Digital Data Preservation

Research into a solution for preservation of digital information

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Presentation Outline

- Defining the Problem
- Evidences of the Problem
- Stimuli toward Research
- Existing Optical Storage
- Research Progress
- Conclusion

Defining the Problem

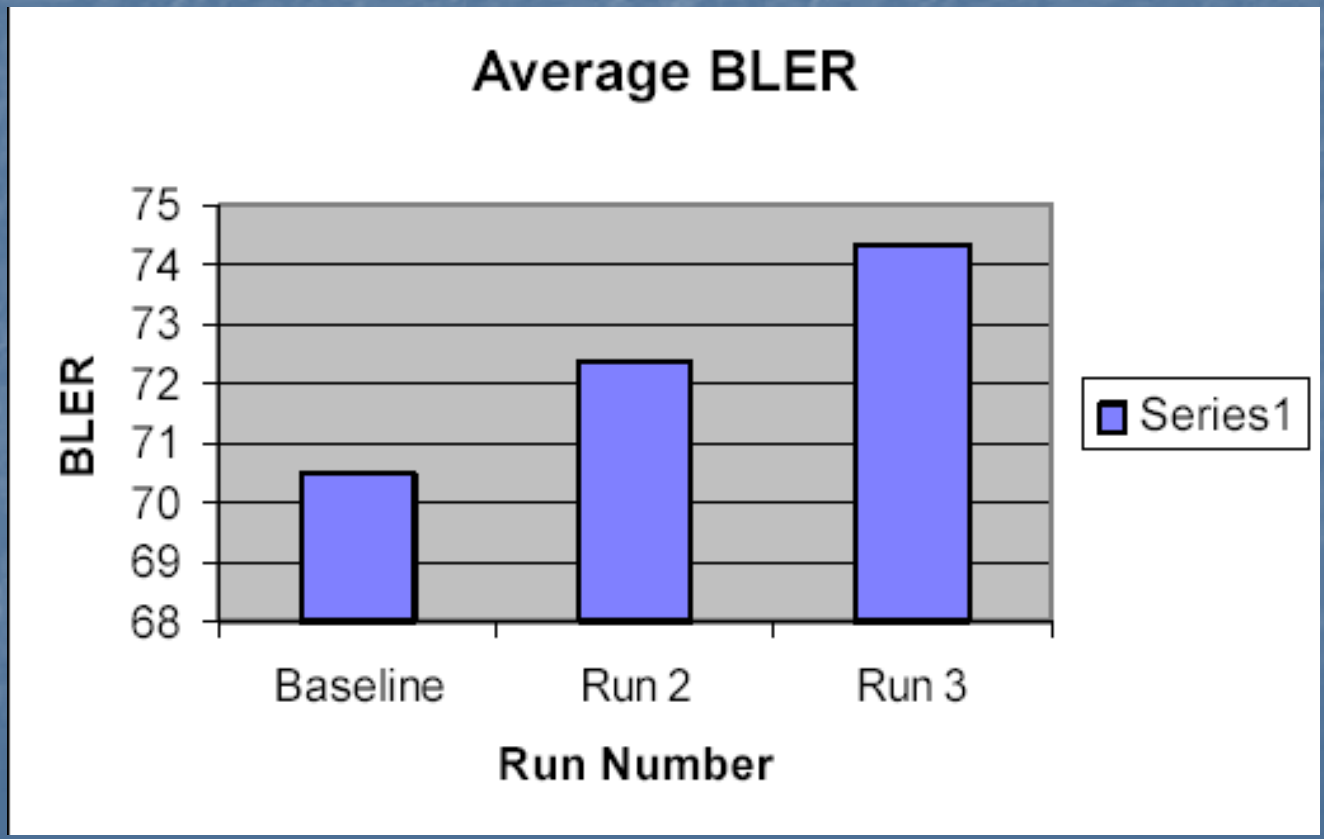
- All current methods of storing digital information are ephemeral, by historical standards:
  - Magnetic: 30 – 50 years
  - Optical (recordable): 7 – 23 years
  - Solid state (Flash memory): 10 – 12 years
- Much modern information has no analog counterpart
- Digital information does not gracefully degrade

Evidences:

"Longevity of CD Media" – Research at the Library of Congress

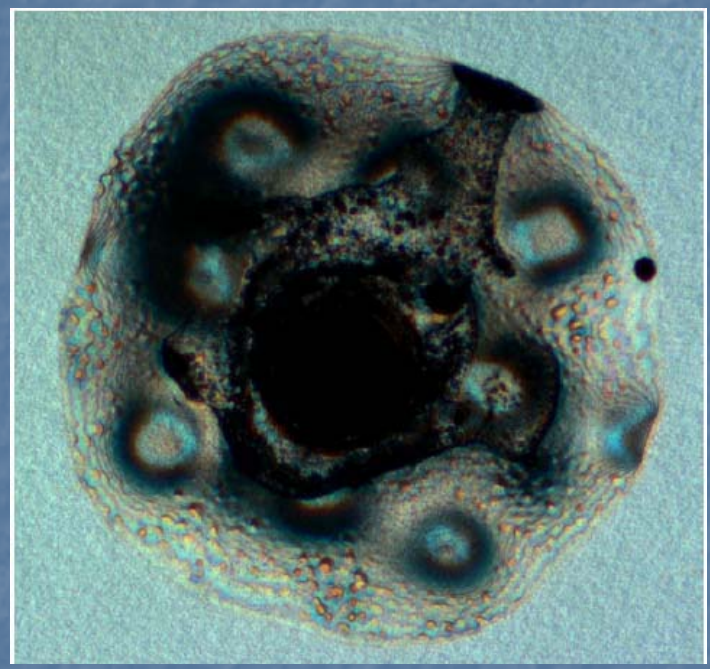
- 125 CDs, randomly selected from 60,000 collection

