

Overview of Magnetic and Optical Recording Technology- Current Status and Near Term Projections

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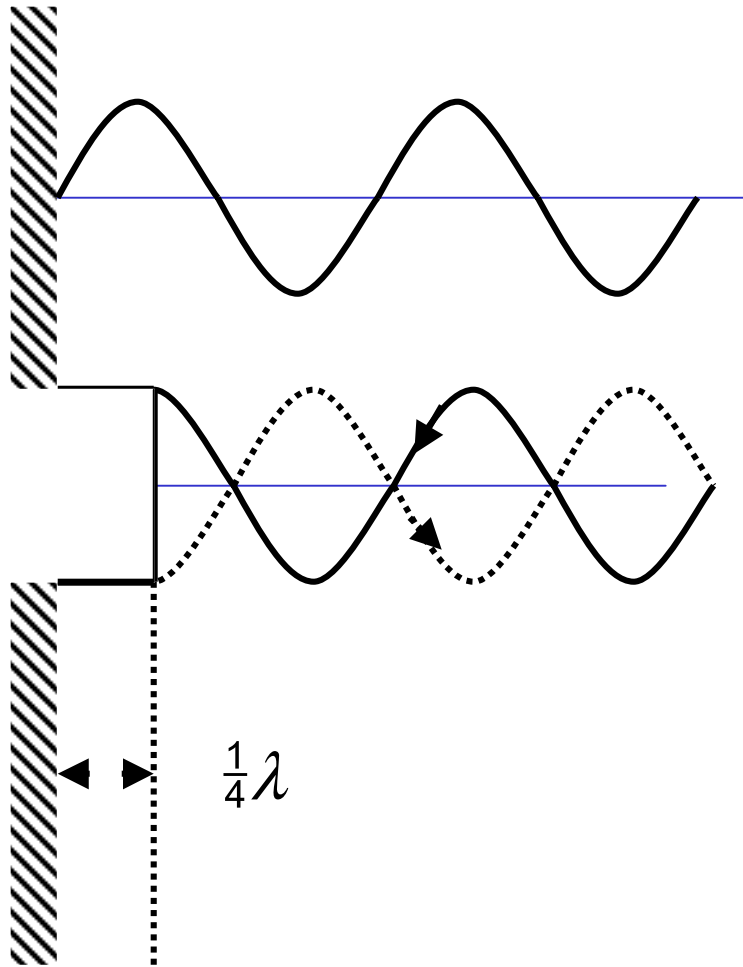
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Del Mar CA 92130-2539

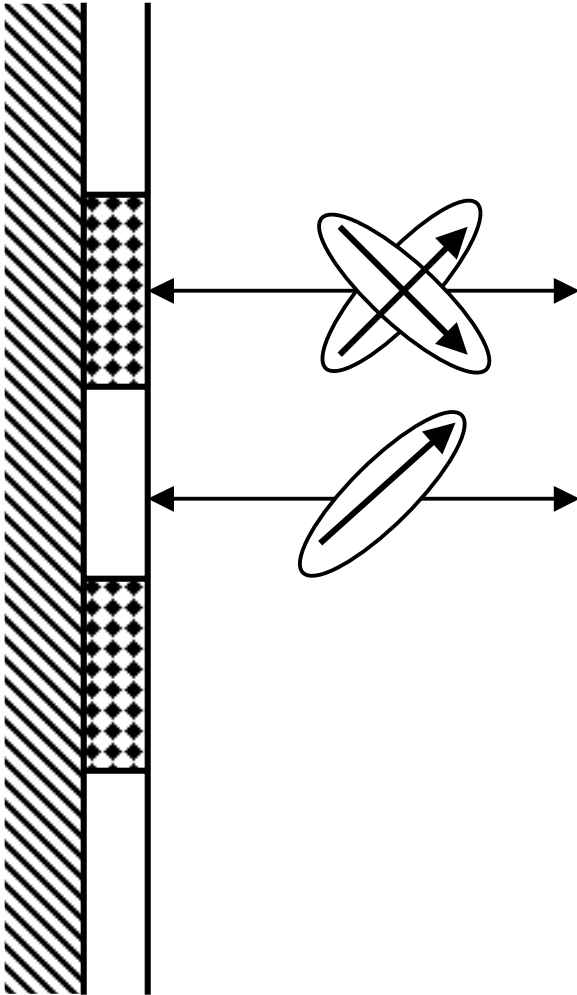
on January 19, 2000

Optical Recording Characteristics



- Recording Type: Physical Height Change (Pit or Land)
- Recording Method: Injection molding
- Reading Method: Optical Path interference
- Products: CD, DVD, CD-ROM

Optical Recording Characteristics 2

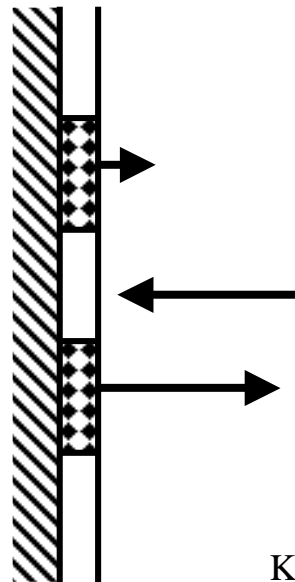


- Recording Type: Magnetization Reversal
- Recording Method: Spot temperature elevation near Curie point
- Reading Method: Kerr Angle differentiation
- Products: MO (Magneto-optical)

