☐ Session Chair, Ken Wood - *@KenWoodOnTech*

☐ Presentations – *Please hold all questions until the end of the session*

- **Optical Media Technical Roadmap –** ~30 minutes
  - Ken Wood, *HDS*
- **Long Term Data Preservation of an Optical Library –** ~30 minutes
  - Akinobu Watanabe, *Hitachi*
- **Achieving 1000-year Data Persistence: "Engraved in Stone" –** ~30 minutes
  - Doug Hansen, *Millenniata*

☐ All 3 presenters will come back on
stage for Q&A&Q

☐ Session Format

☐ A Little Introductory History

☐ Intangibles & Tangibles

☐ 321 == 322

☐ Not all Media is Created Equally

☐ What's Happening Inside?

    ○ Show ~3 minute video with me narrating

☐ More Compatibility

☐ Where are we Going?

NOTE & WARNING
Content presented here about future product, technology, concepts & directions is general in nature, for information only, and does not represent definite plans or commitments and should not be incorporated into any contract.

- ☐ Optical recording since the dawn of man

- ☐ Oldest form of human recording

- ☐ An example of preserving the "bits" forever while not really understanding the application that created it

- ☐ Full circle theme here

☐ The first commercially available audio CD is **Billy Joel's "52nd Street"** released in Japan on October 1st, 1982
  ○ That's almost 31 years ago

☐ 50 titles were also released on CD in those first early years including **Pink Floyd's "Dark Side of the Moon"** in May of 1983

☐ Still plays today on the latest devices supporting the newest formats

☐ All Optical-based Technologies

* o 50 - 100 Year BDXL Media
* o Holographic Storage
* o M-Disc – 1,000 year media
  o DOTS – Digital Optical Technology System
  o Sapphire Hard Disc – 1M yrs
* o Quartz glass plate storage technology – 100M yrs

* Hitachi areas of R&D

Optical Data Storage Benefits
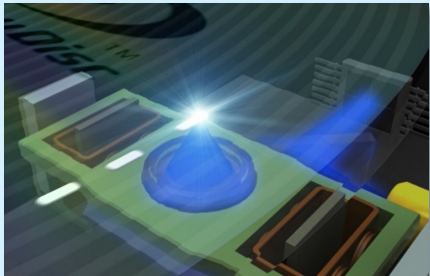
☐ Beyond Speeds & Feeds – the Intangibles

Longevity

"Optical" recording has been used for over 10,000 years in human data recording history.

Compatibility

Since BD can be read on general purpose PCs with consumer devices, there is less possibility that media and data will be inaccessible due to obsolete devices.
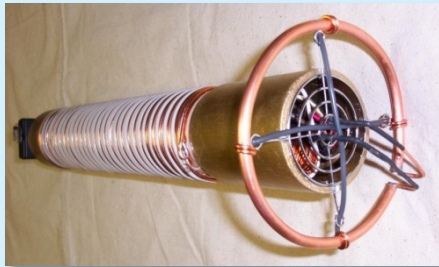
Contactless

Since there is no contact with the media surface, there is less possibility of abrasion, scratch or other media wear.
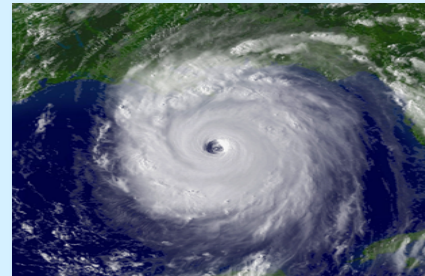
Survivability

Only data stored on optical disc survived hurricane Katrina.

☐ Beyond Speeds & Feeds – the Intangibles

Non-Magnetic
2 recording technologies are needed for a sound data preservation strategy, with magnetic recording being considered as one.

Ubiquitous
Several industries use optical devices which supports a mass volume industry and maintains compatibility. UHD?