All CDs experience the same conditions (normal storage and circulation)



Evidences:

"Longevity of CD Media" – Library of Congress Accelerated aging test



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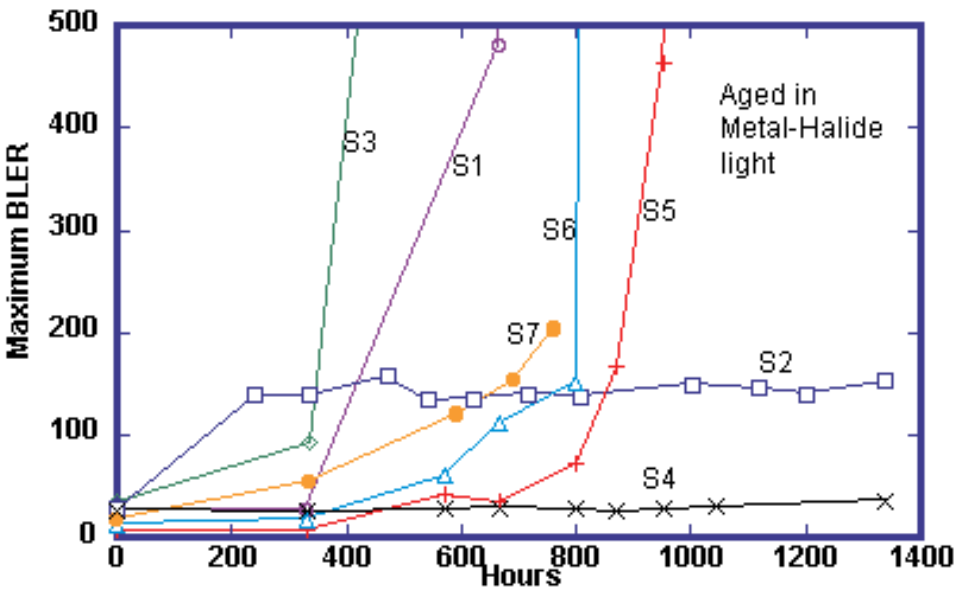
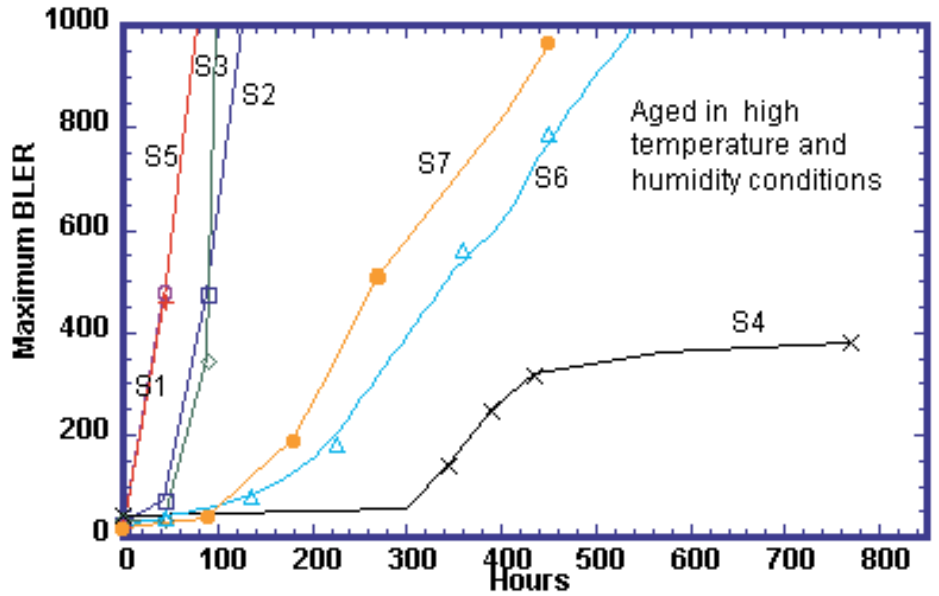
Evidences:
NIST – Accelerated aging test, CD-Rs