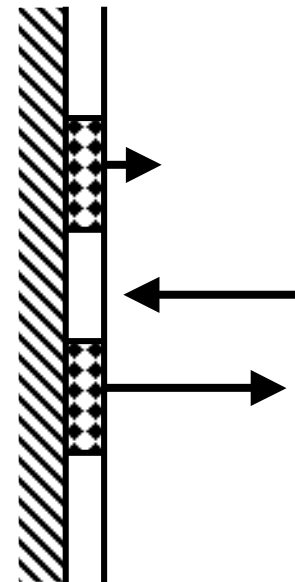
Optical Recording Characteristics 3 & 4

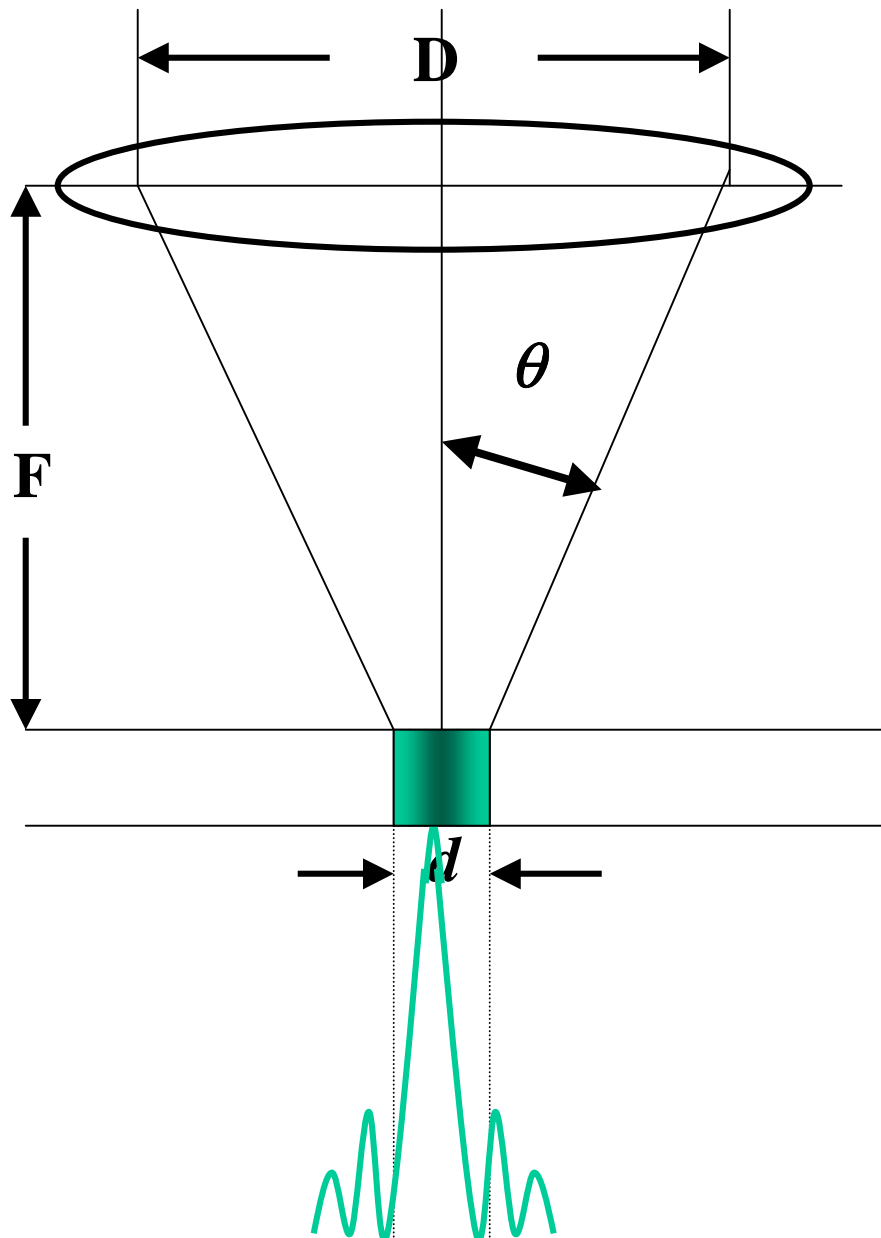
Recording Type	Recording Method	Reading Method	Products
3. State Change 4. Polymer Dyecharacteristic change	3. Pit temperature elevation 4. Pit temperature elevation	3. Reflectivity differentiation 4. Reflectivity differentiation	3. PC (phase change) DVD-RAM 4. CD-R DVD-R

3



4





$$f \text{ number} = F/D$$

Numerical aperture, $NA = \sin \theta$

$$NA = \frac{D/2}{(F^2 + D^2/4)^{1/2}}$$

Spot size = d

$$d = \sigma \lambda / NA$$

Where λ = wavelength of laser

σ = factor determined by beam energy distribution

Areal Density of Data Storage System

Hard disk drive

	1970	1980	1990	1999	2000+
Product	3330	3380	Corsair	Micro-drive	1999 Demo
TPI	192	801	2,238	19,000	67,300
Kbits/in	4.04	15.2	58.9	265	522
Mb/in ²	0.776	12.2	89.5	5,035	35,300
μm ² /bit	830	53	7.2	0.128	0.0018

Areal Density of Data Storage System

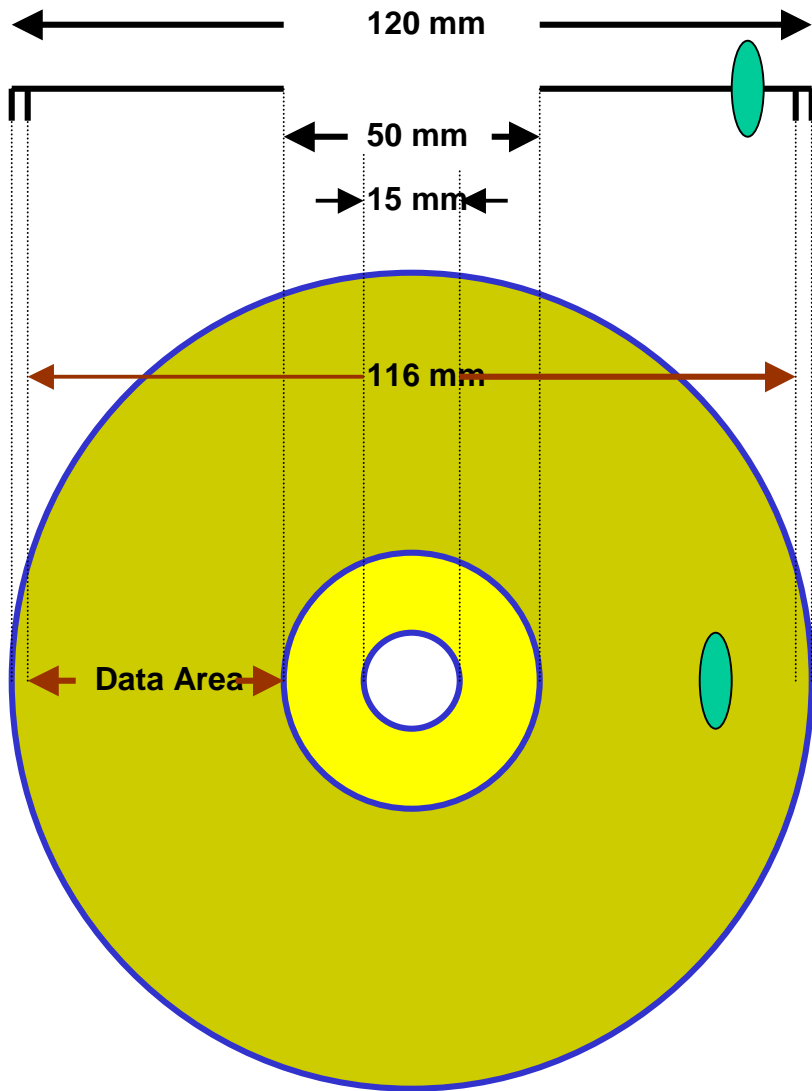
Magnetic Tape

	1970	1984	1985	1998	1999
Product		3480	ID-1	DVC (LP)	DLT-7
TPI		36	655	3,810	336
Kbits/in		49.4	50.8	104	123
Mb/in ²		1.78	33.3	397	41.4
μm ² /bit		362	19.4	1.6	15.6

