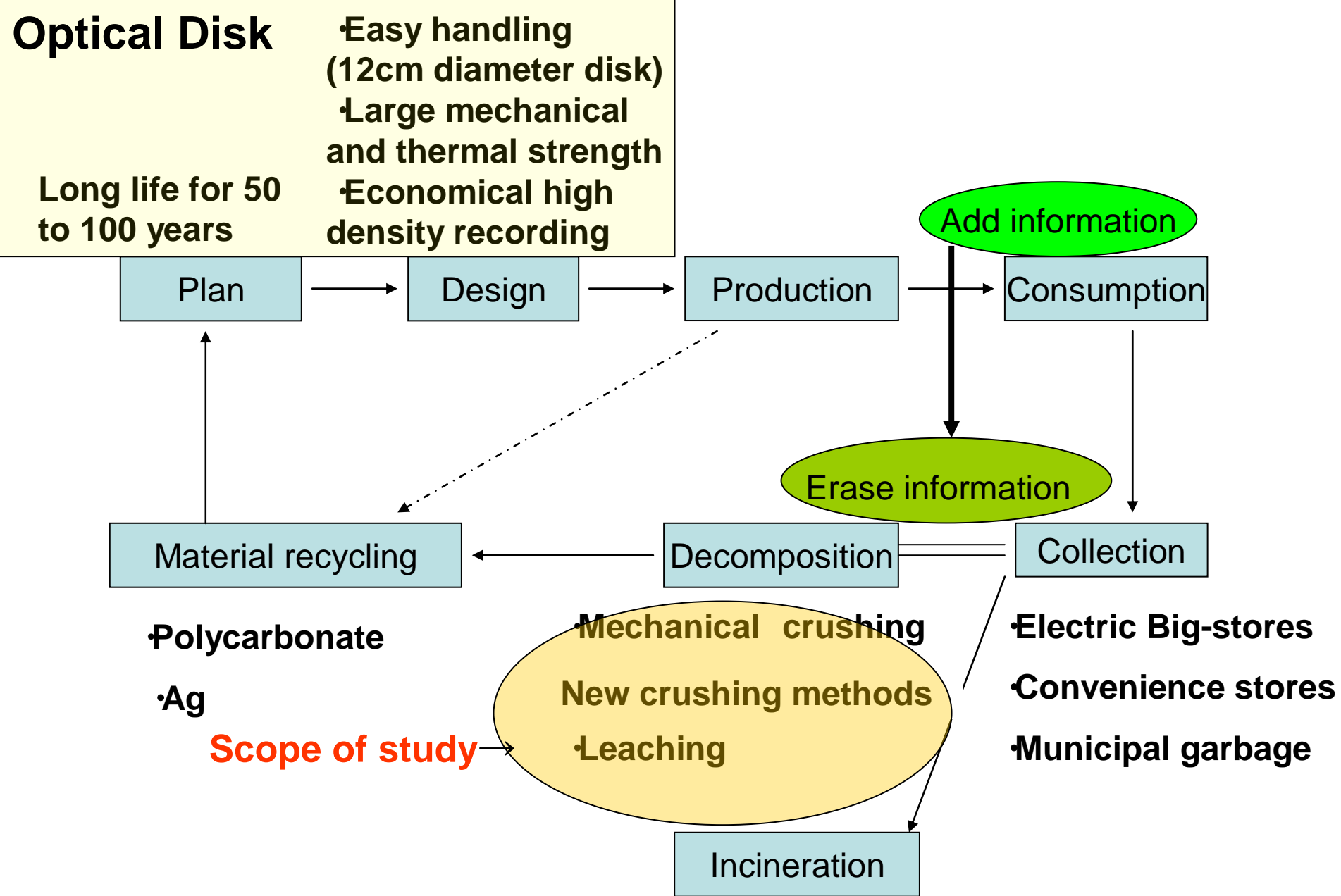


Fig. Life cycle of CD-R and DVD-R.

• Recycling System: Production and Collection sites

Producer. Own recycling by production company

- • • **Disk to disk recycling**

Start Lab in Japan

- • • Recycling of unprinted disk in the production

Collector. Recycling of discarded disk from **company**

(ca. 40%)

- • • **Cascade recycling** of polycarbonate to use as one side board (mount) of disk