Reliable
Since device and media are separated, reliability and replacement of devices doesn't affect the reliability of media.
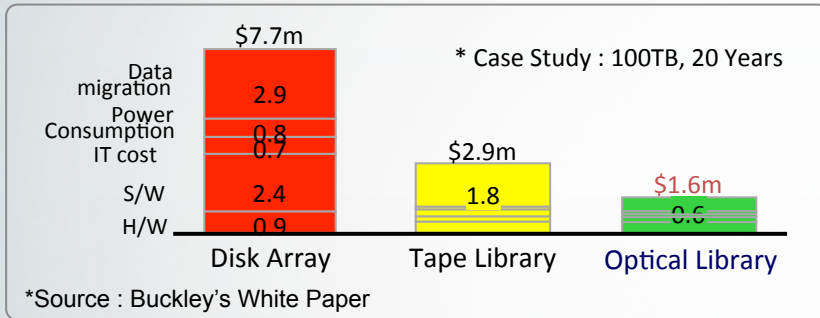
Green
Almost no electricity nor special environmental condition is needed to store media for a long time.
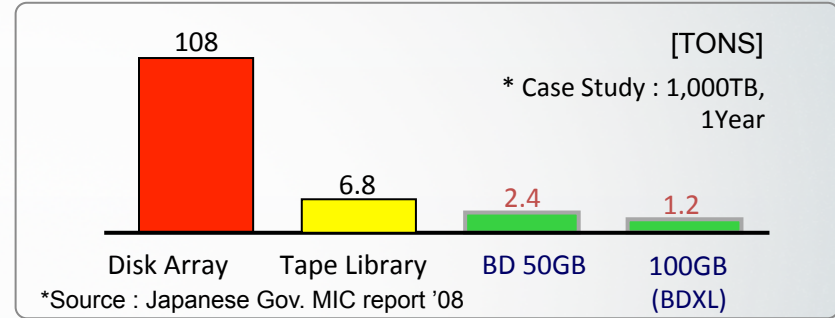
Operating Cost

Real cost for Archiving is OPERATING COST, not just acquisition
"Best TCO"

* Case Study : 100TB, 20 Years

Disk Array	Tape Library	Optical Library
$7.7m	$2.9m	$1.6m

Disk Array:
- Data migration 2.9
- Power Consumption 0.8
- IT cost 0.7
- S/W 2.4
- H/W 0.9

Tape Library: 1.8

Optical Library: 0.6

*Source : Buckley's White Paper

CO_2 Emission

"Eco" is not only "Economy" but also Ecology
"Lowest CO2 Emission"

[TONS]
* Case Study : 1,000TB, 1Year

Disk Array	Tape Library	BD 50GB	100GB (BDXL)
108	6.8	2.4	1.2

*Source : Japanese Gov. MIC report '08

Longevity (Archival Life)

"LONGEST LIFE AND COMPATIBILITY"

	2000s	2010s	2020s	2030s

Not Mechanical or Magnetic
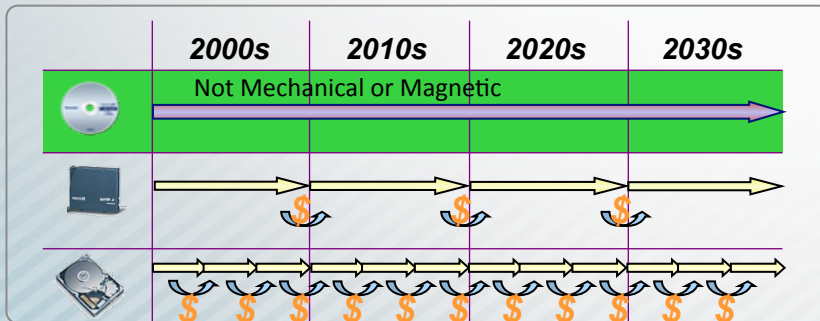
Accessibility