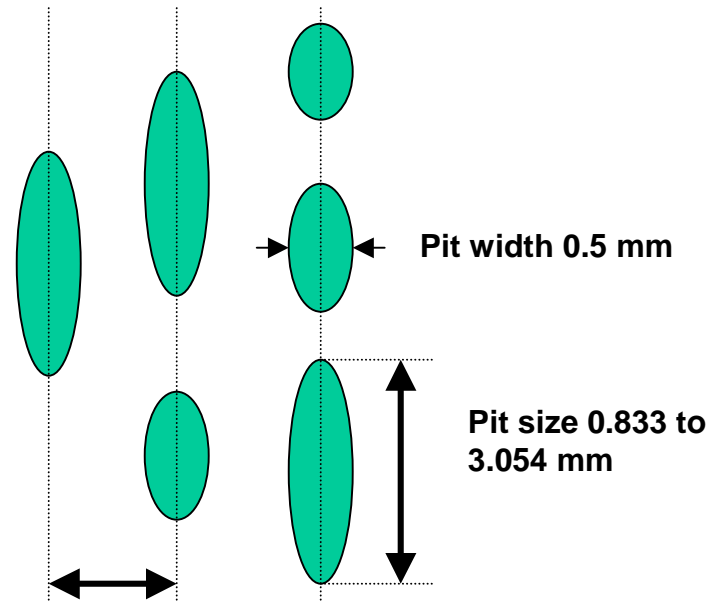
Areal Density of Data Storage System

Optical Disk

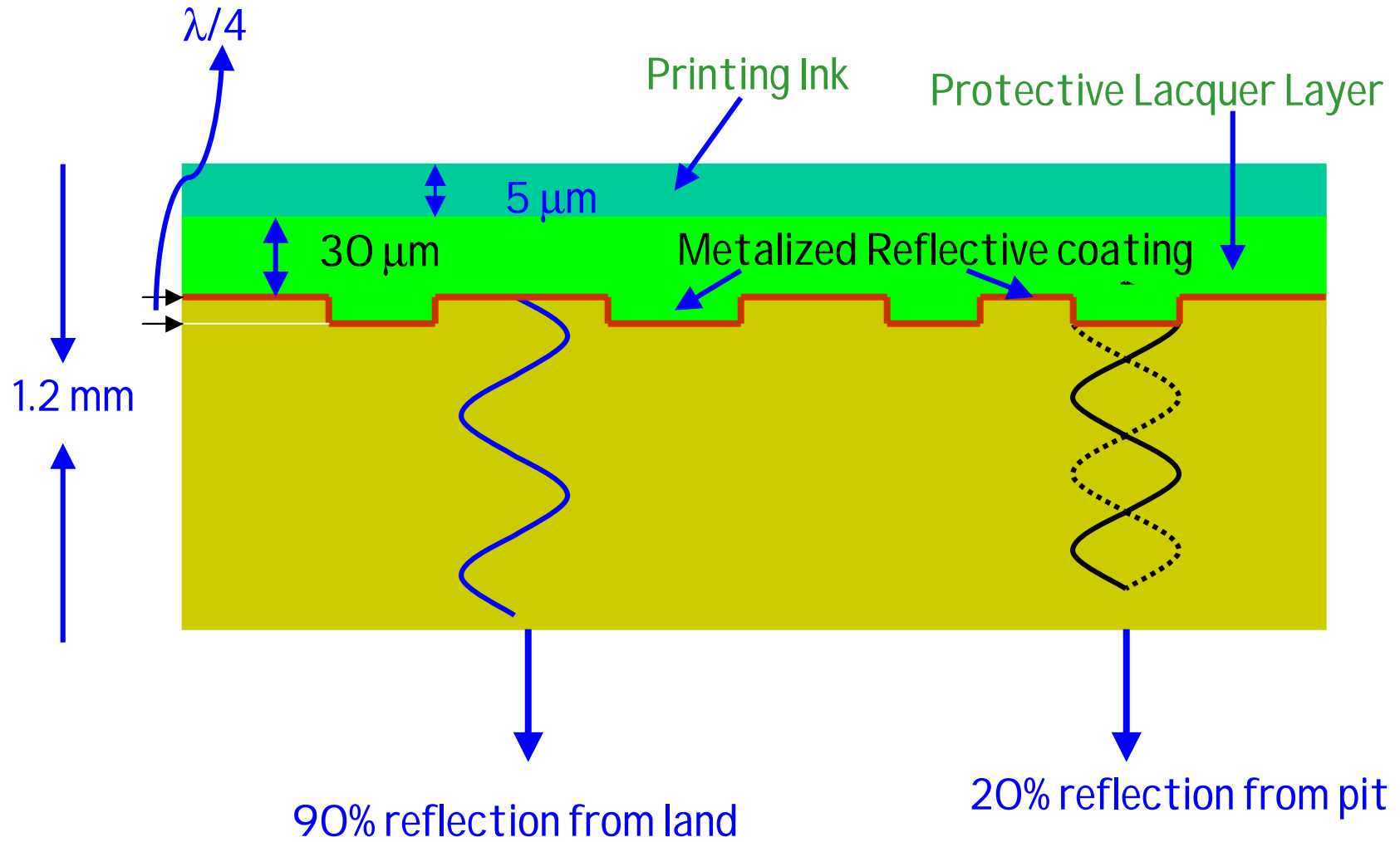
	1970	1982	1998	1999	2000+
Product		CD	DVD- RAM 2.6 GB	DVD- RAM 4.7 GB	Next Gen 15~25 GB
TPI		15,875	34,300	41,300	85,000
Kbits/in		30.5	62.1	90.7	120
Mb/in ²		484	2,130	3,745	10,000
μm ² /bit		1.3	0.303	0.172	0.065