ORIENT INSTRUMENT COMPUTER CO.,LTD

→ Recycle box from the consumers • • •

Safety datum erase is important

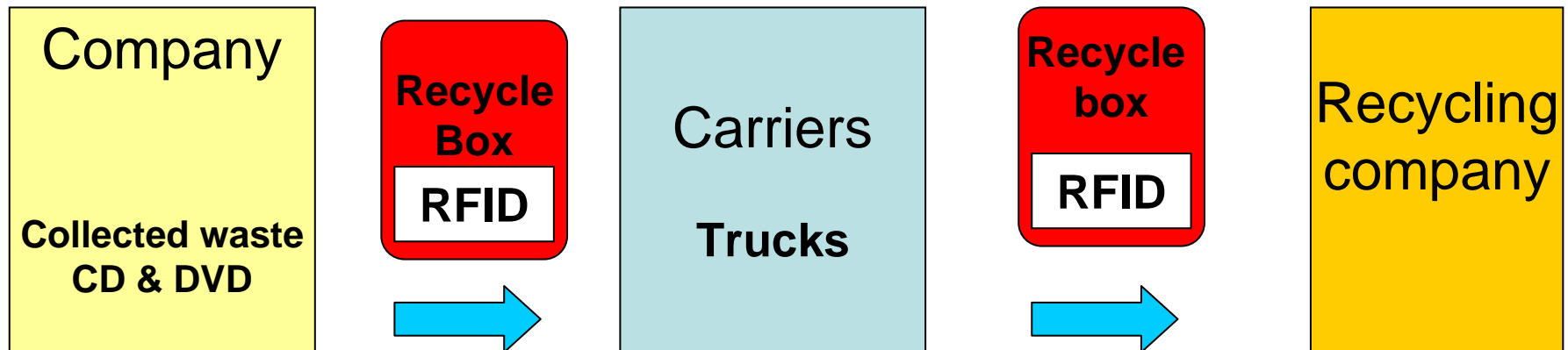
No recycling of discarded disk from **general consumer**

(ca. 60%)

- • • Incineration or landfill as municipal waste

Safety recycle box to carry used CD & DVD including data information

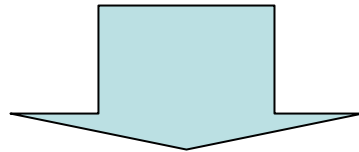
- GPS (Geographical position system)
- RFID (Radio Frequency Identification) is attached on recycle box



Motivation for collection and erasure of the recorded information to general consumers

Investigation of the collection system of optical disk

- Motivation for bring the wasted disks to the collection place
Deposit, Point return, Exchange to new disk, Lottery, Recycle box
- Collection sites:
Electric big store, Convenience store, At house
- Erasure method of the recorded information
By users, Data-crusher Machine



Evaluation method of the recycling efficiency

- **Merit and demerit**
- **Weight estimation by questionnaire datum**
- Estimation of **best collection system**

•Evaluation of the collecting system

1. Merit for system: p factors, Demerit for system: q factors,

Weights are: $m_1, m_2, \dots, m_p, d_1, d_2, \dots, d_q$

$$\sum_{i=1}^p m_i = 100, \quad \sum_{j=1}^q d_j = 100$$

2. Merit for collection system: m_{ti} ,

Demerit for collection system: d_{ti}

Weights are: $m_{t1}, \dots, m_{tp}, d_{t1}, \dots, d_{tq}, m_{t1} < m_1$

Weight of collection system: r_t

$$r_t = \sum_{k=1}^p m_{tk} - \sum_{l=1}^q d_{tl}$$

R_{max} is shown in the next equation. Here, 15 systems are planned.

$$r_{max} = \text{MAX}(r_1 : r_{15})$$

•Example 1

		R_1	\dots	R_t	\dots
m_1	M_1	m_{11}	\dots	m_{t1}	\dots
\dots	\dots	\dots	\dots	\dots	\dots
m_p	M_p	m_{1p}	\dots	m_{tp}	\dots
100	Total merit				
d_1	D_1	d_{11}	\dots	d_{t1}	\dots
\dots	\dots	\dots	\dots	\dots	\dots
d_q	D_q	d_{1q}	\dots	d_{tq}	\dots
100	Total demerit				
100	Total weight	$\mathbb{1}$	\dots	$\mathbb{1}$	\dots

