Research on New Archival Media

A solution for preservation of digital information

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Presentation Outline

- Defining the Problem
- Evidences of the Problem
- Stimuli toward Research
- Existing Storage Options
- Research Progress & Test Results
- Conclusion

Defining the Problem

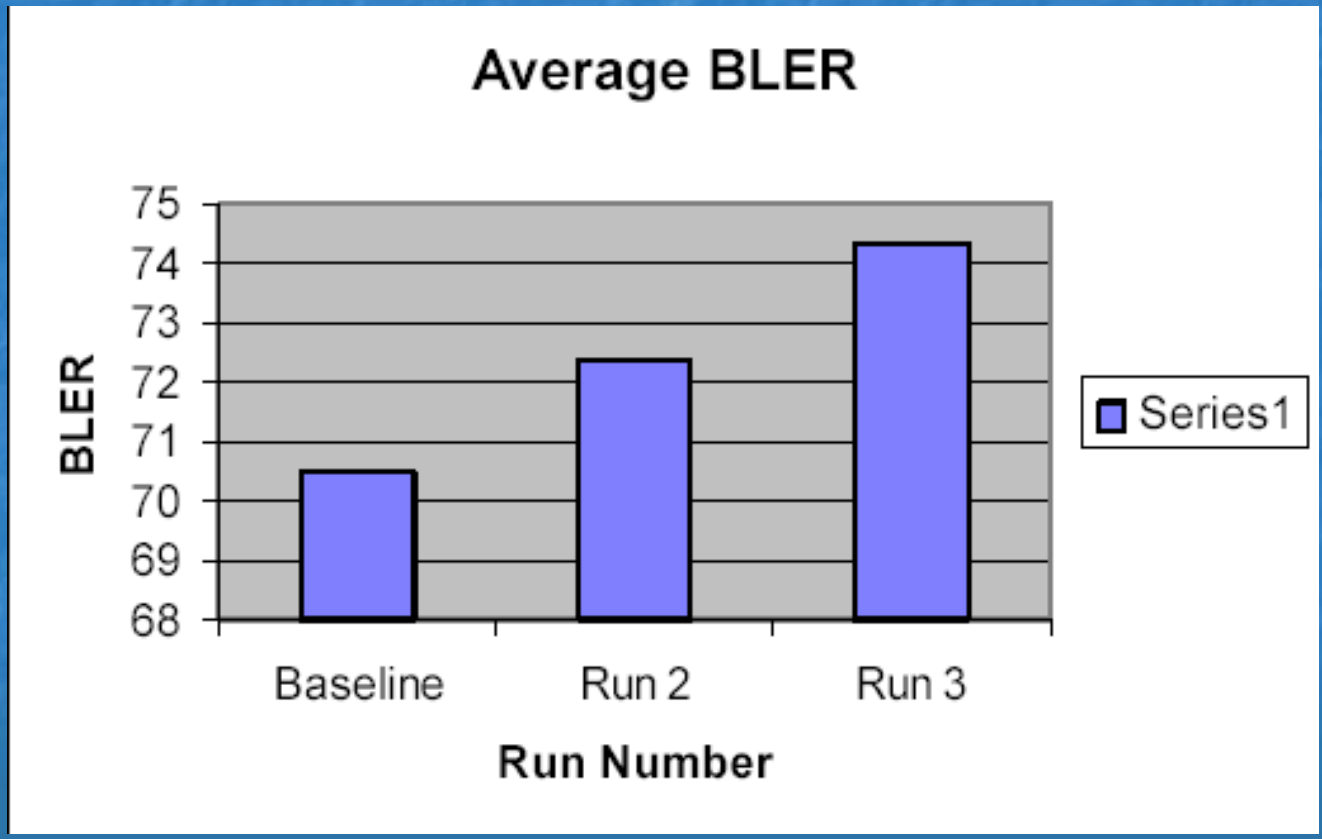
- All current methods of storing digital information are ephemeral, by historical standards:
  - Magnetic: 30 – 50 years
  - Optical (recordable): 7 – 23 years
  - Solid state (Flash memory): 10 – 12 years
- Much modern information has no analog counterpart
- Digital information does not gracefully degrade

Evidences:

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

- 125 CDs, randomly selected from 60,000 collection

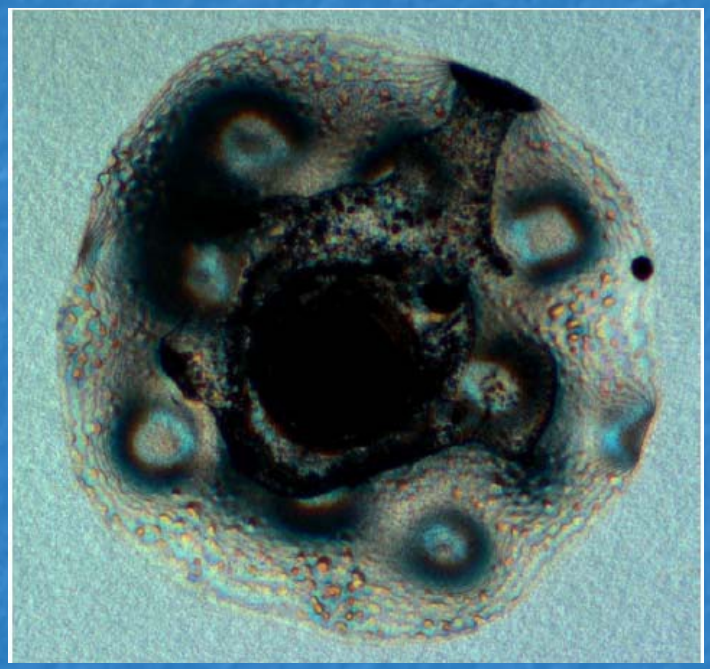
All CDs experience the same conditions (normal storage and circulation)