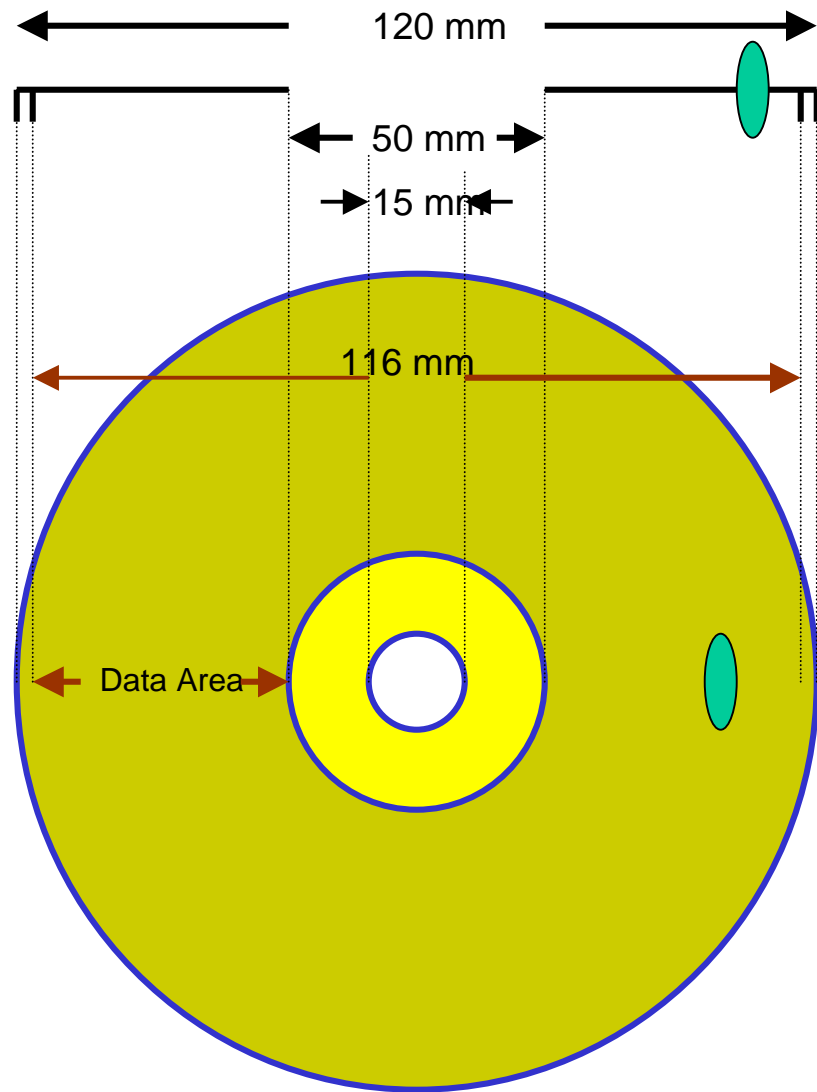


Structure of Compact Disc

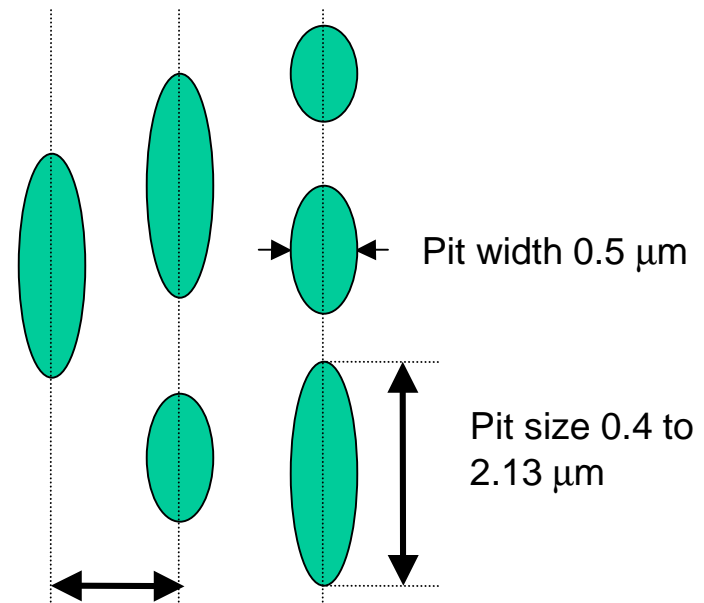


Compact Disc Structure





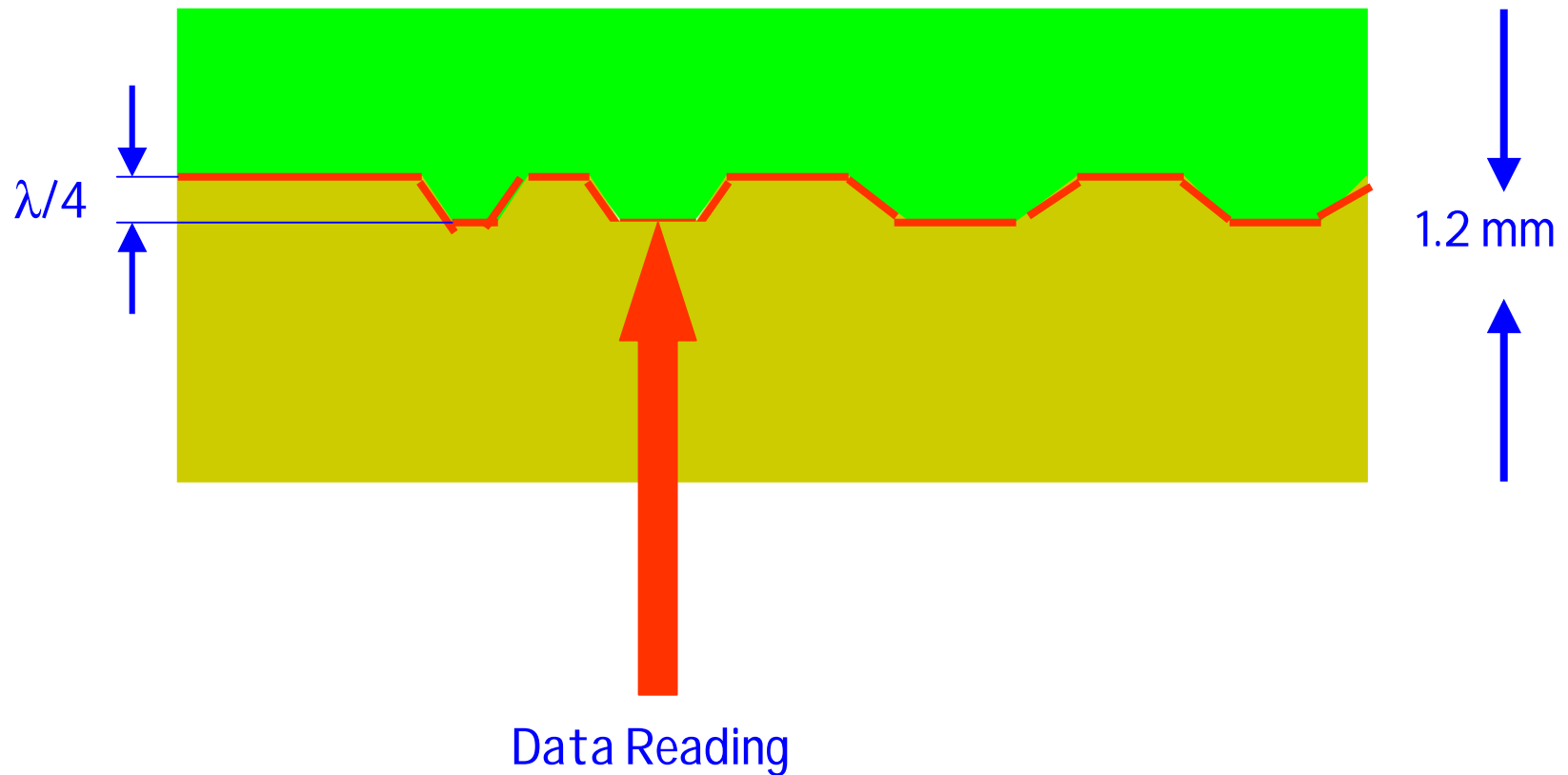
Structure of DVD



Track pitch 0.74 μm

DVD Disc Structure

Single Layer Disc (4.7 GB)



DVD Disc Structure

Double Layer Disc (8.5 GB)