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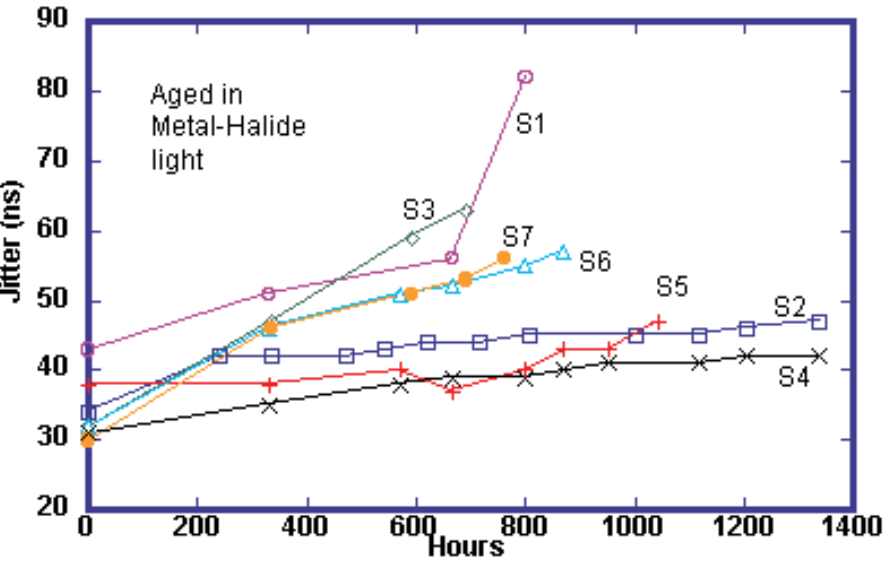
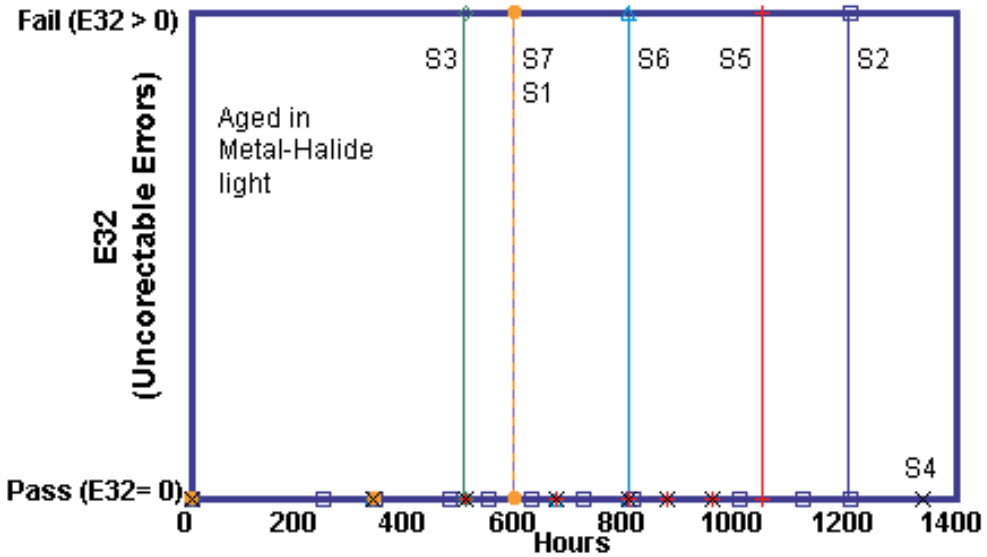
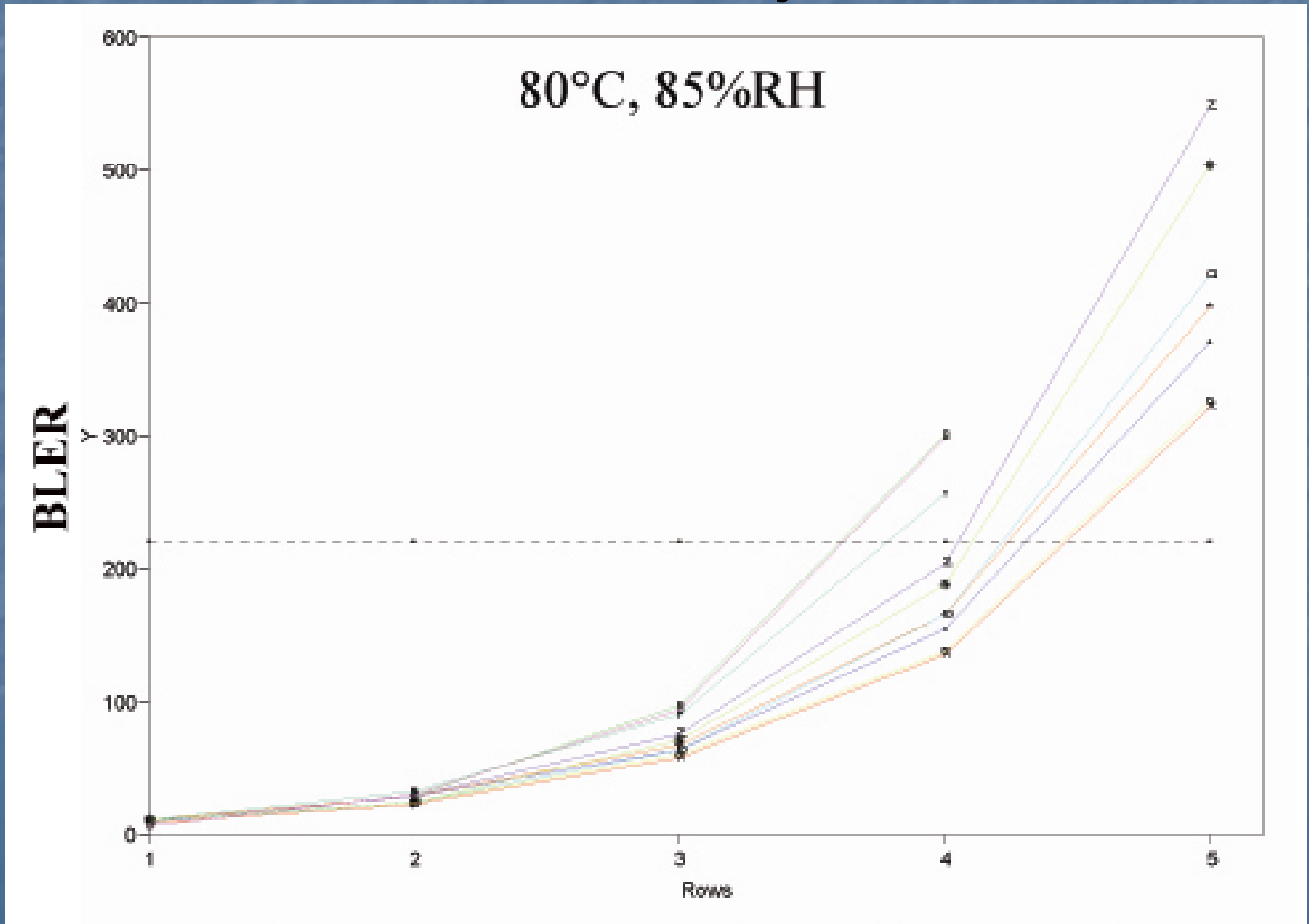




Evidences: Fred Byers (NIST): Accelerated aging test, CD-Rs

Projected Time to Failure: 14.75 years; 23.09 years



Evidences:
International Journal for the Preservation of Library and Archival Material

The Relative Stabilities of Optical Disc Formats

The Relative Stabilities of Optical Disc Formats

Table 3: Percentage of discs with a change in average BLER less than 220 for the CD samples and average change in PI less than 280 for the DVD samples.

