4th Annual Optical Storage Symposium

Near-Field Recording Technologies

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Basic Concept of SIL Based Near-Field Recording

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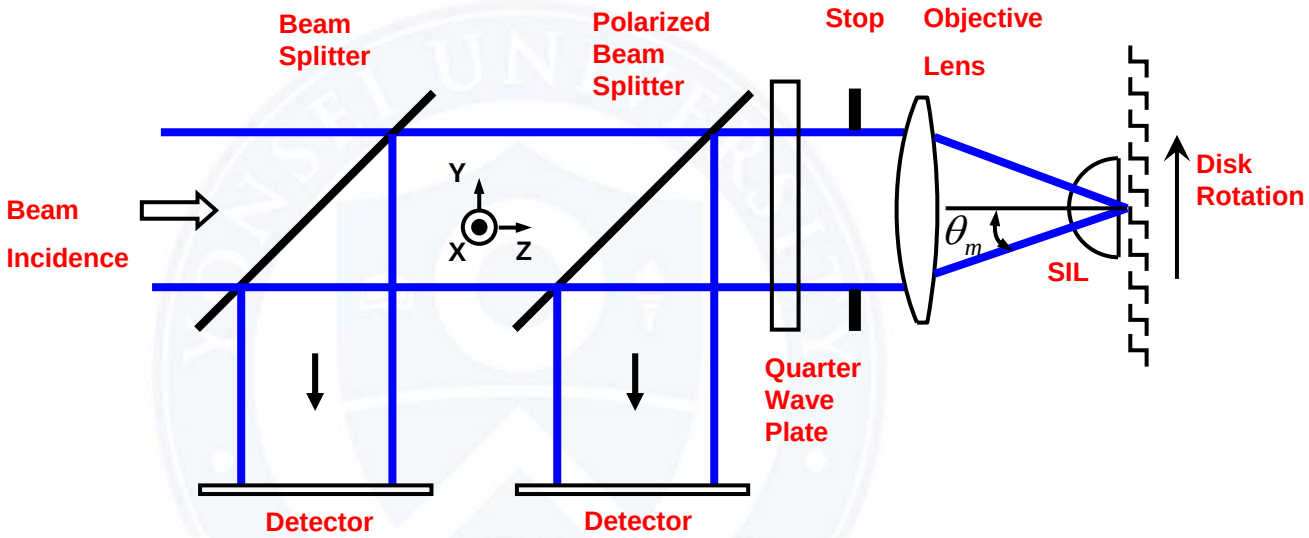
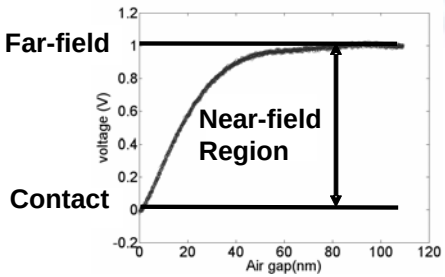
- **Super high resolution has been achieved by virtue of SIL applied optical system.**
- **Polarization characteristic of near-field light is used to seek near-field air gap signal and tracking signal.**



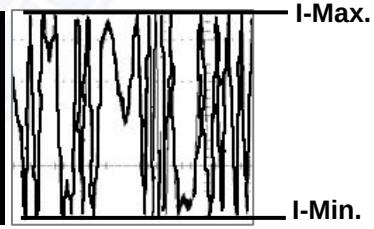


Gap Error Signal

(Total Internal Reflection Method)

|| Pol.

⊥ Pol.



Tracking & Focusing Error Signal

(Push-Pull Method)

Various Types of Optical Heads for SIL based NFR

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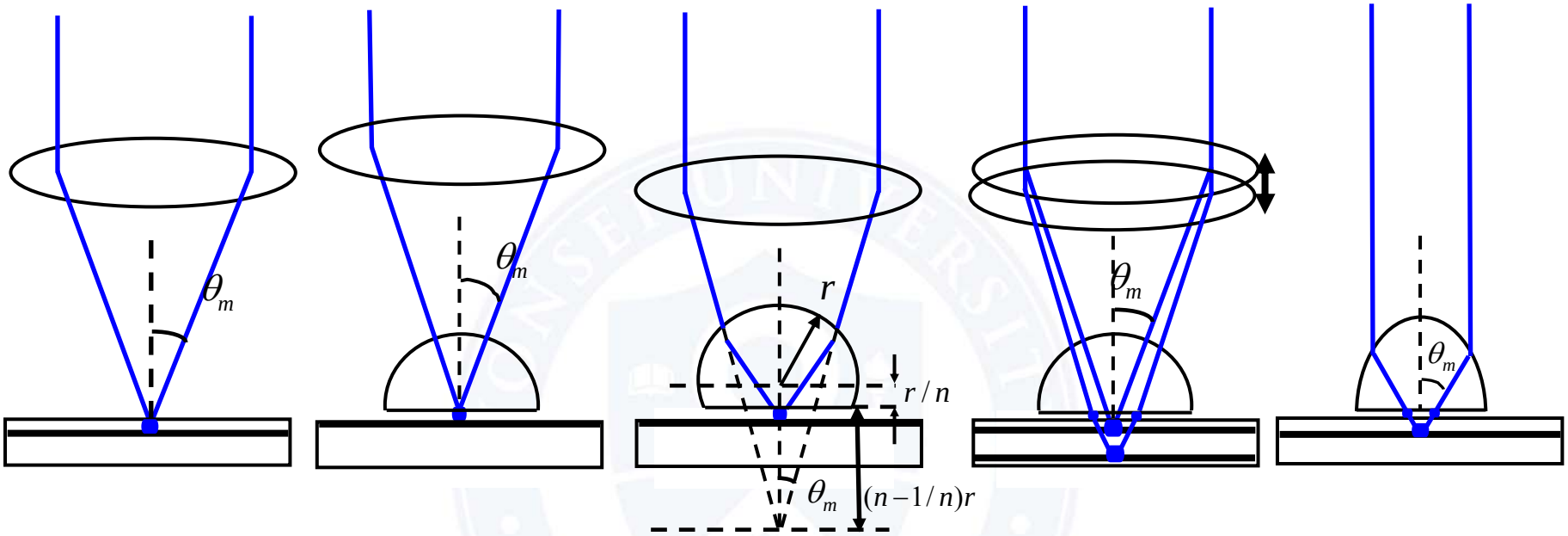
Two main streams of SIL based NFR → Disk 1st surface NFR system/ Cover-layer incident NFR system