• The comparison of several collection methods for optical disks

	Collection place	Electric Big-stores		Convenience store		Electric Big-stores		Electric Big-stores		Convenience store		Electric Big-stores		Convenience store		at house
	System at the collection place	Deposit system				Point back		Exchange				Drawing bts				Box
	Erasing of recorded informations	by myself	Machine	by myself	Machine	by myself	Machine	by myself	Machine	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	11	11	11	11	11	11	11	11	11	11	11	11	11	2.88
10	Benefit of consumers	2.56	2.56	2.56	2.56	5.11	5.11	10.2	10.2	10.2	10.2	5.11	5.11	5.11	5.11	0
13	Safety of mechanical crushing	0	12.9	0	12.9	0	12.9	0	12.9	0	12.9	0	12.9	0	12.9	12.9
14	Motive of consumers to recycle	11.1	11.1	11.1	11.1	8.33	8.33	11.7	11.7	11.7	11.7	4.44	4.44	4.44	4.44	1.67
14	Advertisement of recycling	6.94	6.94	6.94	6.94	6.94	6.94	13.9	13.9	13.9	13.9	13.9	13.9	13.9	13.9	6.94
8.7	Total collected amount	3.82	3.82	5.21	5.21	3.82	3.82	6.6	6.6	7.29	7.29	6.6	6.6	7.29	7.29	1.04
8.7	Collected amount at one place	8.68	8.68	0.4	0.4	8.68	8.68	8.68	8.68	0.4	0.4	8.68	8.68	0.4	0.4	0
17	Feasibility of recycling	13	17.4	13	17.4	13	17.4	13	17.4	13	17.4	13	17.4	13	17.4	17.4
100	Total point of merit	57.1	74.3	50.2	67.4	56.9	74.1	75	92.2	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	5.08	5.08	5.08	5.08	0	0	0	0	10.2
9.8	Payment by consumers	4.92	4.92	4.92	4.92	0	0	0	0	0	0	0	0	0	0	9.85
12	Cost to carry wastes	12.4	12.4	2.65	2.65	12.4	12.4	12.4	12.4	2.65	2.65	12.4	12.4	2.65	2.65	0
12	Management cost to erase datum	9.02	0	9.02	0	9.02	0	9.02	0	9.02	0	9.02	0	9.02	0	0
6.3	Cost to make recycling system	6.35	6.35	6.35	6.35	3.17	3.17	3.17	3.17	3.17	3.17	6.35	6.35	6.35	6.35	3.17
13	Cost by recycling company	6.35	6.35	6.35	6.35	8.47	8.47	12.7	12.7	12.7	12.7	12.7	12.7	12.7	12.7	0
13	Competition with cost of overseas	12.7	12.7	12.7	12.7	0	0	0	0	0	0	0	0	0	0	0
13	Energy to collect the wastes	4.23	4.23	8.47	8.47	4.23	4.23	4.23	4.23	8.47	8.47	4.23	4.23	8.47	8.47	12.7
11	Cost of machine to erase datum	0	11.1	0	11.1	0	11.1	0	11.1	0	11.1	0	11.1	0	11.1	11.1
100	Total point to demerit	56	58.1	50.5	52.5	37.3	39.4	46.6	48.7	41.1	43.2	44.7	46.8	39.2	41.3	47
	Total amount	1	16	-0	15	20	35	28	44	26	41	18	33	16	31	-4

Erasing data prior to recycling CD and DVD

- **CD: Data crusher** is an effective method for erasing data from CD.
- **DVD:**
 - Crushing by hand or scissors
 - Mechanical crushing
 - Microwave heating
 - Electrical crushing in water
 - Thermal heating
 - Explosion crushing in water

Recycling of polycarbonate and silver

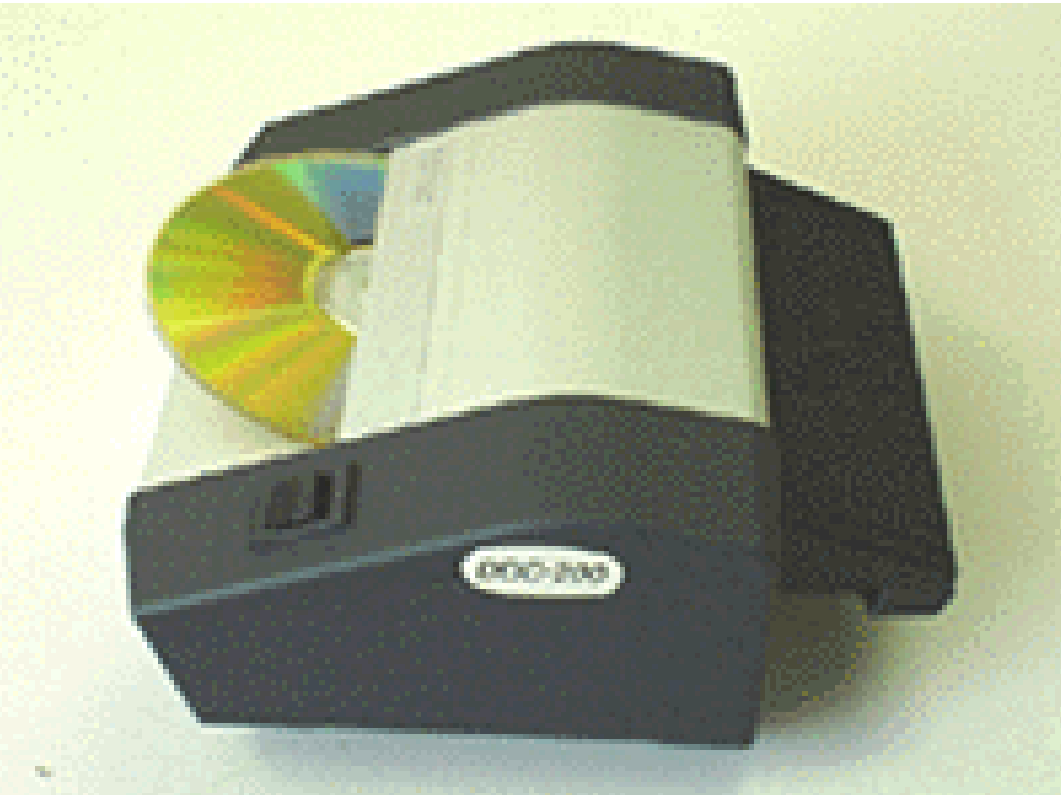
Silver is leached in HNO_3 solution and electro wining.