Evidences:

"Longevity of CD Media" – Library of Congress

Accelerated aging test: Corrosion



Evidences:

"Longevity of CD Media" – Library of Congress

Accelerated aging test: Delamination

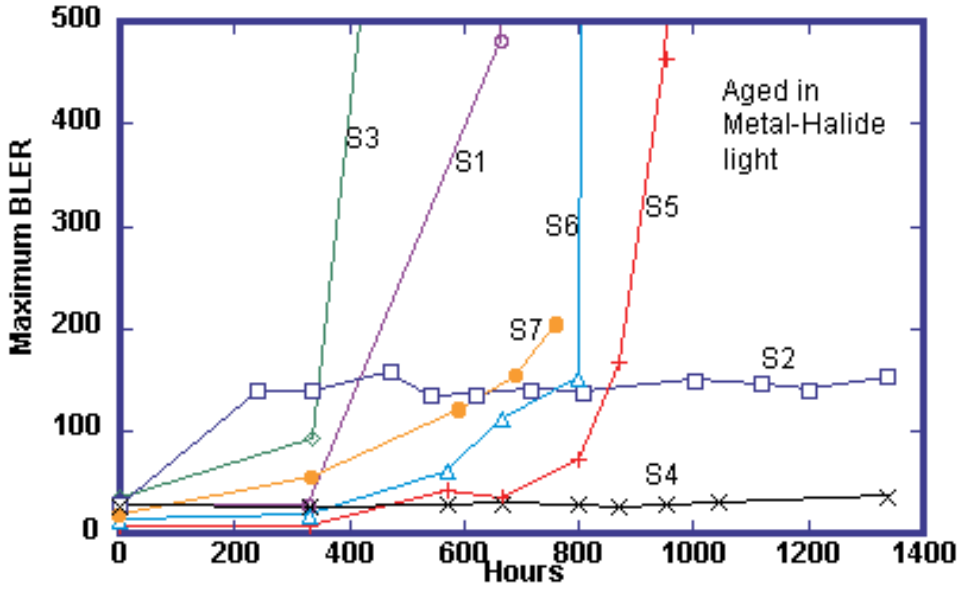
Evidences:

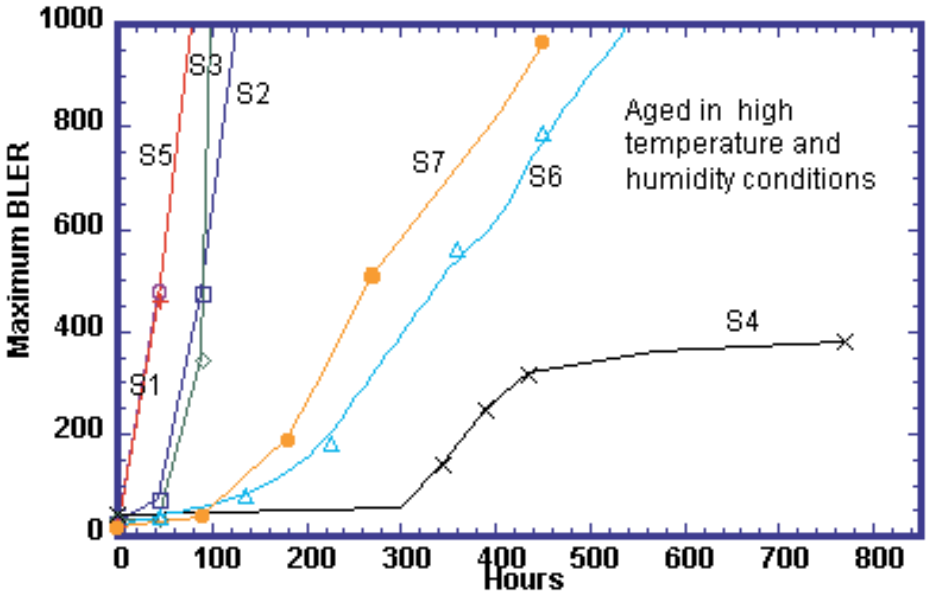
"Longevity of CD Media" – Library of Congress

Accelerated aging test: Oxidation

Evidences:

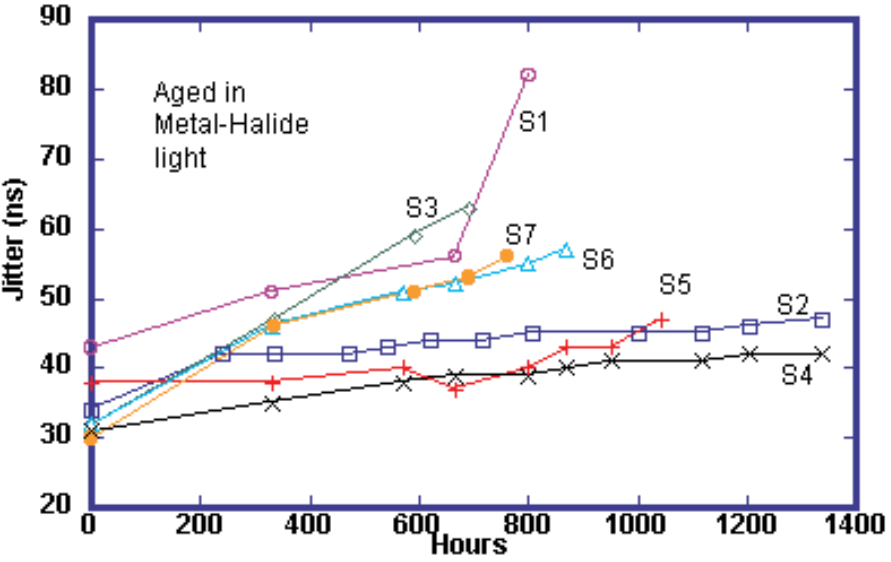
NIST – Accelerated aging test, CD-Rs

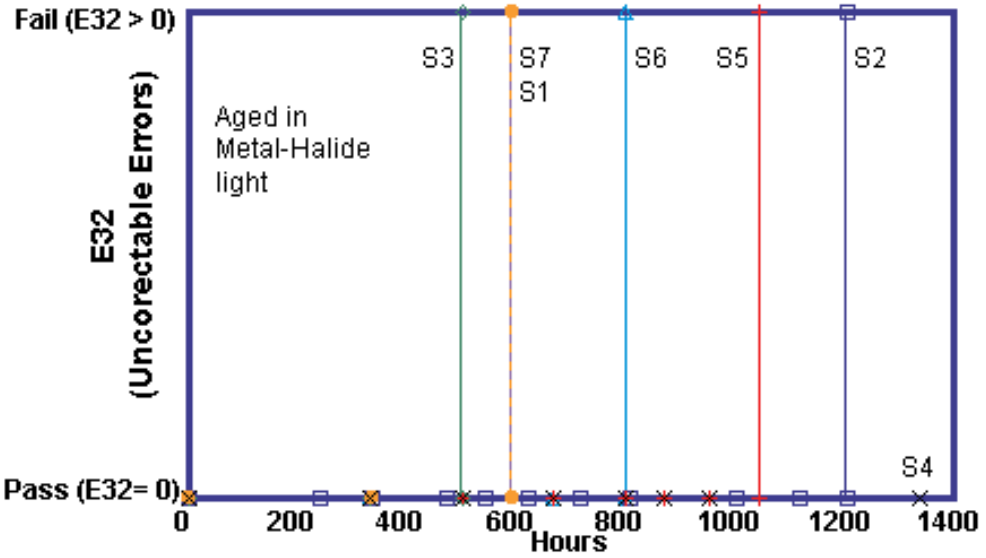




Evidences:

NIST – Accelerated aging test, CD-Rs

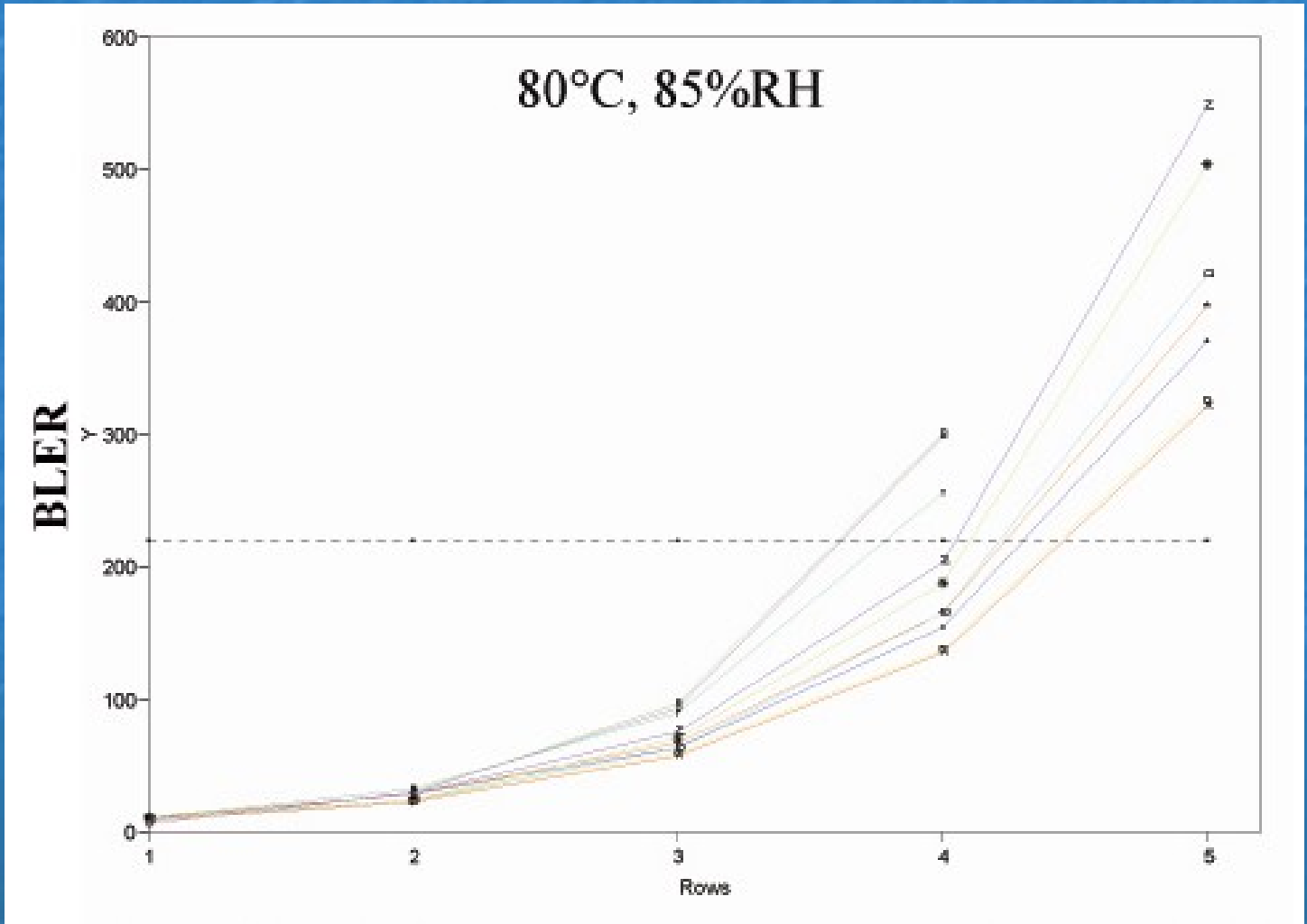




*Evidences:*Fred Byers (NIST):

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: 100 Year Archive Task Force

- "The '**two grand technical challenges'** of long term digital information retention are logical and physical migration…. Physical migration means to copy the information to newer storage media to preserve the ability to access it and to protect it from media corruption. Best practices today require logical and physical migration every 3-5 years…. How do organizations expect to do that and keep up with the growth, the cost, and the complexity? The answer is they can not. They will not. It is the contention of the 100 Year Archive Task Force that migration as a discrete long-term preservation methodology is broken in the data center. Today's migration practices do not scale cost-effectively and won't be done until a crisis erupts. This means that today's reliance on migration is taking us down a 'dead-end path'. Hear this clearly. Under these practice guidelines, the world's digital information is at great risk!"

Stimuli: Digital Documents

- Digital photos, videos
- Digital journals, personal histories
- Computer software
- Computer models
- Blogs
- Other personal websites

Stimulus

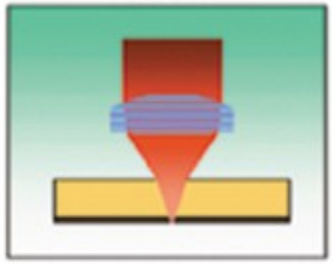
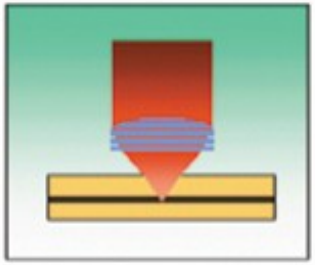
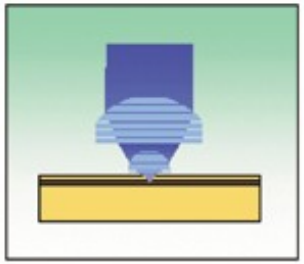
- "Predicting the Life Expectancy of Modern Tape and Optical Media"

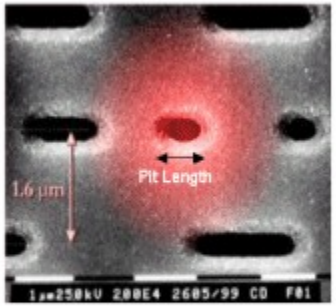
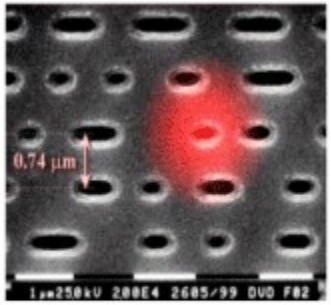
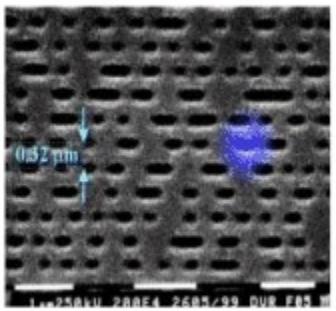
  (Vivek Navale, National Archives and Records Administration; Aug 15, 2005, Vol 9, #4)

  "[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."