Metalized Reflective Layer

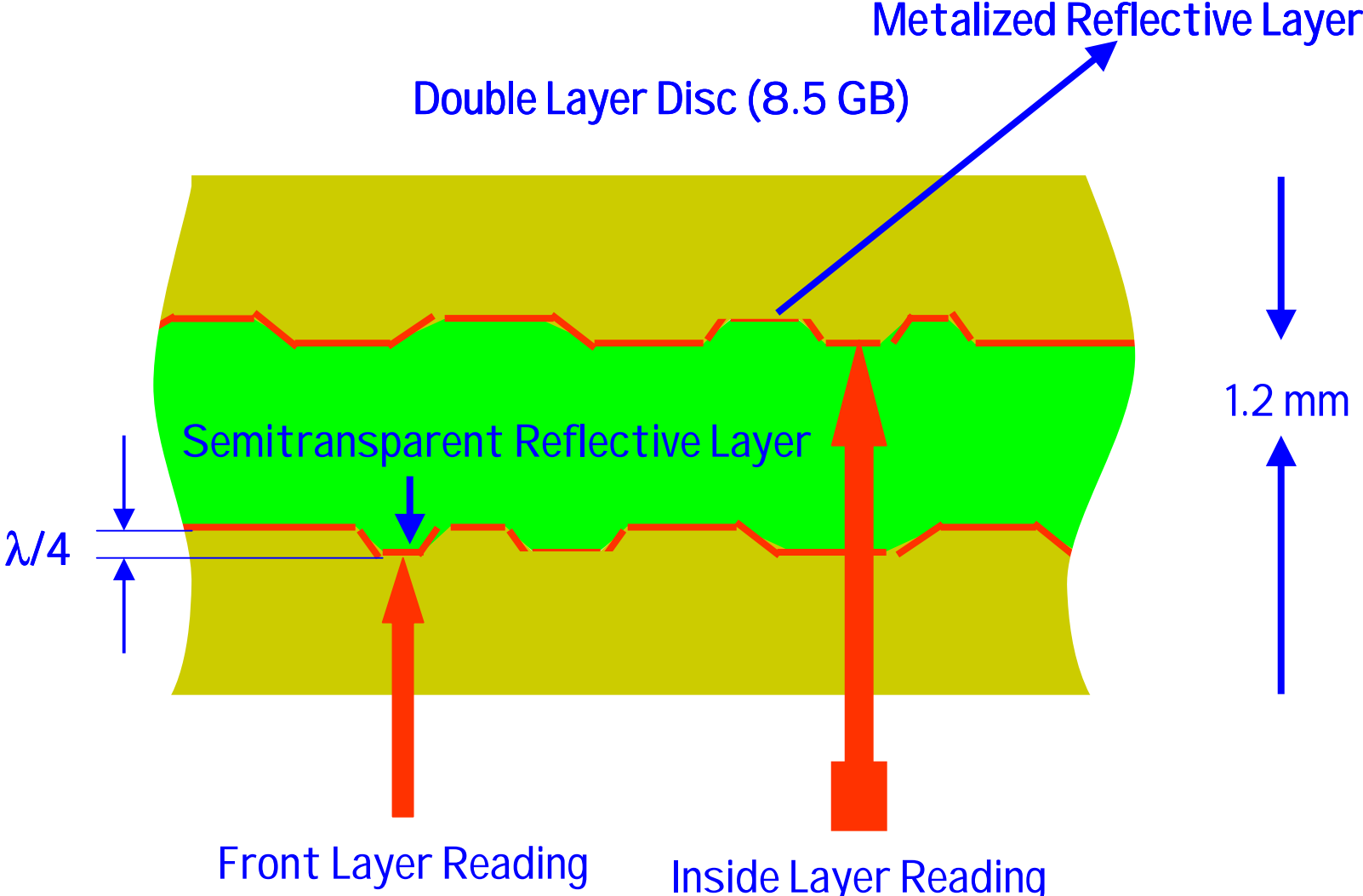
Semitransparent Reflective Layer

$\lambda/4$

1.2 mm

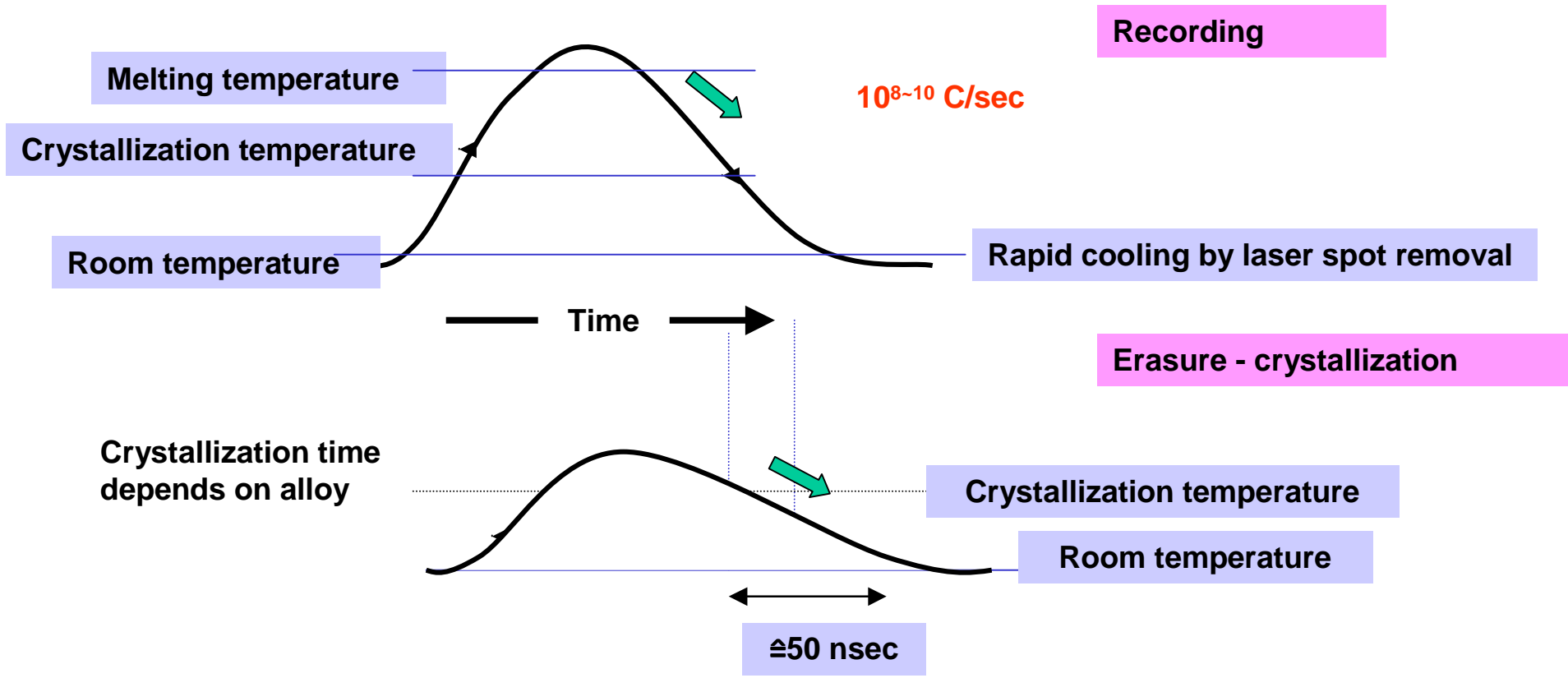
Front Layer Reading

Inside Layer Reading



Recording Process (Phase Change)

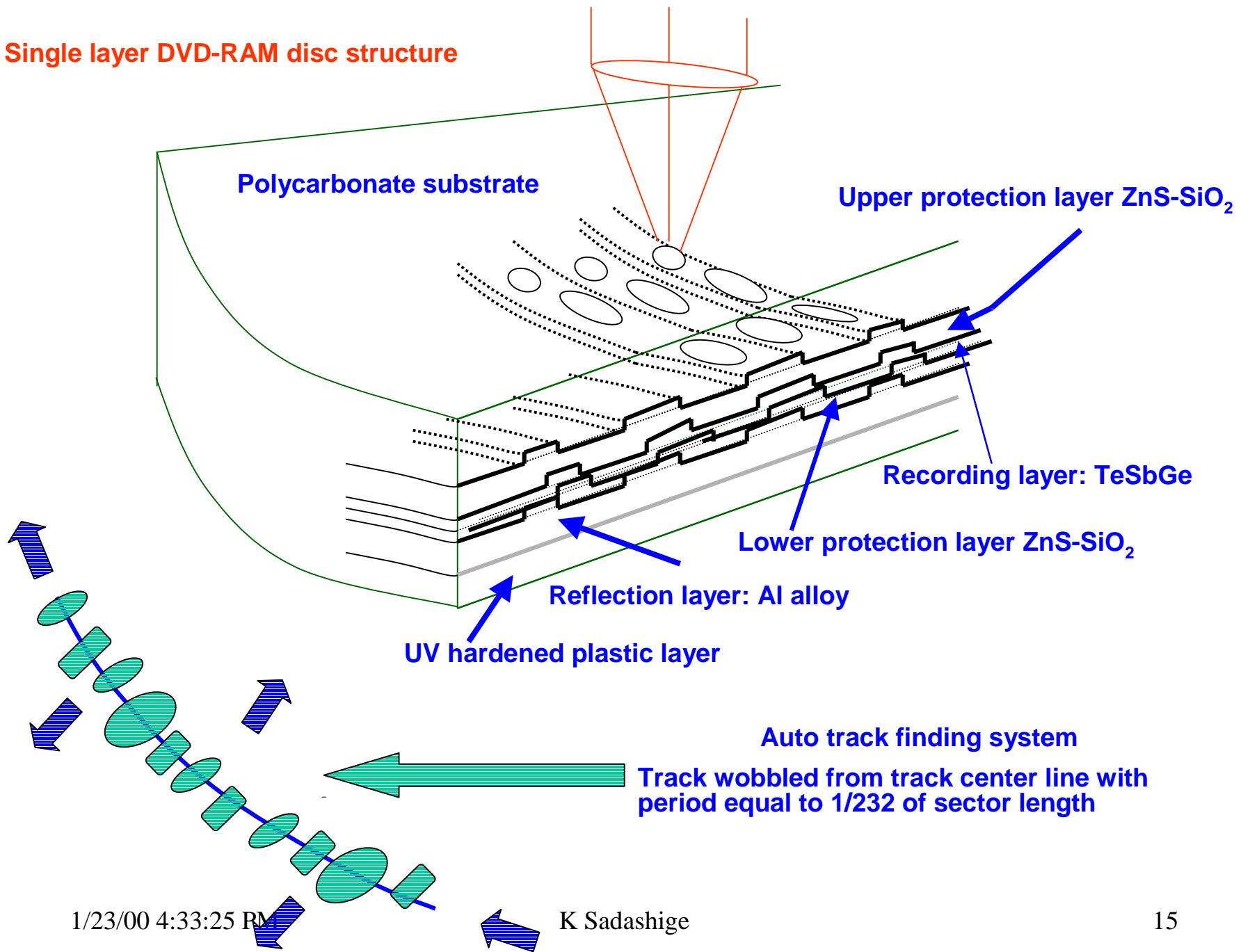
- Erased state ----- Crystalline phase
- Recorded state ----- Amorphous phase