"FASTER THAN TAPE & Glacier" Retrieval

[msec]
To 1st Byte

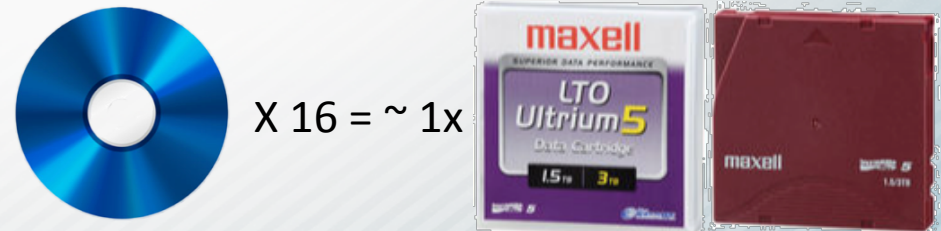|	
HDD	3.3
ODD	100
Tape	30,000
Glacier	3-5 Hours
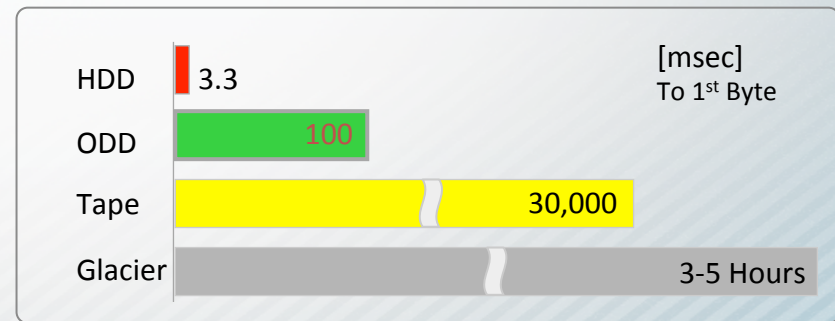
ODD = Optical Disk Drive

- ☐ BD is 25GB & 50GB per disc - 2006
- ☐ BDXL is 100GB & 128GB per disc - 2010

- ☐ A 128GB disc is 157GB/ci uncompressed (.8ci)
  - ○ Dual sided is 314GB/ci
- ☐ A 1.5TB LTO5 tape is 114GB/ci (13ci)

- ☐ That's 2.5TB in 13 ci, the same space that a LTO5 cartridge occupies
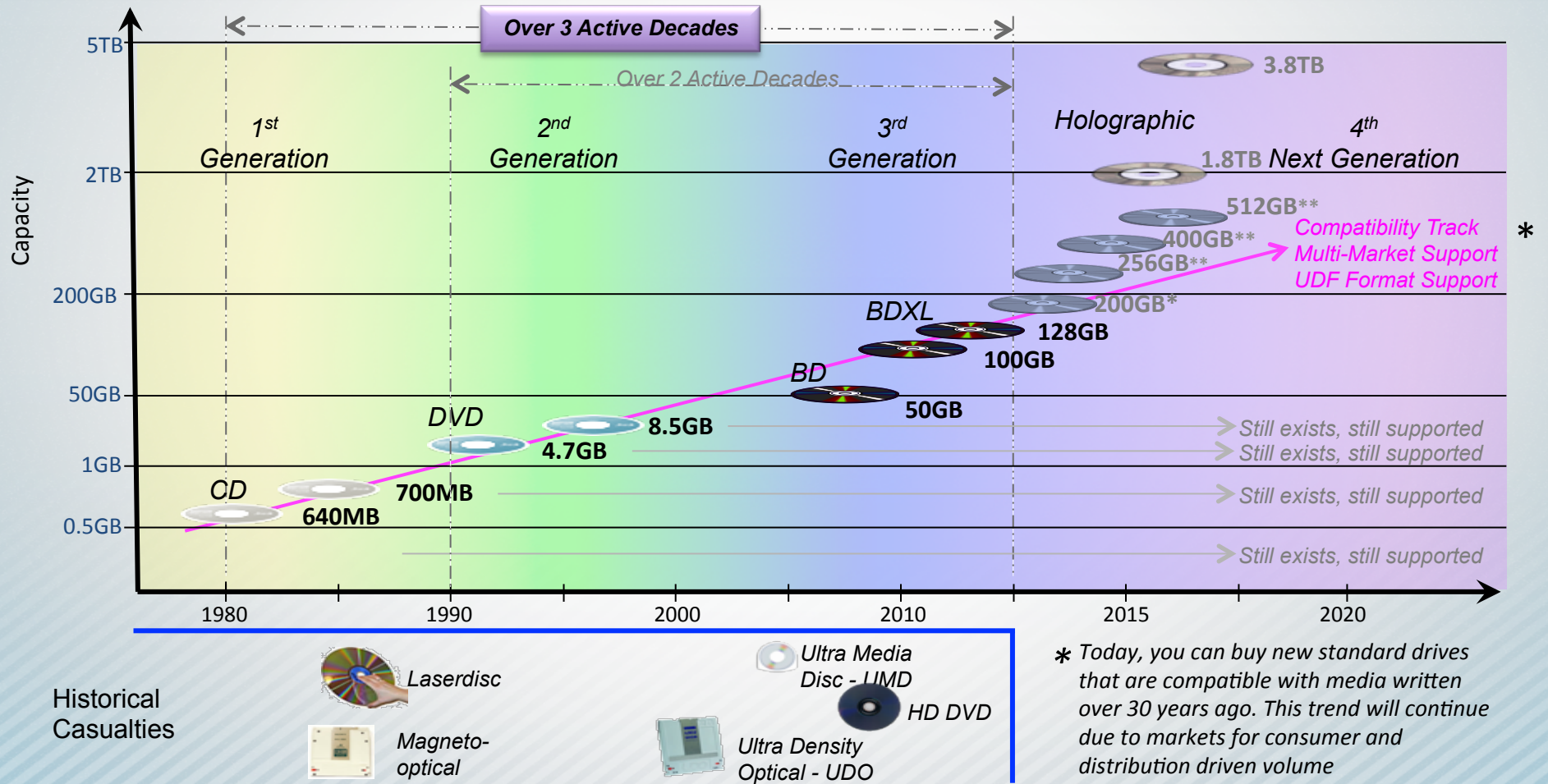 - ○ Double sided is 5TB