Stimulus, cont’d

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

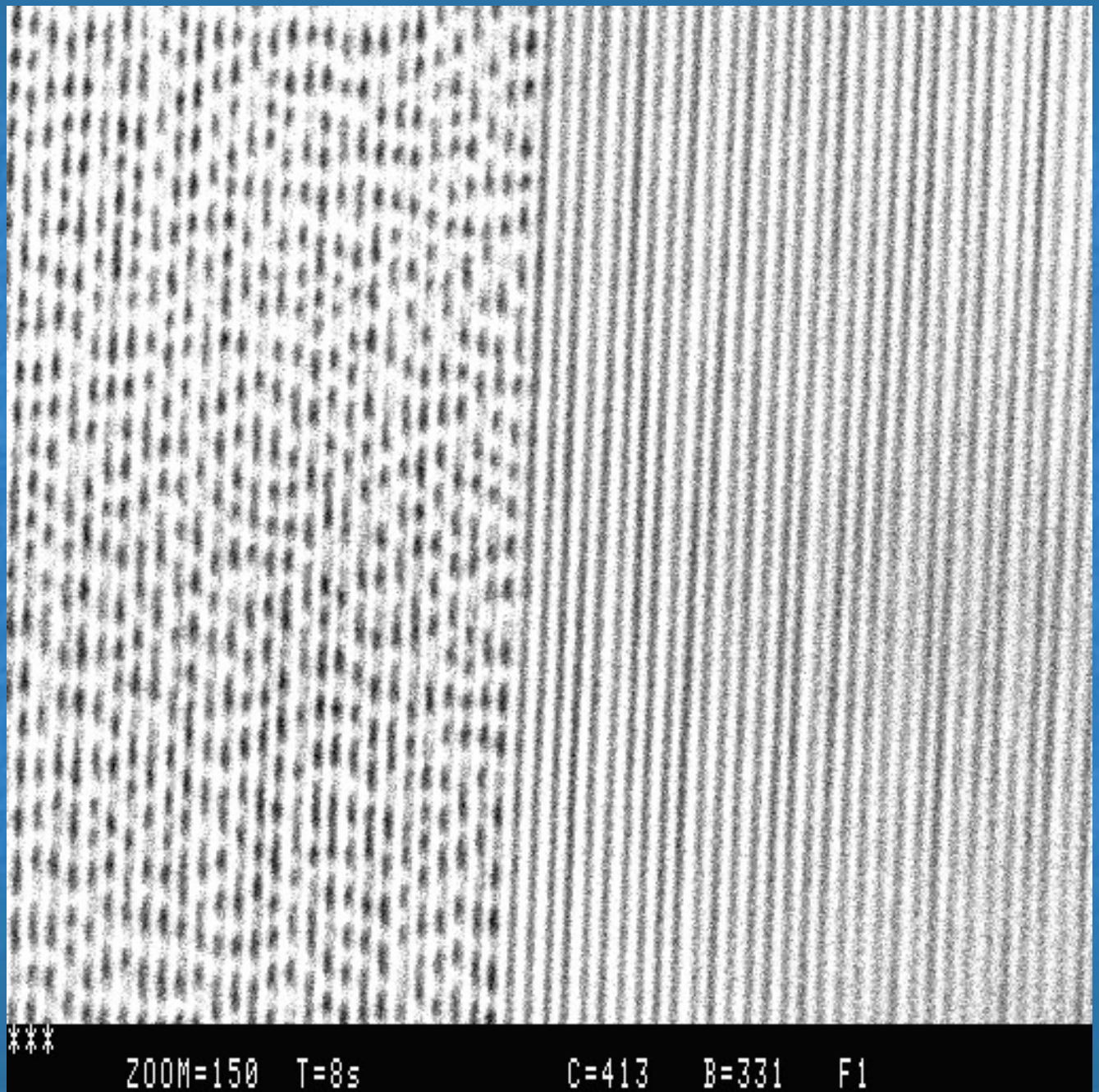
CD	DVD	BD
		
1st generation	2nd generation	3rd generation
Audio	SD Video	HD Video
0.7 GB	4.7 GB	27 GB
1X: 1.2 Mb/s	1X: 11 Mb/s	1X: 36 Mb/s
λ = 780 nm	λ = 650 nm	λ = 405 nm
NA = 0.45	NA = 0.60	NA = 0.85
1.2 mm substrate	0.6 mm substrate	0.1 mm substrate