	Aging (days)				Rank after	Overall
	21	42	63	84	84 days	rank*
CD-R (phthalocyanine dye)	97	81	75	72	1	1 (4)
CD (audio)	75	67	54	38	2	2 (9)
DVD (movie); double-sided/single layer	54	27	27	27	3	3 (18)
DVD (movie); single-sided/dual layer (gold)	81	56	12	6	6	3 (18)
DVD-R; single-sided/single layer	50	37	18	8	5	5 (22)
CD-RW	38	22	20	12	4	6 (26)
DVD (movie); single-sided/dual layer (light gold)	75	25	0	0	9	7 (28)
DVD (movie); single-sided/single layer	42	26	16	5	7	7 (28)
CD-R (azo dye)	75	0	0	0	9	9 (32)
DVD (movie); single-sided/dual layer (silver)	56	11	0	0	9	10 (34)
CD-R (cyanine dye)	20	12	12	4	8	11 (36)
DVD-RW	21	0	0	0	9	12 (40)

* Overall rank is based on the sum of the ranking for each aging interval. For example, the phthalocyanine discs aged the best in each aging interval and therefore were given a value of 4 (1+1+1+1).

Stimuli: Computerworld

- www.computerworld.com/blogs/note/625
  - Marian Prokop, 7/22/05

"Federal employees involved in preservation and archiving want the optical disks they use to have a lifespan of at least 40 years, according to a survey. The Government Information Preservation Working Group is working the National Institute of Standards and Technology to establish a long-term, or archival, standard measurement for recordable CD and DVD media."

Stimuli: Digital Documents

- Digital photos
- Digital videos
- Computer software
- Computer models
- Blogs
- Other personal websites

Stimulus

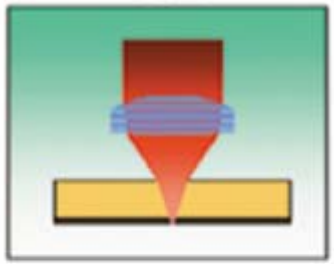
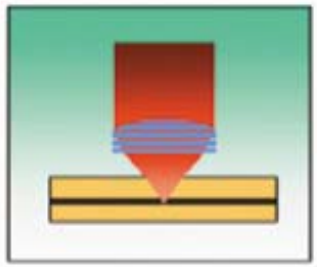
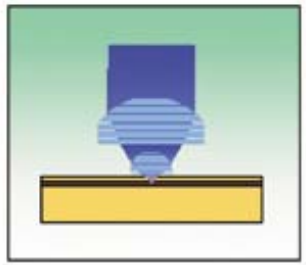
- "Predicting the Life Expectancy of Modern Tape and Optical Media"

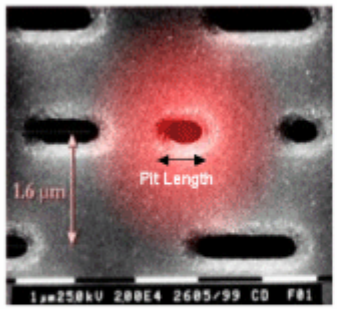
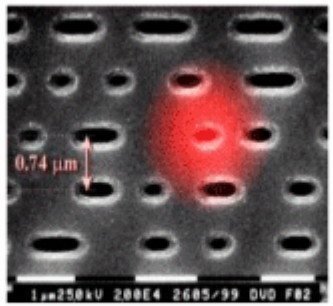
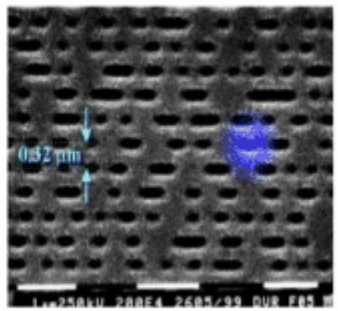
  (Vivek Navale, National Archives and Records Administration; Aug 15, 2005, Vol 9, #4)

  "[The study] shows the probability of failure as a function of time at 25°C and 50% RH. It predicts a mean life time of **1592 years** for CD-ROMS stored under those conditions."