After Polycarbonate is crushed, pellet is produced.

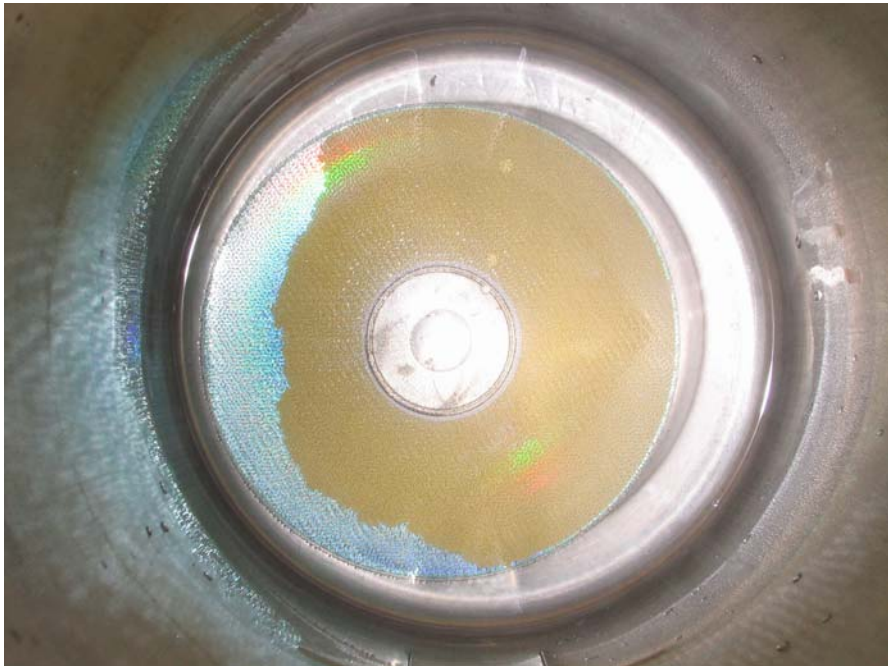
1. CD

Mechanical crushing

Data crusher



After CD-R passed through the data crusher,
it is immersed into 8 mol/L HNO_3 solution.
→ Silver is dissolved completely after 2
minutes.

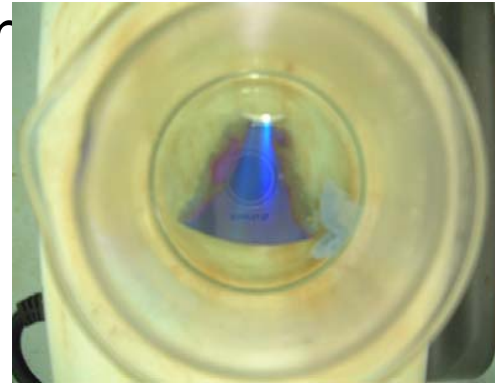


2. DVD

1. Mechanical crushing

Data crusher is not able to erase data from DVD because the recorded layer is sandwiched by **0.6 mm thickness of 2 polycarbonate disks**. Therefore, the DVD was cut 5 pieces and immersed into 8 mol/L HNO_3 solution

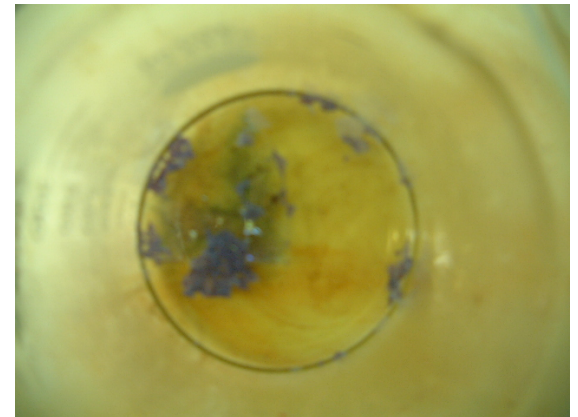
→It is difficult to dissolve the Ag layer.