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

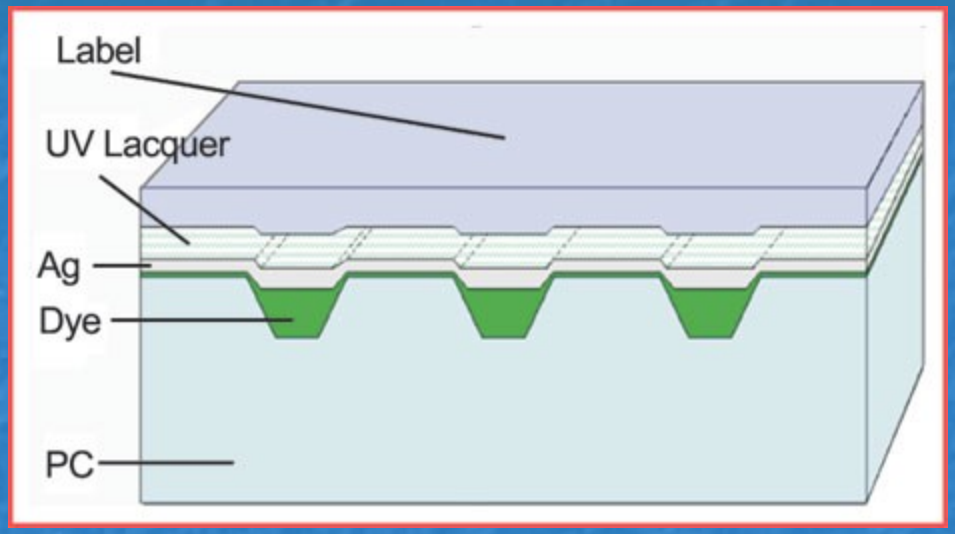
SEM of Stamped CD

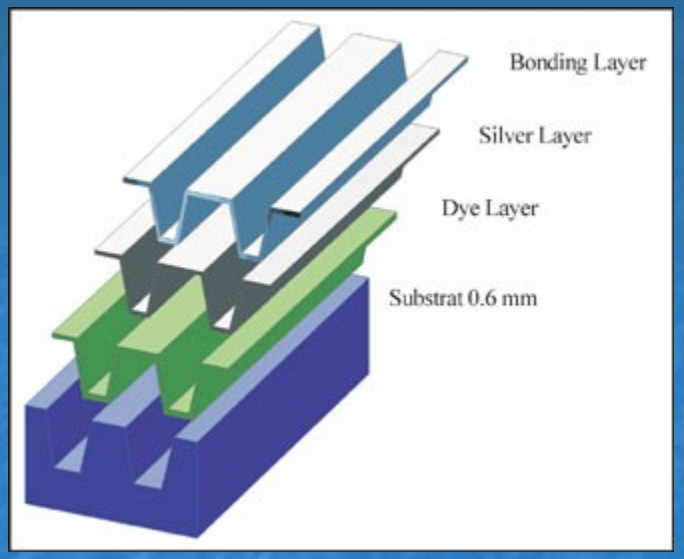
SEM of CD-R

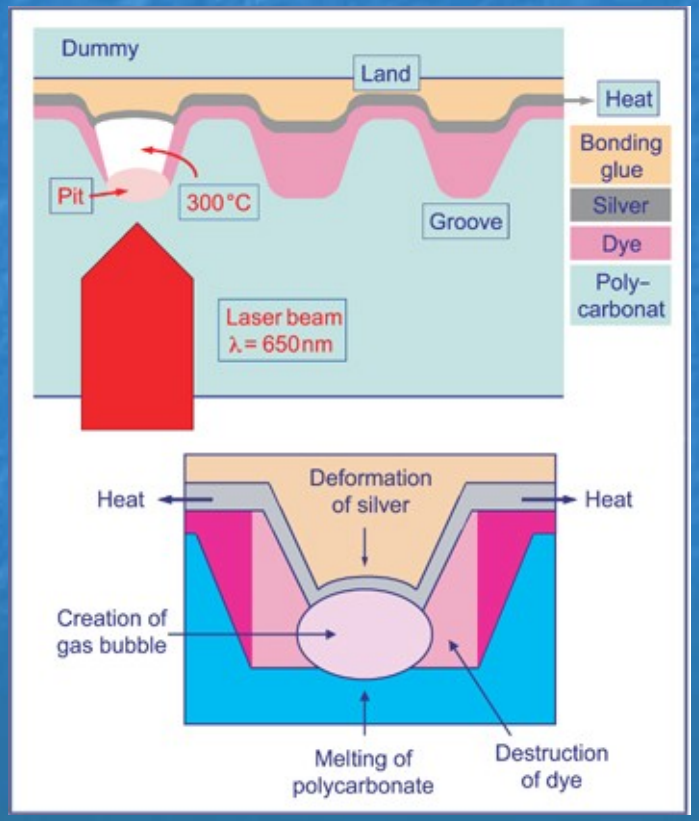
Confocal image of CD-R



RecordableOptical Discs







- Use Groove tracking for “Writing”

function. Pit-like Gratings for the

- Works primarily through the use of

“Reading” function.