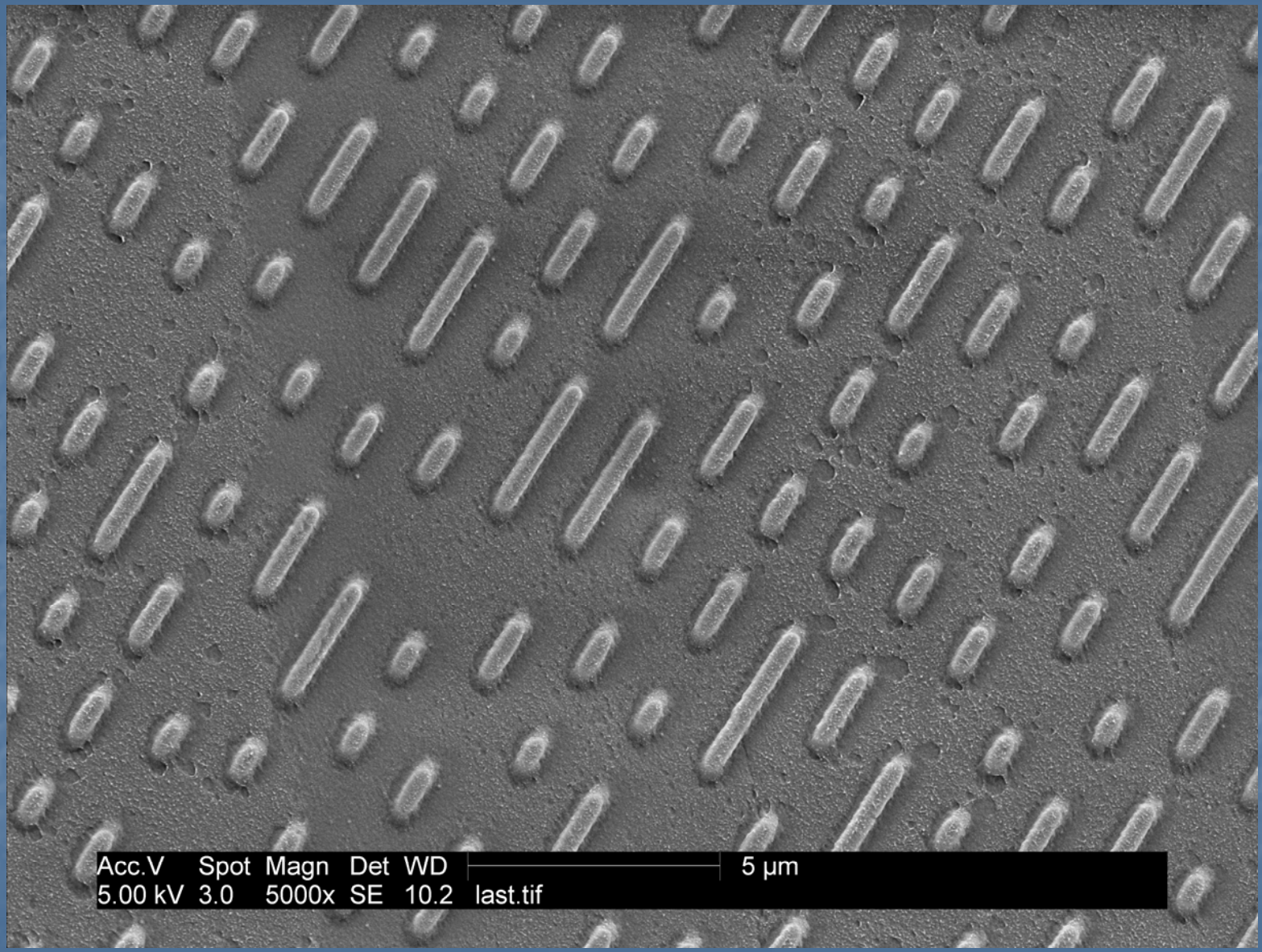
- Recording technologies
  - Comparison of CD, DVD, BRD
  - Stamped
  - ROM (writeable) – dye-based
  - R/W (re-writeable) – phase-change
  - R/W (re-writeable) – magneto-optical