2. Microwave treatment

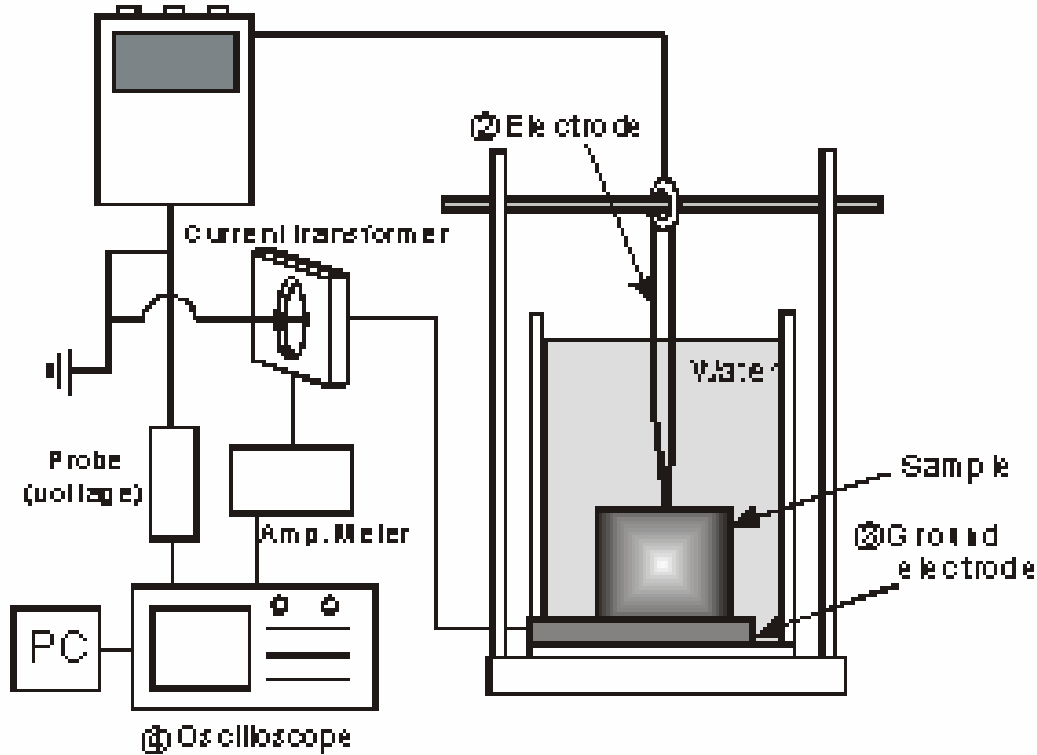
500W microwave was applied to DVD for 3 seconds.

→It is easy to dissolve Ag layer of DVD in 8 mol/l HNO_3 solution for 2 minutes.