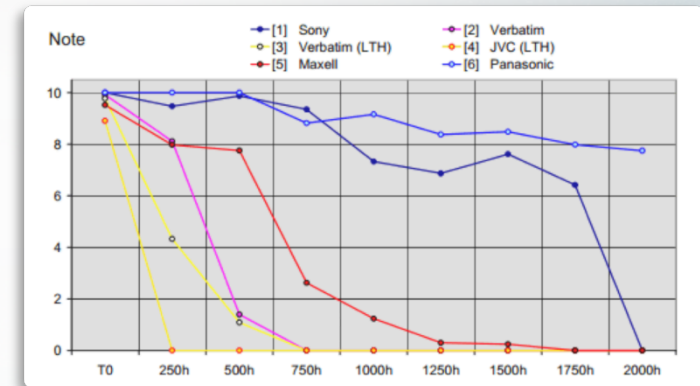In the same physical volume

X 16 = ~ 1x

Technology Longevity chart showing Capacity vs. Year. Optical disc formats are plotted along a magenta trend line:

- **CD** — 640MB
- **DVD** — 700MB, 4.7GB, 8.5GB
- **BD** — 50GB
- **BDXL** — 100GB, 128GB
- Holographic — 200GB*, 256GB**, 400GB**, 512GB**, 1.8TB, 3.8TB

Generations labeled: 1st Generation, 2nd Generation, 3rd Generation, Holographic, 4th Next Generation

Over 3 Active Decades

Over 2 Active Decades

Compatibility Track
Multi-Market Support
UDF Format Support

Still exists, still supported (×4)

Historical Casualties: Laserdisc, Magneto-optical, Ultra Media Disc - UMD, Ultra Density Optical - UDO, HD DVD

*Today, you can buy new standard drives that are compatible with media written over 30 years ago. This trend will continue due to markets for consumer and distribution driven volume

☐ 321 == 3 copies, 2 sites and 1 other technology, *or visa versa*

☐ 322 == 3 copies, 2 sites and 2 technologies

☐ Several long-term data preservation strategists are coming to consensus that the 2 recoding technologies used today, hard disks and tape, are considered the same technology – magnetic
  o Similar vulnerabilities