Technology Migration

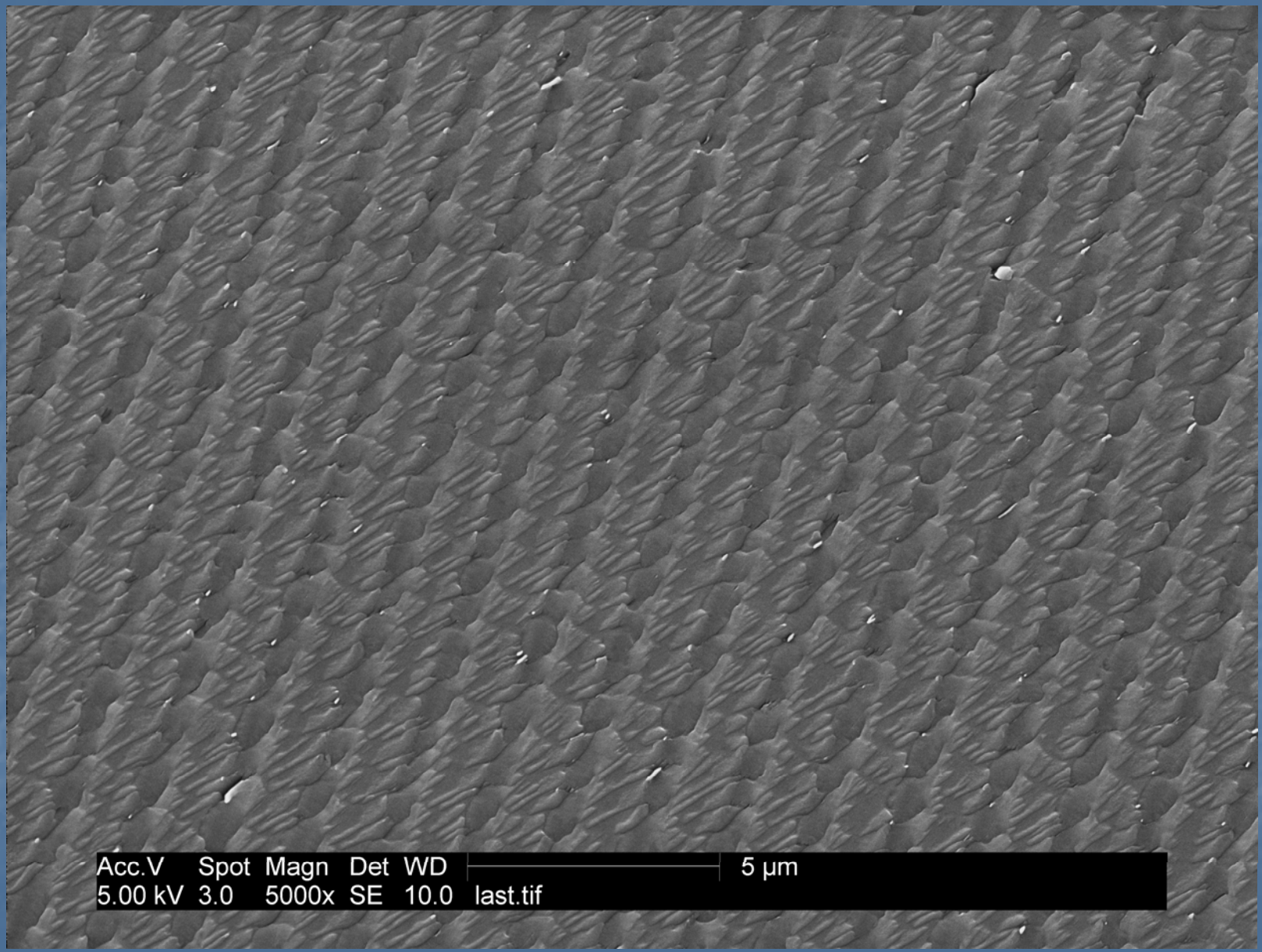
CD	DVD	BD
		
1st generation	2nd generation	3rd generation
Audio	SD Video	HD Video
0.7 GB	4.7 GB	27 GB
1X: 1.2 Mb/s	1X: 11 Mb/s	1X: 36 Mb/s
λ = 780 nm	λ = 650 nm	λ = 405 nm
NA = 0.45	NA = 0.60	NA = 0.85
1.2 mm substrate	0.6 mm substrate	0.1 mm substrate

CD 0.7 Gbyte	DVD 4.7 Gbyte	Blu-ray Disc 25 Gbyte
		
Track Pitch: 1,6 micron	Track Pitch: 0,74 micron	Track Pitch: 0,32 micron
Minimum Pit Length: 0,8 µm	Minimum Pit Length: 0,4 µm	Minimum Pit Length: 0,15 µm
Storage Density: 0,41 Gb/inch^2	Storage Density: 2,77 Gb/inch^2	Storage Density: 14,73 Gb/inch^2