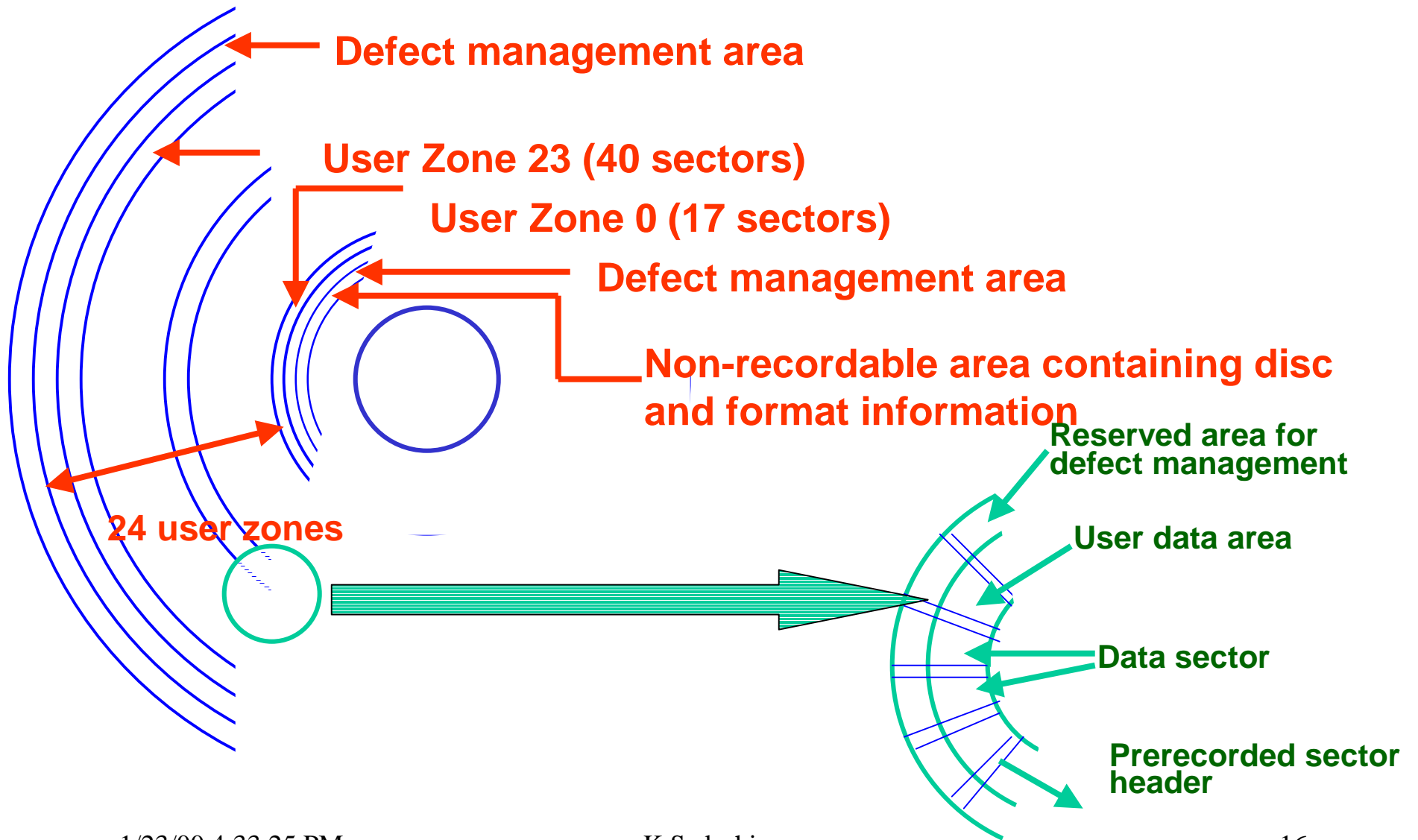
Data rate limited by crystallization time characteristic of the alloy