☐ Long-term TCO is still a key goal
  o Life of the company
  o Life of the republic
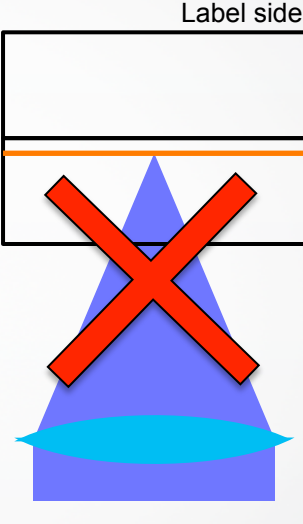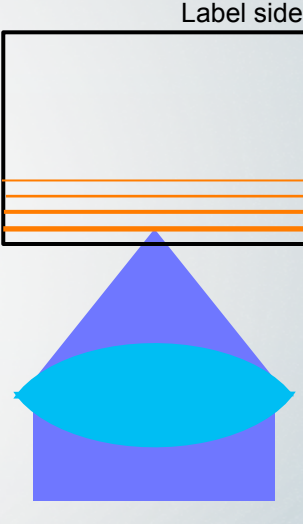 o Life that spans republics
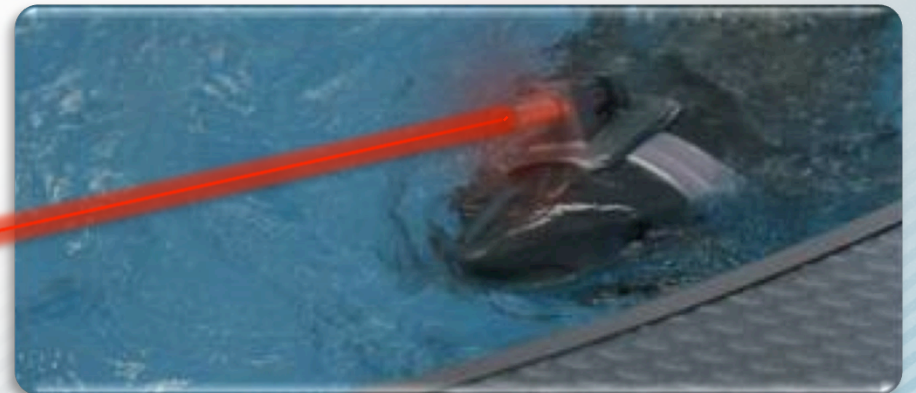
- ☐ Low-to-High – LTH low cost, organic dye based
  - ○ Dye Change Recording
    NOT FOR LONG TERM ARCHIVING!
  - ○ Gives Optical technology a bad name

- ☐ High-to-Low – Normal Blu-ray characteristic
  - ○ Phase Change Recording using in-organometallic compound
  - ○ Basis for long-term optical archiving

- ☐ True WORM Media
  - ○ Hard concept to grasp
  - ○ Other flaws

- ☐ Zero-space race

Note
[1] Sony [2] Verbatim
[3] Verbatim (LTH) [4] JVC (LTH)
[5] Maxell [6] Panasonic

Source: http://www.myce.com/news/french-research-avoid-blu-ray-lth-discs-for-data-archival-64265/

	CD	DVD	HD DVD (Obsolete)	BD
Disc Layout	Label side — Data Layer — 1.2mm	Label side	Label side	Label side
Capacity (per Layer)	640MB - 700MB, etc	4.7GB	15GB	25GB/33GB
r	1.4um	0.89um	0.51um	0.39um
λ	780nm (Near infrared)	650nm (Red)	405nm (Violet Blue)	405nm (Violet Blue)
Numerical Aperture	0.45	0.60	0.65	0.85