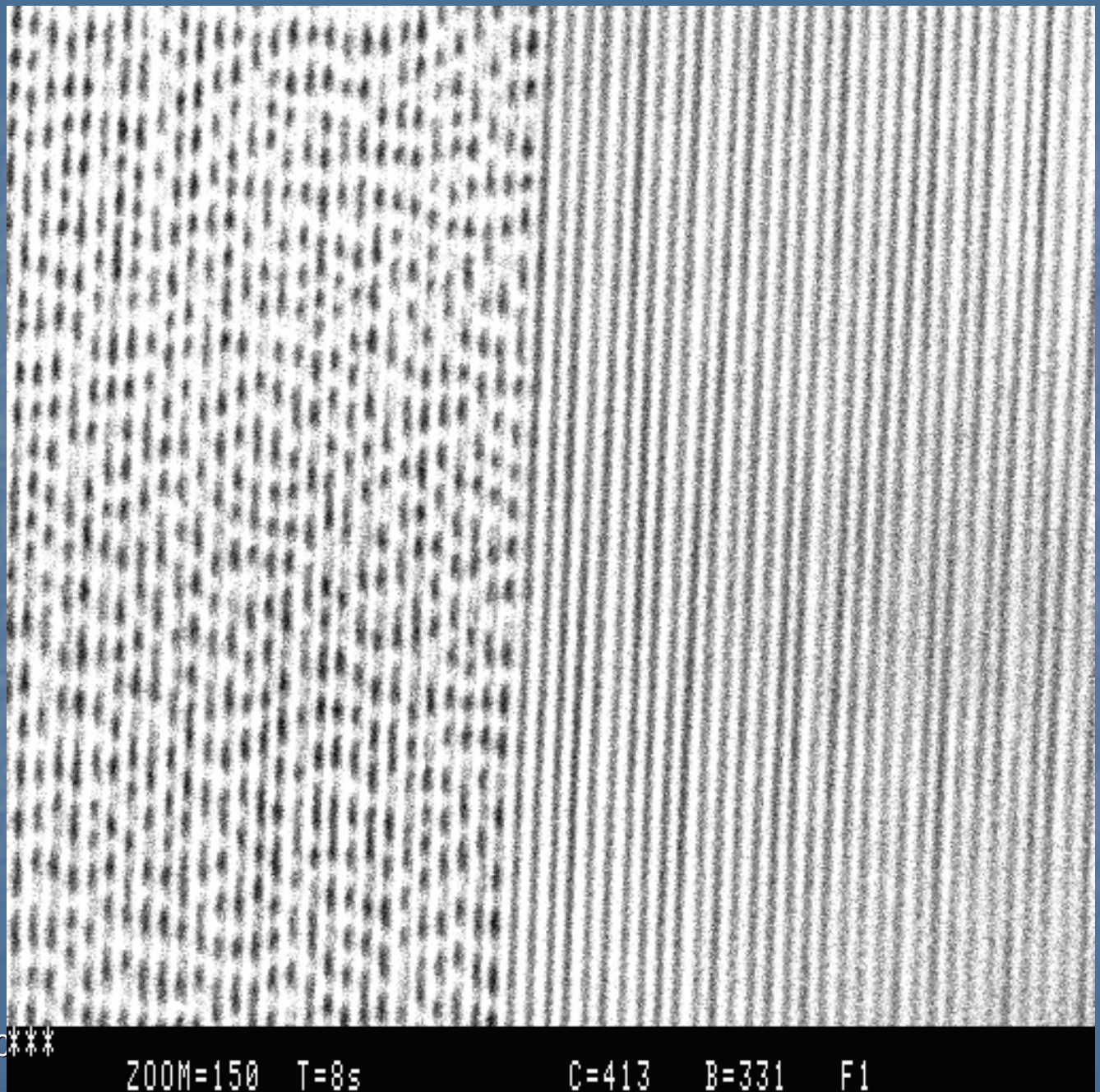
SEM of Stamped CD



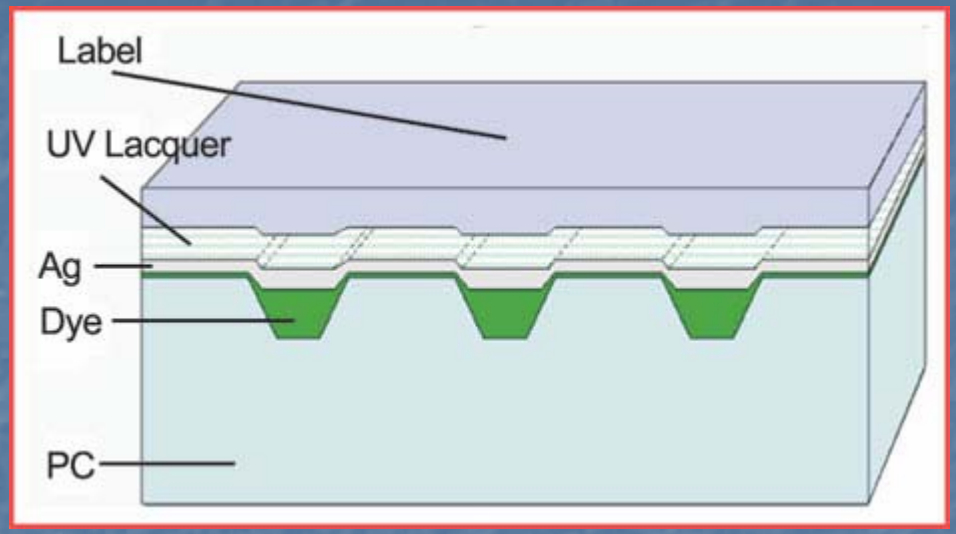
SEM of CD-R

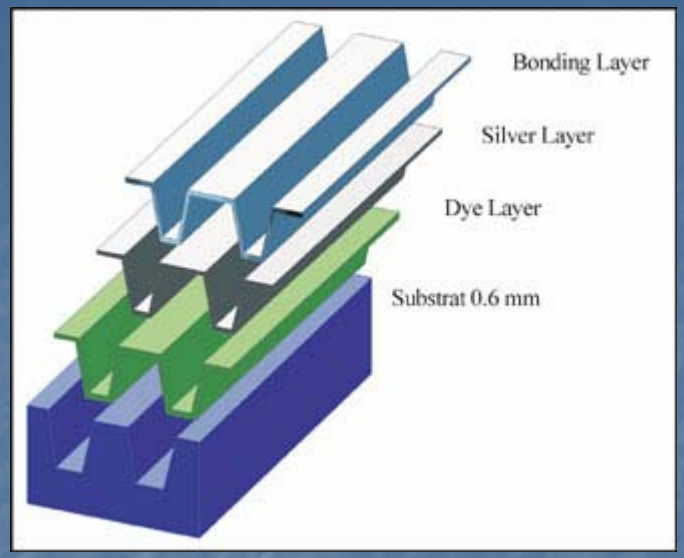


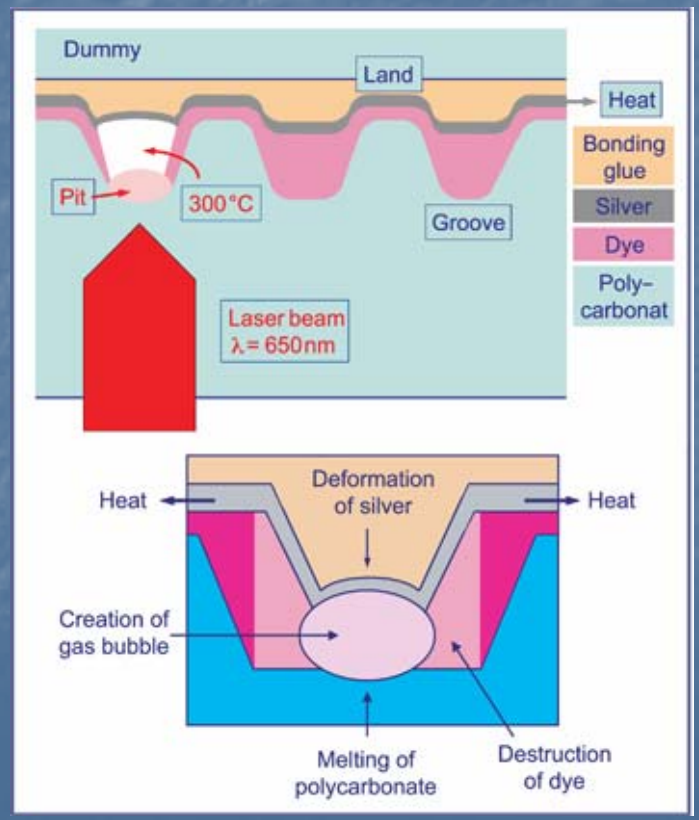
Confocal image of CD-R



Recordable Optical Discs





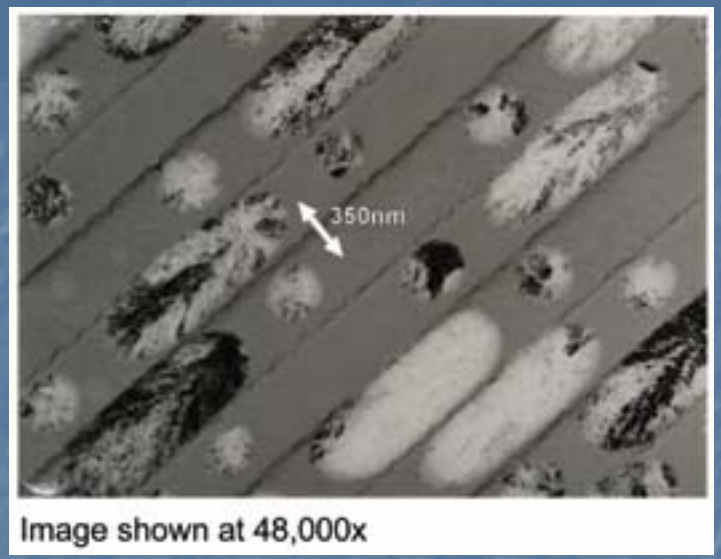


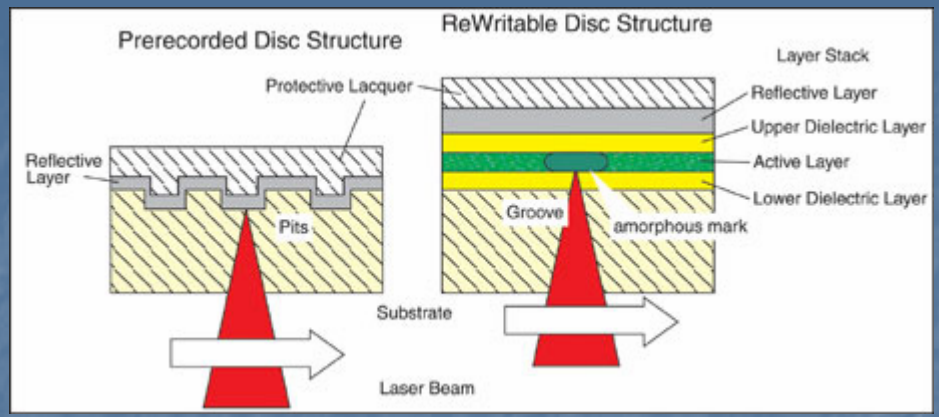
- Use Groove tracking for “Writing” function. Pit-like Gratings for the “Reading” function.

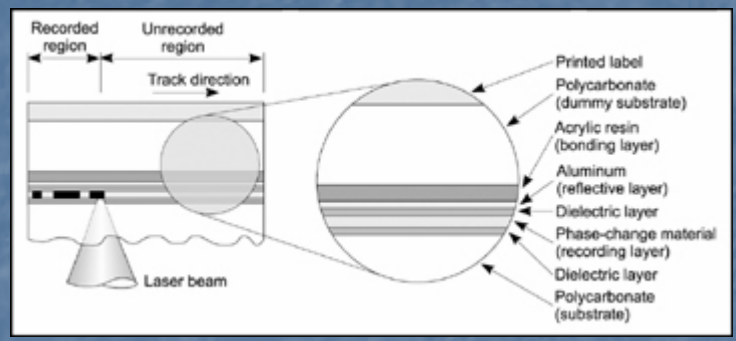
- Works primarily through the use of cyanine dyes that absorb energy and create a pit-like structures that act as Amplitude Gratings.

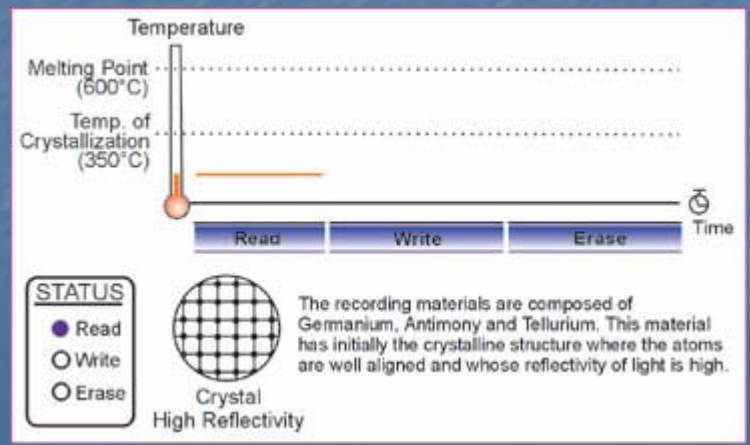
Courtesy of Mark Worthington

REWRITABLE OPTICAL DISCS









-RW technologies use phase change materials. Active layer (metallic stack) changes states when exposed to pulsed low energy level. Returns to reflective state when exposed to higher energy level. (crystal/amorphous)

Courtesy of Mark Worthington

Magneto-Optical Technology

- Based on Curie point of magnetic materials
- Uses:
  - Laser to heat material to near Curie point
  - Magnetic field to change magnetization
  - Kerr effect in read-back
- Features:
  - Magnetic domain as small as spot size of laser
  - Nearly infinite R/W cycles

Research Progress to Date

- Research on stability and adhesion of metal films
  - Tape test for adhesion
  - Boil test for stability
- Research on size and optical properties of recorded bits
- Protective layer for recording

Recording

- Excellent optical contrast
- Consistent spot characteristics
- Can easily be made into the size necessary
- Estimated lifetime of at least 1,000 years
- Can be readily reduced to practice

Conclusion

- The problem is real
- The need is great
- Existing archival options are inadequate
- Solutions exist using familiar materials and processes