- Current status -- 3 MB/sec
- Near term objective --10 MB/sec

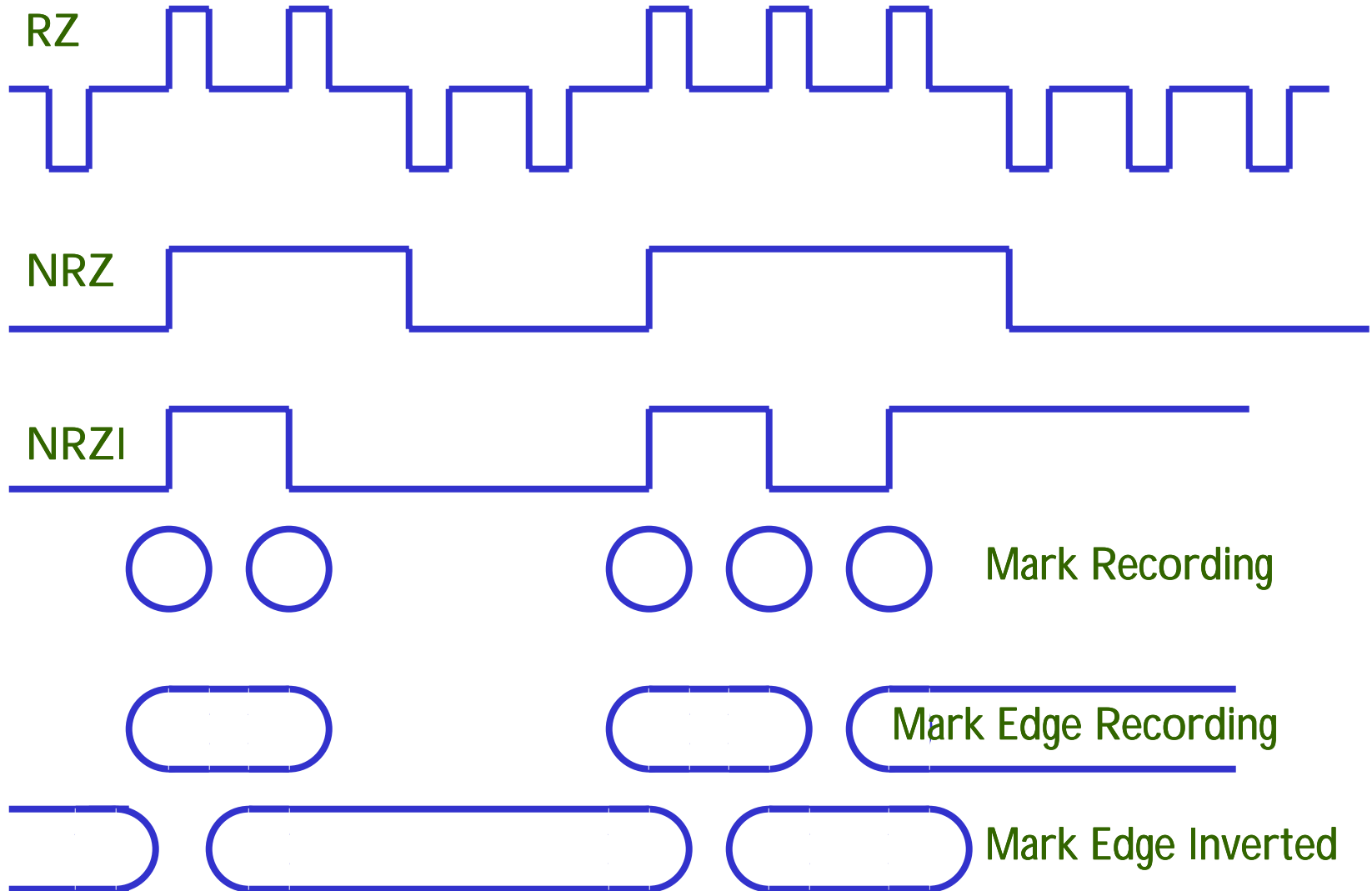
Single layer DVD-RAM disc structure



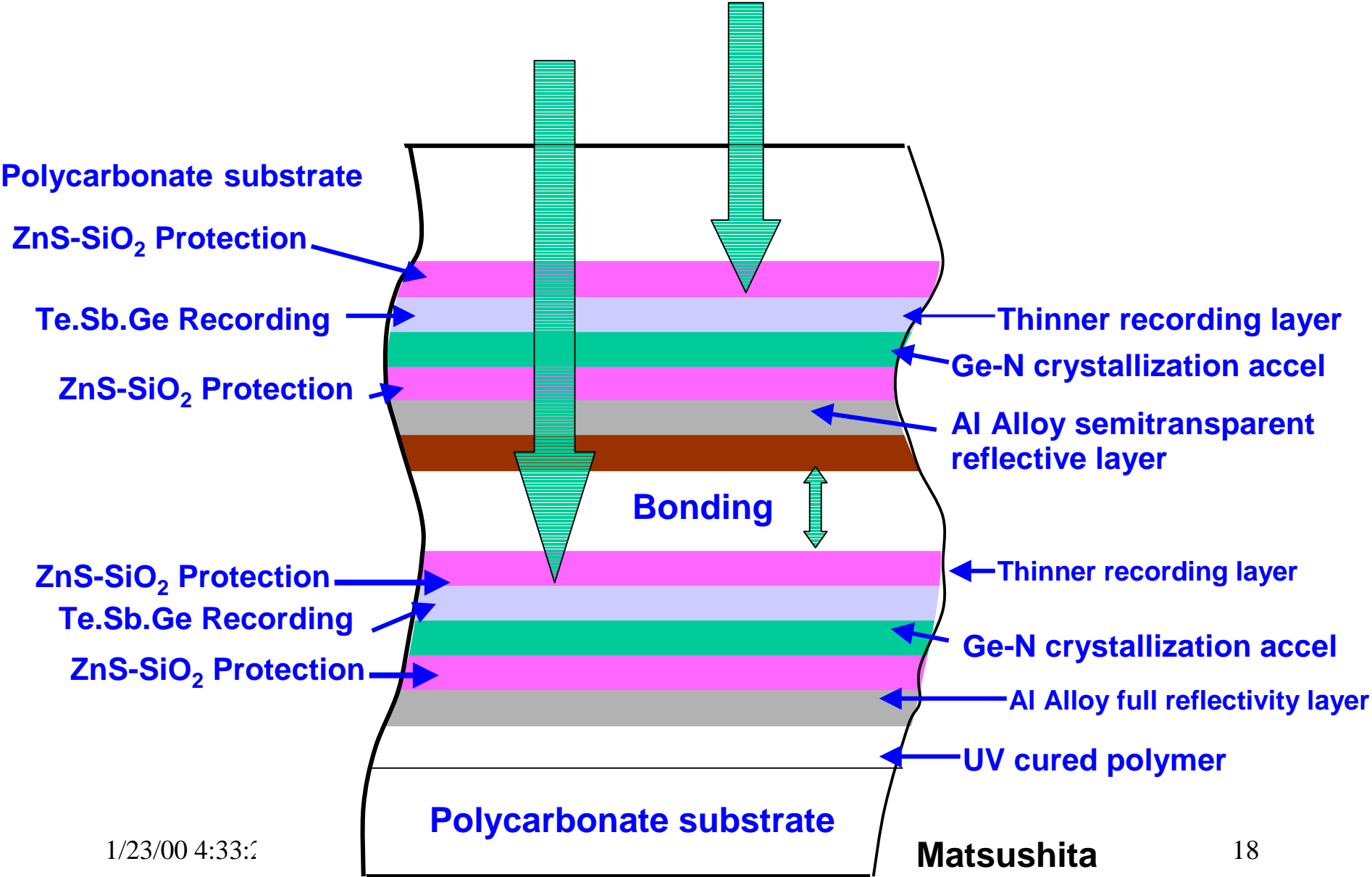
DVD-RAM Disc (Version 1.0) 2.6 GB user data



Mark and Mark Edge Recording



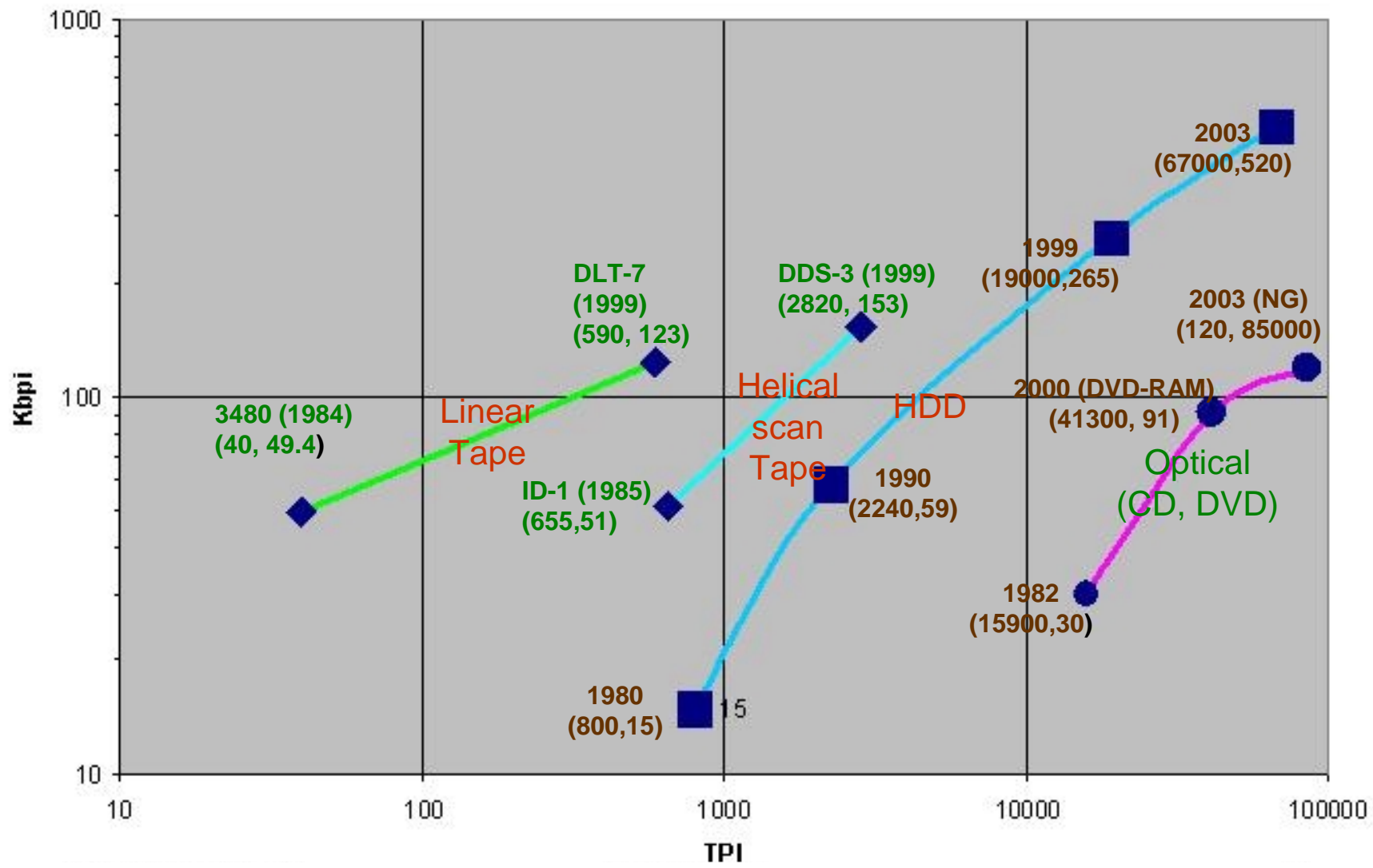
Possible Dual Layer DVD-RAM Disc Configuration