3. Pulse electrical crushing in water

① Impulse high voltage generator



50-100kV, 1000A/μs

$$E = \sum VI \Delta t$$



4. Thermal Treatment in oven

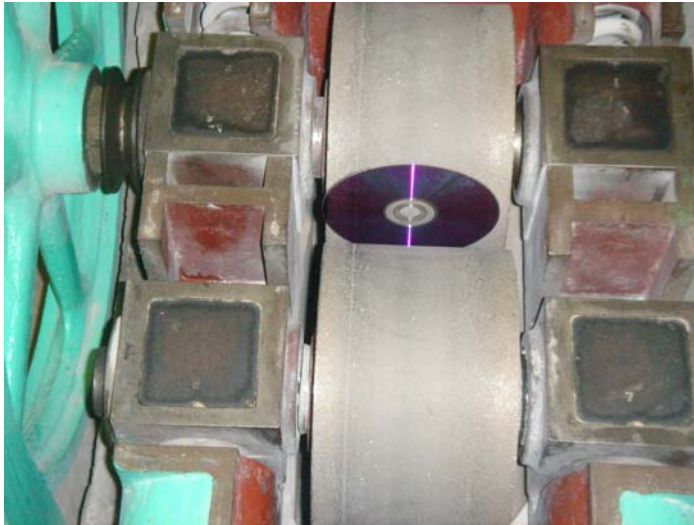


110-130°C

for 2-3 minutes



5. Roll mill of high pressure

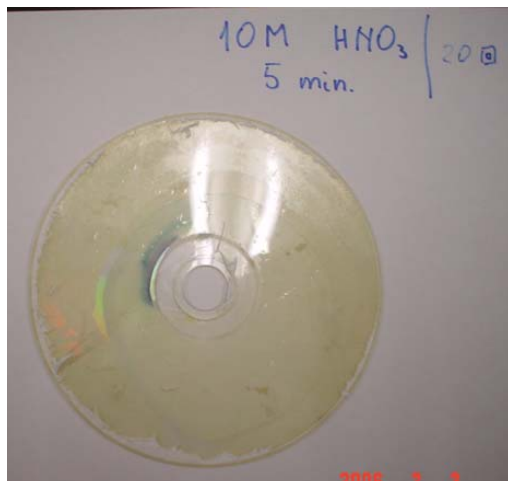


Roll mill to split DVD