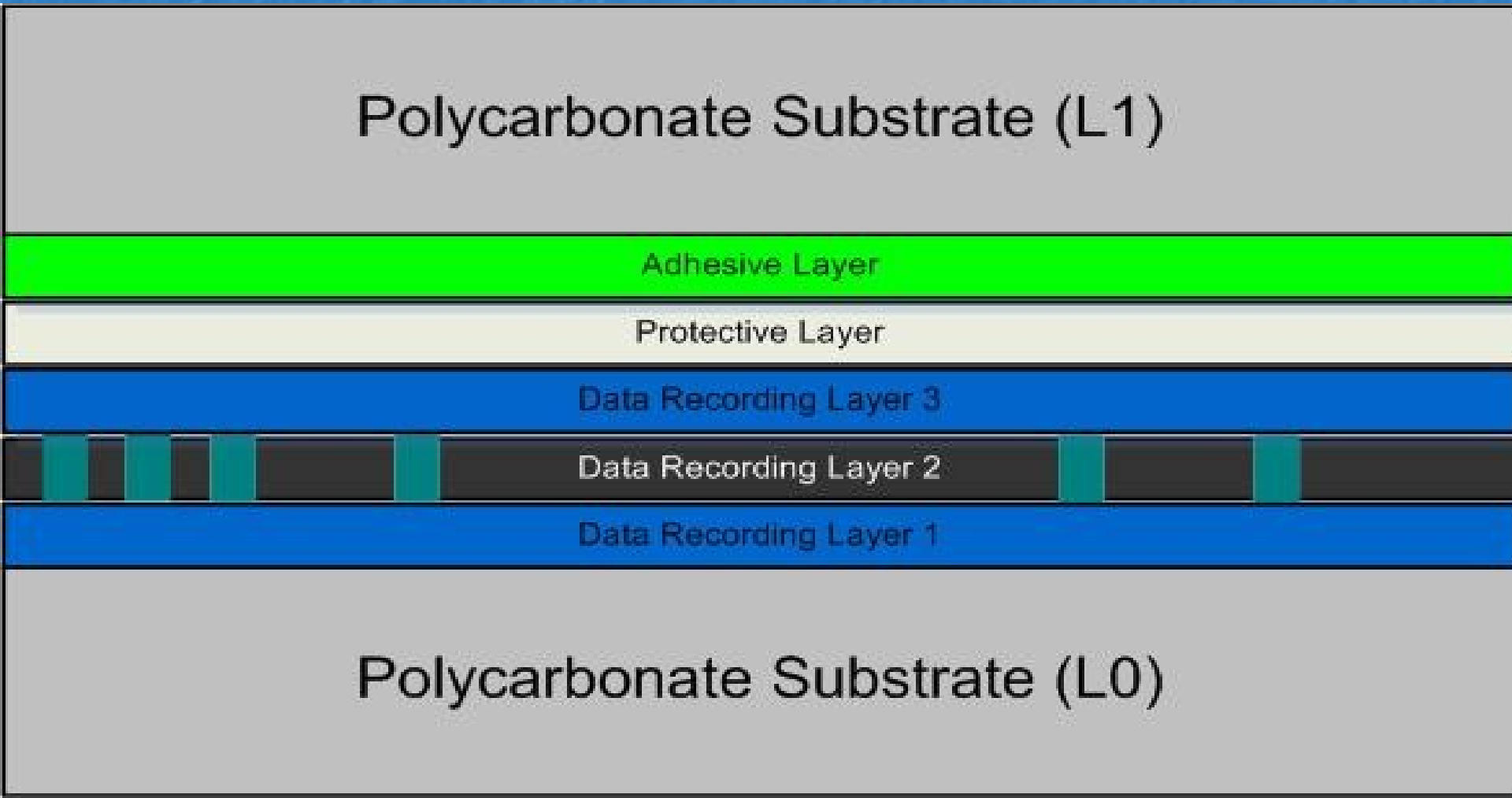
cyanine dyes that absorb energy and

create a pit-like

Courtesy of Mark Worthington

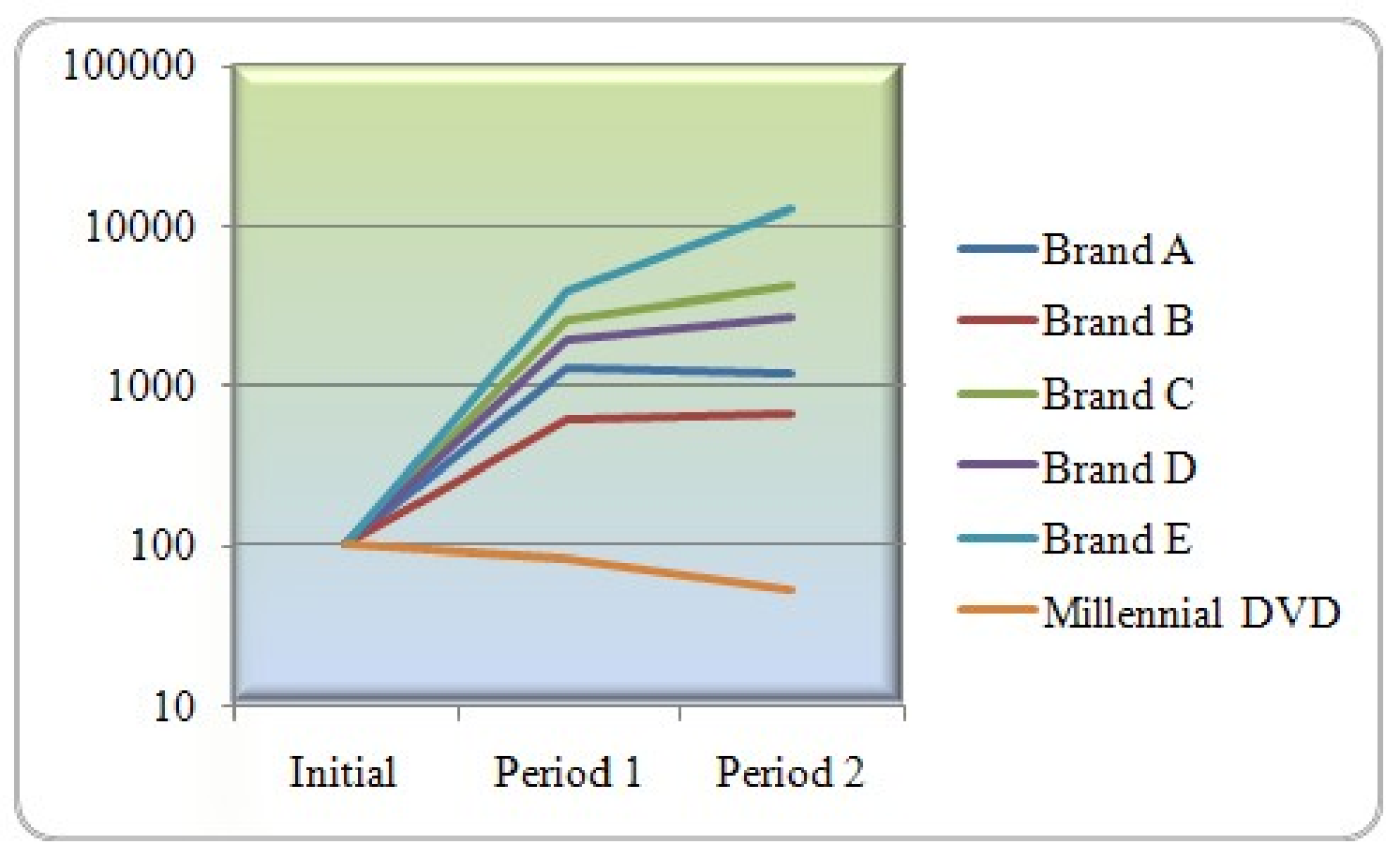
Research Progress to Date

- Materials chosen, tested, consolidated, tested
  - Completely new recording layer



Research Progress to Date, cont'd

- New, more aggressive accelerated testing
  - Elevated temperature, humidity & full-spectrum light