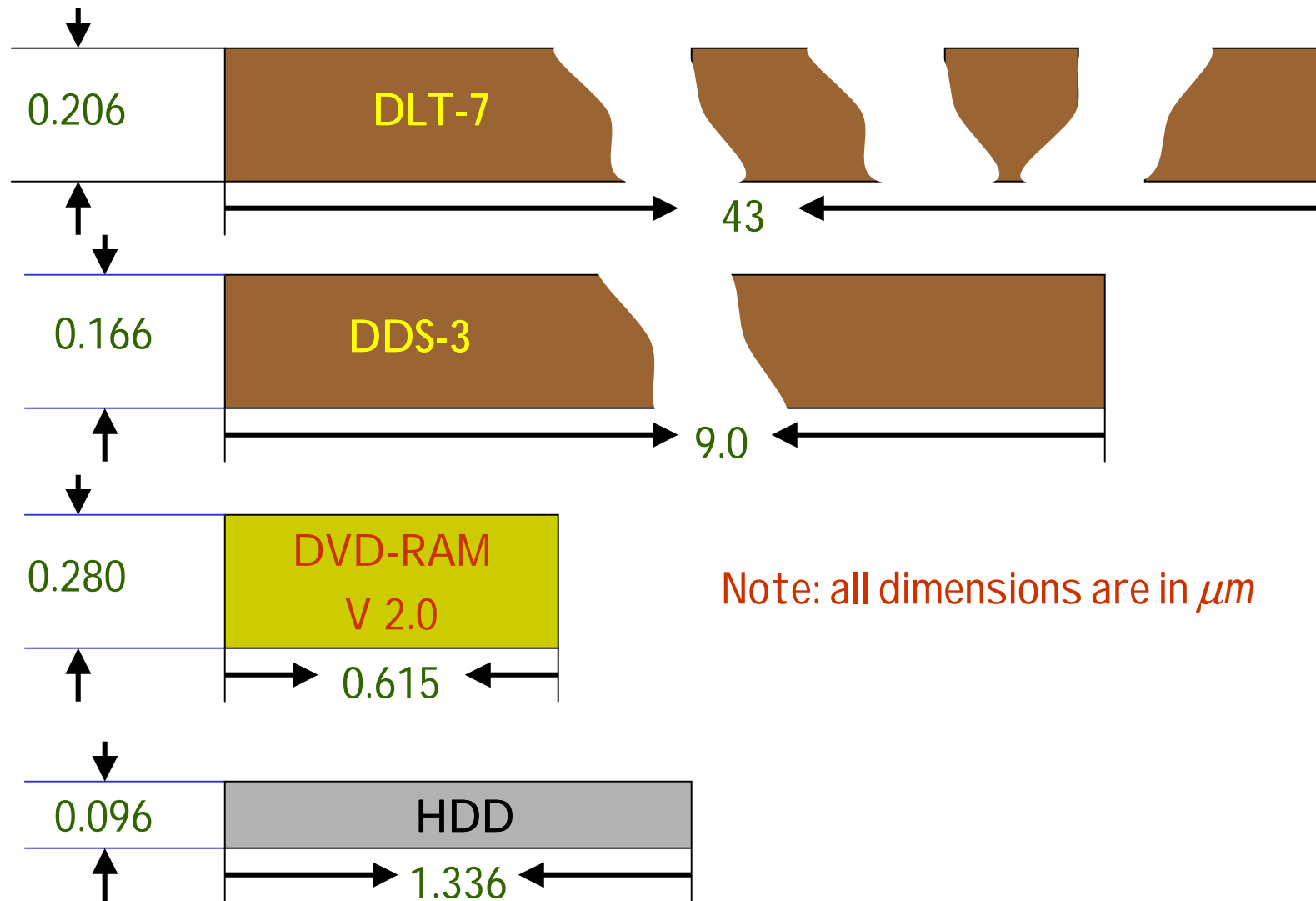
Areal Recording Density of Representative Products (1999)

Areal Density				Bit Cell (μm)		
Product	TPI	Kbpi	Mb/mm ²	Width	Length	Area
DVD-RAM (V 2.0)	41300	90.7	3745	0.615	0.28	0.172
IBM HDD Microdrive	19000	265	5035	1337	0.096	0.128
DDS-3	2824	153	432	9.0	0.166	1.494
DLT-7	590	123	42.8	43	0.206	8.858

Areal Density Growth: 1980 to 2000+



Bit cell size and Aspect Ratio *circa 1999*



DVD-RAM Characteristics

	Version 1.0	Version 2.0	Dual Layer Proposal	Future
Year of introduction	1998	1999	1999	2002
Capacity per surface, GB	2.6	4.7	4.7	12~18
Double sided media	Yes	Yes		
Laser / nm	650	650	650	450
Objective lens NA	0.6	0.6	0.6	0.8~0.85
Track pitch μm	0.74	0.615	0.6	0.3
Minimum mark length μm	0.409	0.28	0.3	0.2
Max Transfer rate, MB/s	1.38	2.76	2.76	6~9

DVD-RAM Characteristics (continued)

Common Characteristics

- Disc: diameter = 120 mm, thickness = 1.2 mm
- Single sided disc: in protection jacket. Disc can be removed from special jacket.
- Double sided disc: in protection jacket. Disc **not** removable from jacket. Disc must be flipped and reinserted in order to write to/read from second side.
- Dual layer disc: Both layers can be written to and read from the side the layers are on.

Tape dimensional instability

Source of dimension change	MD (Length)	TD (Width)
Heat shrinkage	XXX	XXX
Temperature variation	XX	XX
Humidity	XX	XX
Tape Tension (Young's Modulus)	X	X
Poisson's Ratio	--	X

XXX – major influence

XX – measurable influence

X – minor influence

Tape dimensional instability (contd)

Effects	MD (Length)	TD (Width)
Rotary Head	X	X
Fixed Head	--	XXX

XXX – major influence

XX – measurable influence

X – minor influence

Note: In a rotary drive equipped with active tracking servo, dimensional changes along both MD and TD can be entirely compensated.

Tape width change computation

Sample case: $\frac{1}{2}$ " tape, PET, base film thickness = $7 \mu\text{m}$, total thickness = $9 \mu\text{m}$ cross-sectional area = 0.9 mm^2 .

- Heat shrinkage: 30 min at 75 C -0.5%
- Temperature variation: 15 C decrease in temperature -0.01%
- Humidity variation: 40% decrease in RH -0.02%
- Tension variation: Tape tension increase of 0.15 N over recording during playback
 - Tape length change +0.03%
 - Tape width change due to Poisson's law (0.3) -0.01%
- Total width change -0.54%

Track Pitch reduction possibilities for Magnetic Tape Recording

Current Status:

Rotary Head – 7 μm

Fixed Head – 40 μm

Product Objectives: 2003-2005

Rotary Head – 3-5 μm

Fixed Head – 10-20 μm

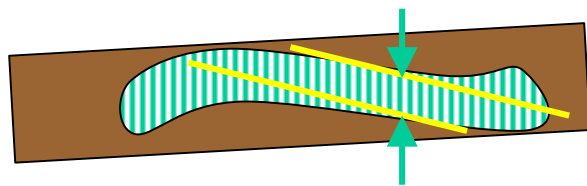
Enabling Technologies:

- Physically more stable tape base film
- Higher output (volts/meter of track width) Read Head

Format Specific Enabling Technologies

Rotary Head

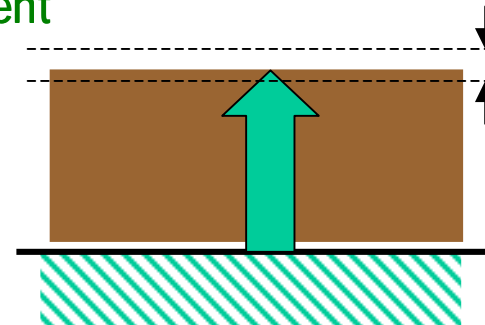
Improved helical track linearity
 μm p-p \rightarrow 0.5 μm p-p



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Fixed Head

active tape width measurement and auto 1 head placement



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