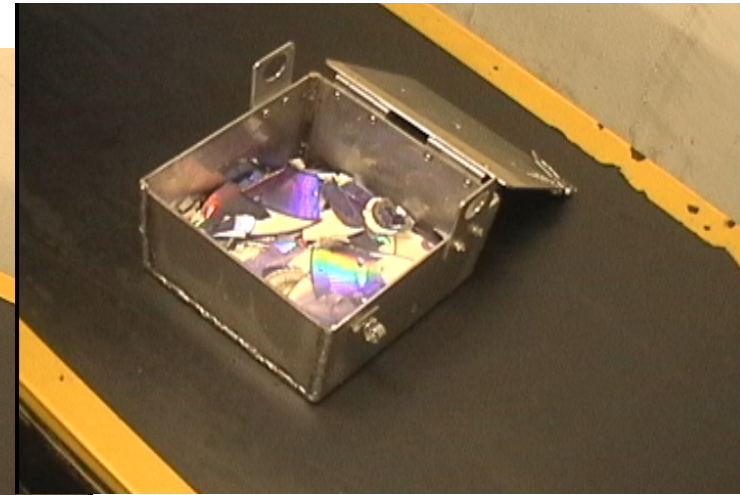
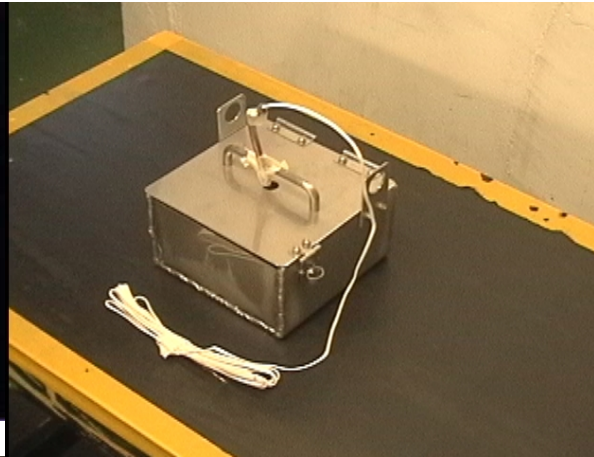
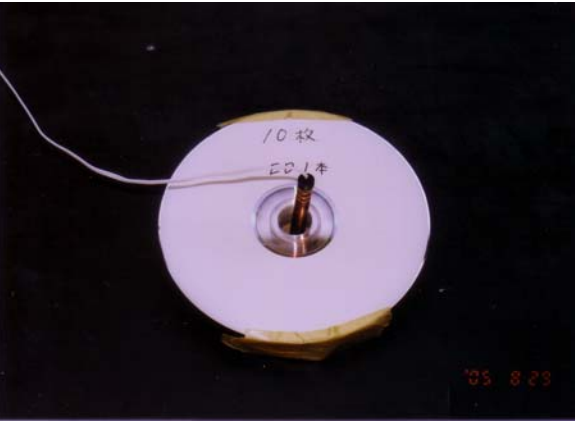
Roll mill to split DVD by applying pressure

Several MPa to 100MPa



After HNO_3 leaching

6. Explosion in Water



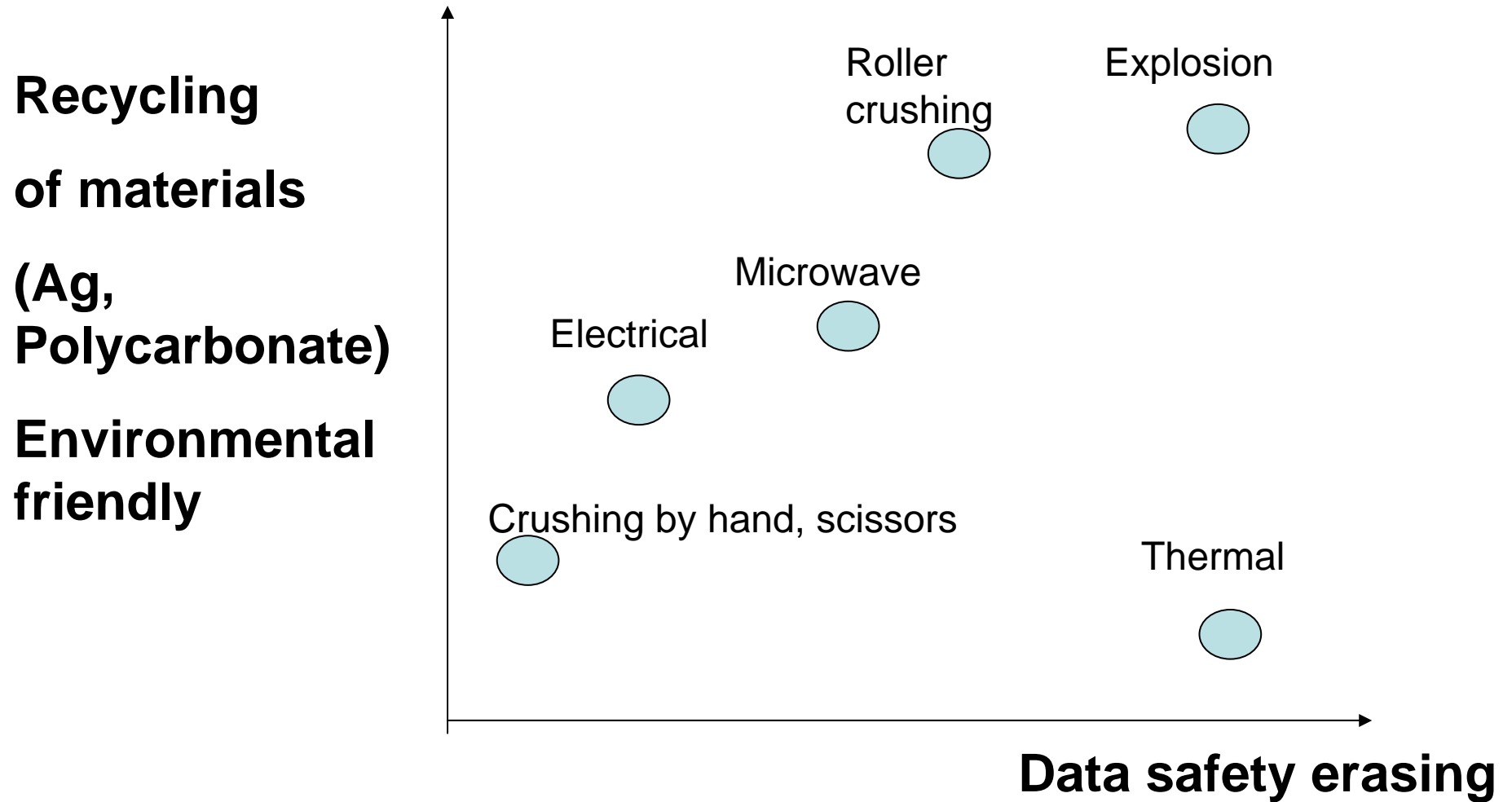
blasting powder . . .