  - Local test results:



Research Progress to Date, cont'd

Naval Air Warfare Center Weapons Division (China Lake, CA) Test Results:

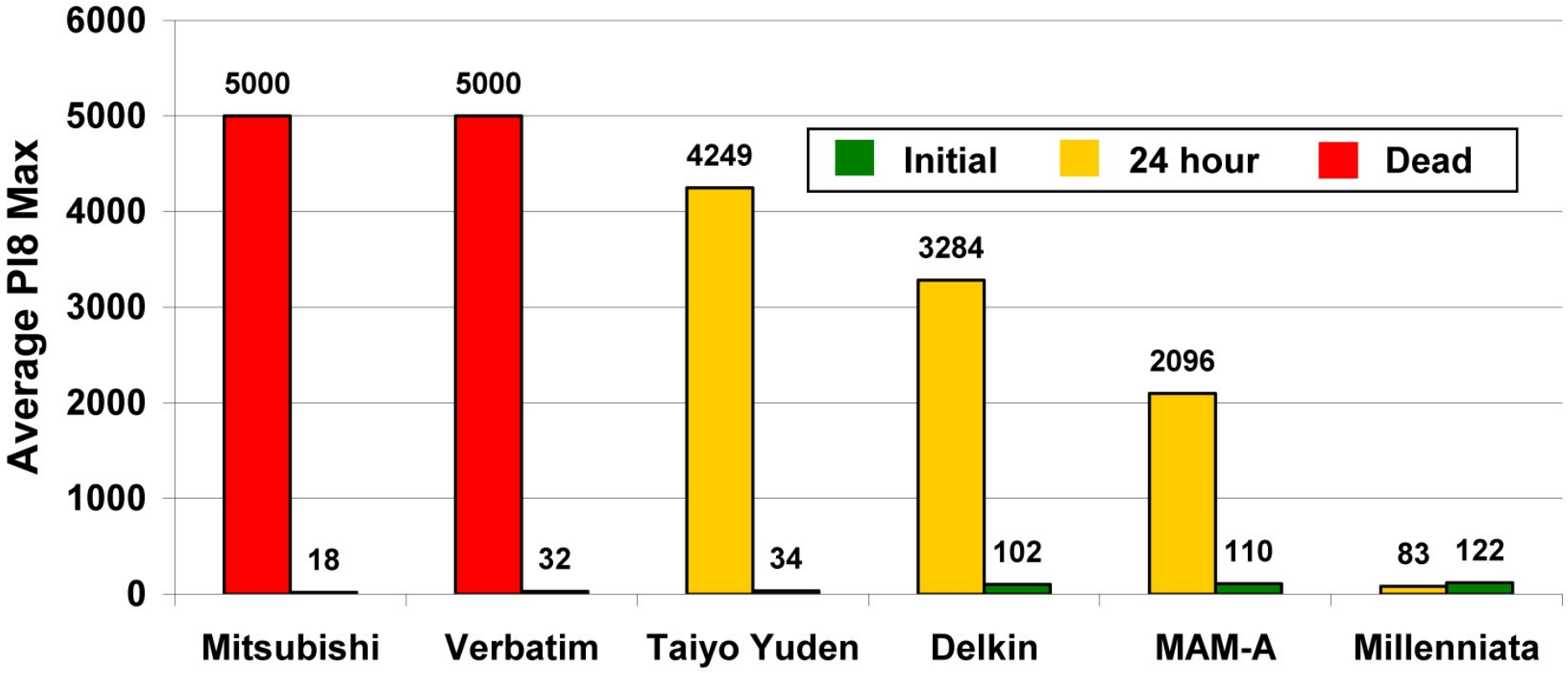


Figure 3-23 PI8 Max Average by Manufacturer Including Dead Discs

Conclusion

- The problem is real
- The need is great
- Existing archival options are inadequate
- Solution has been proven