- ☐ Very inexpensive to build and support

- ☐ Over 500 media types, write strategies and formats supported

- ☐ Already in the firmware
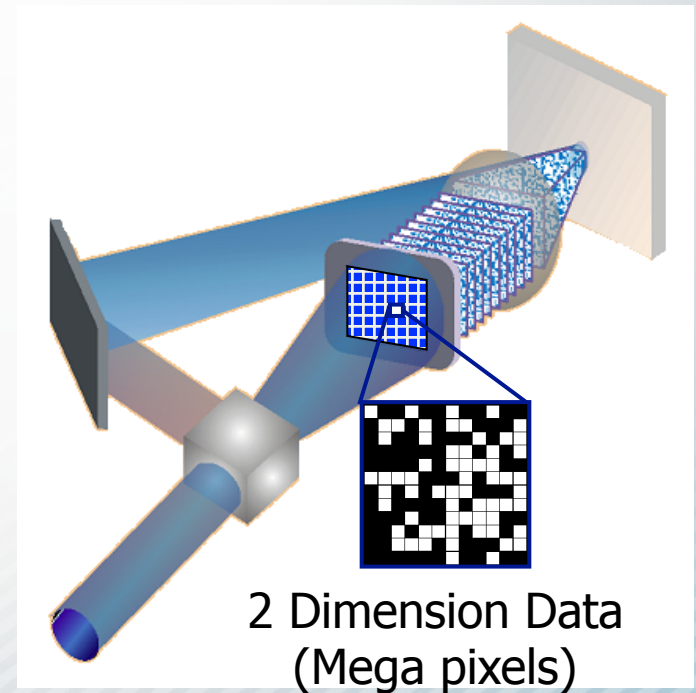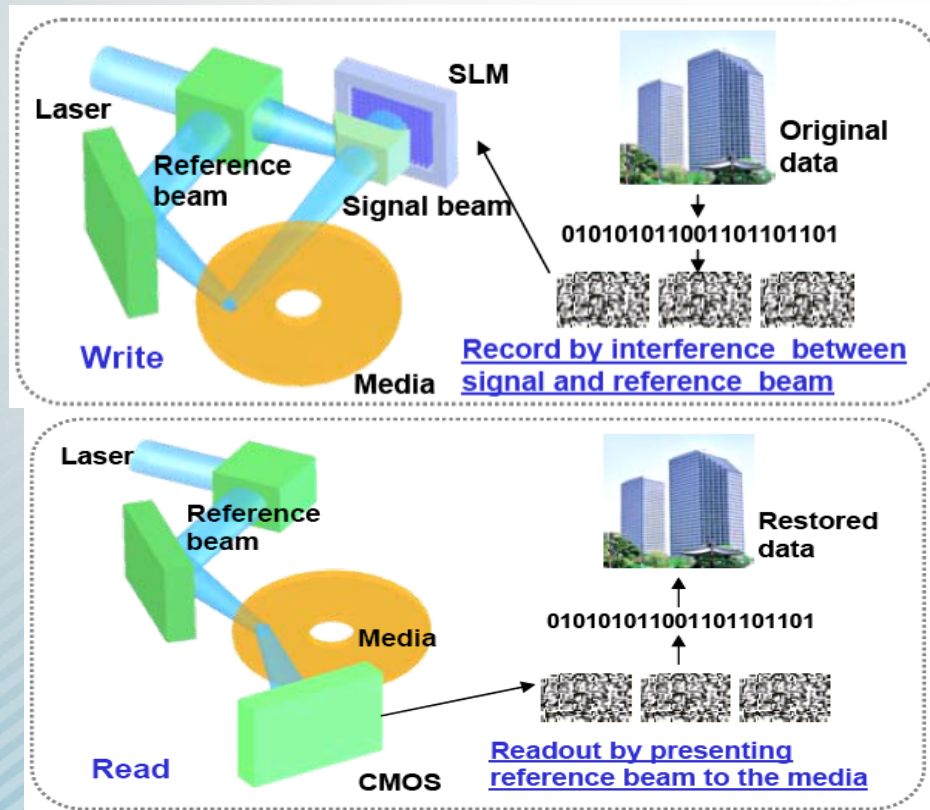
- ☐ Many devices can support new "types" with new firmware
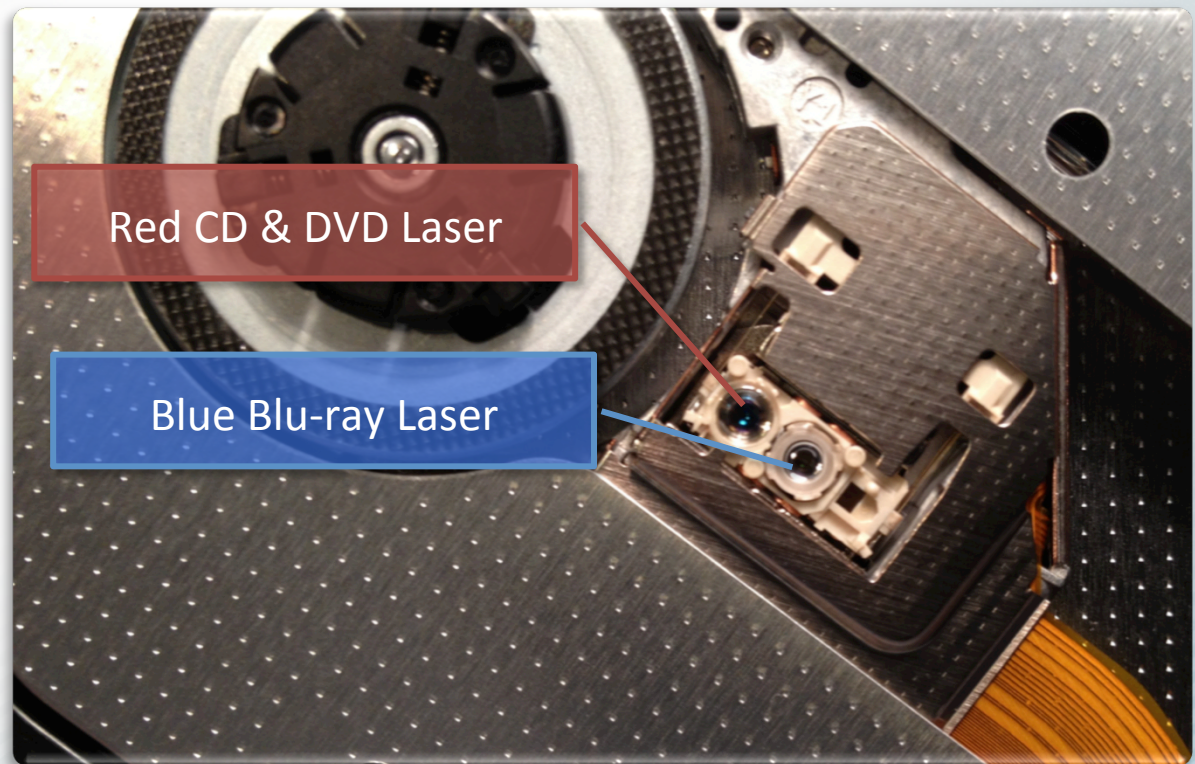
Red CD & DVD Laser

Blue Blu-ray Laser

HLDS Model: BP40NS20

☐ Holographic Storage store data elements as images at different angels

SLM
Laser
Reference beam
Signal beam
Original data
01010101100110110101
Record by interference between signal and reference beam
Write
Media

Laser
Reference beam
Media
Restored data
01010101100110110101
Readout by presenting reference beam to the media
Read
CMOS

2 Dimension Data
(Mega pixels)

	Angular Multiplexing	Collinear	Micro−Hologram
Principle Concept			
Transfer Rate (Published value)	Page−based Read/Write	Page−based Read/Write	Bit by Bit Read/Write
	300 Mbps (2006)	200 Mbps (2008)	20〜30 Mbps (2009)
Capacity (Published value)	3D Recording	3D Recording	Multi−layered bitwise Recording
	610Gbits/in^2 = 500 GB（2010）	415 Gbits/in^2 (2009)	6 GB×34 layer= 204 GB（2009）
BD compatibility	Not Compatible with BD	Some Compatibility	Compatible

Thank You