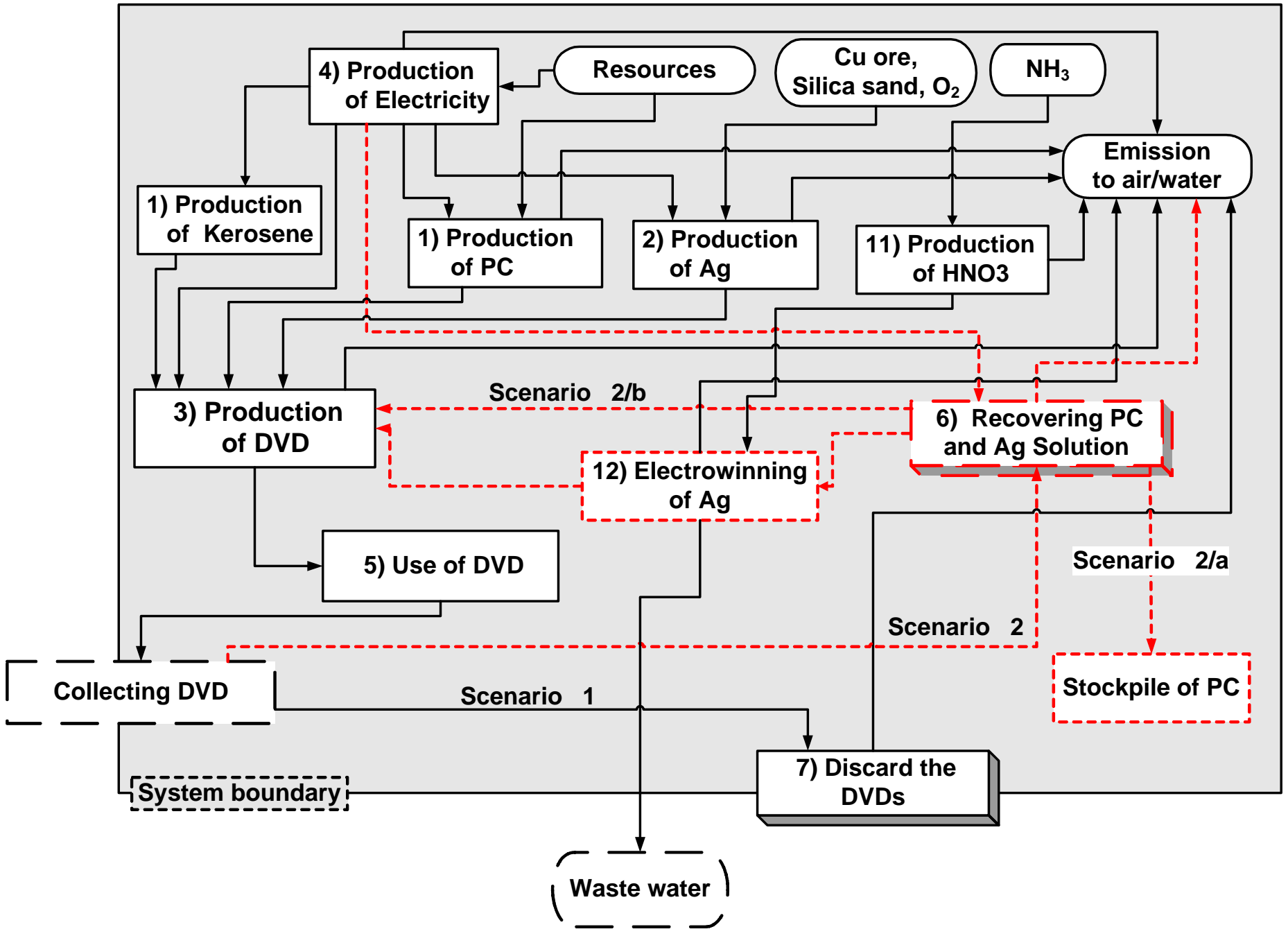
High explosive 1g/100 DVD

Bubble detached the DVD
plates

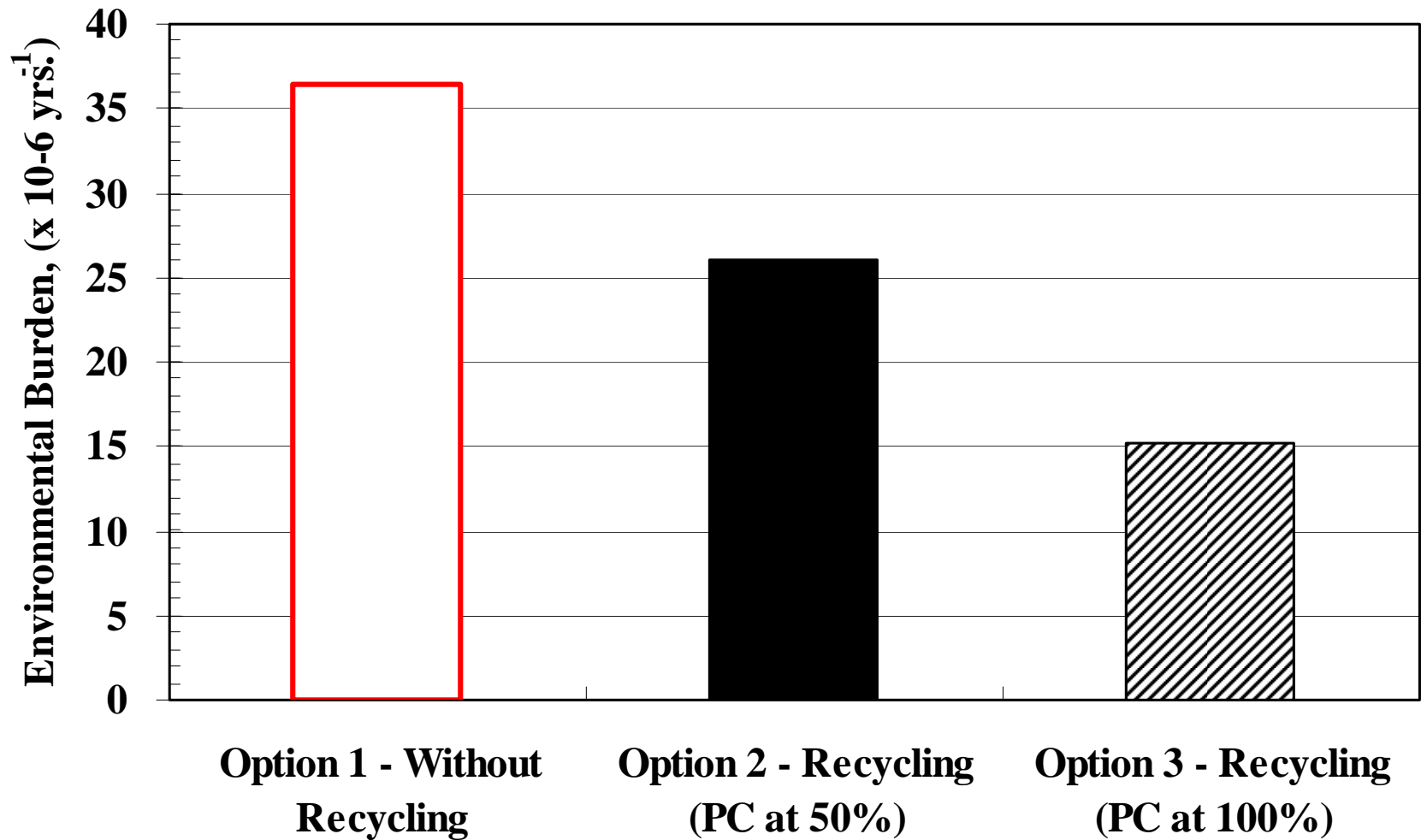
6000-7000m/s, several 10GPa

Estimation of DVD crushing methods





Estimation of PC recycling from DVD by LCA



Conclusion

- **Purpose**→ **Complete safety data erasing and material recycling** of CD-R, CD-RW and DVD-R, DVD-RW

1. Optimum Collection method and data erasing

Company consumer→ safety with **RFID** of recycle box

The effective methods for data erasing → the **explosion in water** treatment of recycle box

General consumer→ At the **electric big-store** to **exchange** the old CD and DVD with **new ones**. The data erasing for themselves by a **roll mill** installed in the store.

Recycling company: Silver **leaching by nitric acid** and **PC pellet production**

Producer→ **Cascade recycling** of polycarbonate as disk mount

2. LCA for recycling

Environmental burden decreases in larger **material recycling** comparing with small recycling rate.