(a) $NA_{EFE}=\sin\theta$ **NA$_{Max}$ ≈ 0.9**

(b) $NA_{EFE}=n_{SIL}\sin\theta$ **NA$_{Max}$ ≈ 1.75**

(c) $NA_{EFE}=n_{SIL}^{2}\sin\theta$ **NA$_{Max}$ ≈ 2.3**

(d) $NA_{EFE}=n_{SIL}\sin\theta$ **NA$_{Max@1^{st}}$ ≈ 1.6**
NA$_{Max@2^{nd}}$ ≈ 1.6

(e) $NA_{EFE}=n_{SIL}\sin\theta$ **NA$_{Max}$ ≈ 1.5**

- ***(a) Conventional far-field optical pickup optics***
- ***(b) Disk 1st surface NFR optics using a hemispherical SIL***
- ***(c) Disk 1st surface NFR optics using a super-hemispherical SIL***
- ***(d) Cover layer incident dual layer NFR optics using a hemispherical SIL***
- ***(e) Cover layer incident NFR optics using a elliptic SIL***

Technical Hurdles of SIL based NFR Technology

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- ✓Pickup actuator
- ✓Detection of gap signal
- ✓Disc runout
- ✓Residual gap error
- ✓Tracking signal offset

- ✓Hard coating
- ✓Shape of SIL tip
- ✓Clean, smooth and flat media Surface
- ✓Dust-free cartridge

- ✓Lightweight SIL assembly
- ✓Improved gap and tracking servo
- ✓Multiple readout and recording channels

- ✓Design of the SIL optics
- ✓Improving of the optical performance of the SIL system
- ✓Use of wave plate

Component Challenges of NFR Technology

- **Fabrication of SIL assembly →** Super-hemisphere SIL has very small thickness tolerance less than 100nm and hemisphere SIL is very sensitive to axis tolerance. Therefore, additional aspheric lens surface added on the 1st surface of the SIL or another optical component is necessary.

- **Media fabrication →** Optical disk has to be robust to user's environment. Therefore, hard thin film coating or lubricant layer may be essential for disk 1st surface NFR media. In case of cover-layer incident NFR system, there are needs of cover-layer material which has high refractive index to increase data capacity.

- **Light and small SIL assembly →** To increase data transfer rate and stability of air gap servo system, light SIL assembly can be a solution. Wafer scale fabrication of SIL assembly using semi-conducting material is good for the fabrication of very small SIL and mass production.

- **Focusing position adjusting optics →** In the cover-layer incident NFR system, there is a critical focusing problem due to the cover-layer thickness variation and dual or multiple recording layer. Additional optical components such as liquid crystal (LC) lens or zoom optics can be used.

- **Spherical aberration compensator →** In cover-layer incident NFR optics, μm-thick cover and spacer layers occur additional spherical aberration, and chromatic aberration is getting severe. Diffractive optical element or LC lens component can be used to compensate generic problem of optics.

Design of the SIL for Improving Tolerance

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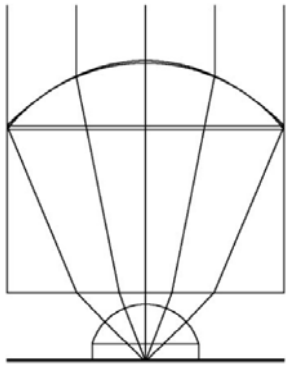
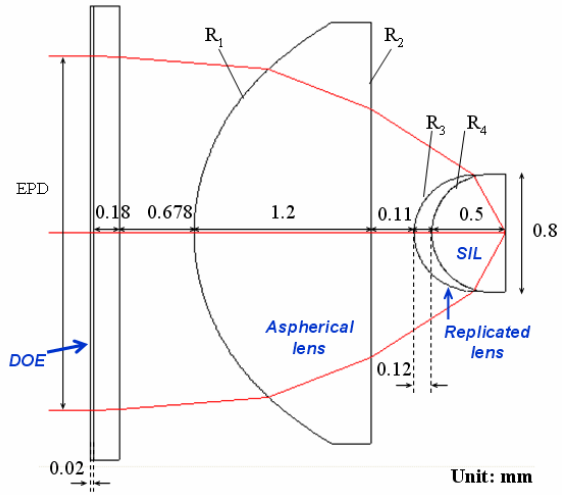
Hemisphere SIL for cover layer incident recording (Philips)



Super-Hemisphere SIL with Replicated Lens and DOE (CISD)



Tolerance of SIL

NA	1.45
Field of view (deg)	0.24
SIL thickness (μm)	10
OL thickness (μm)	5
SIL off-axis (μm)	9
OL off-axis (μm)	2

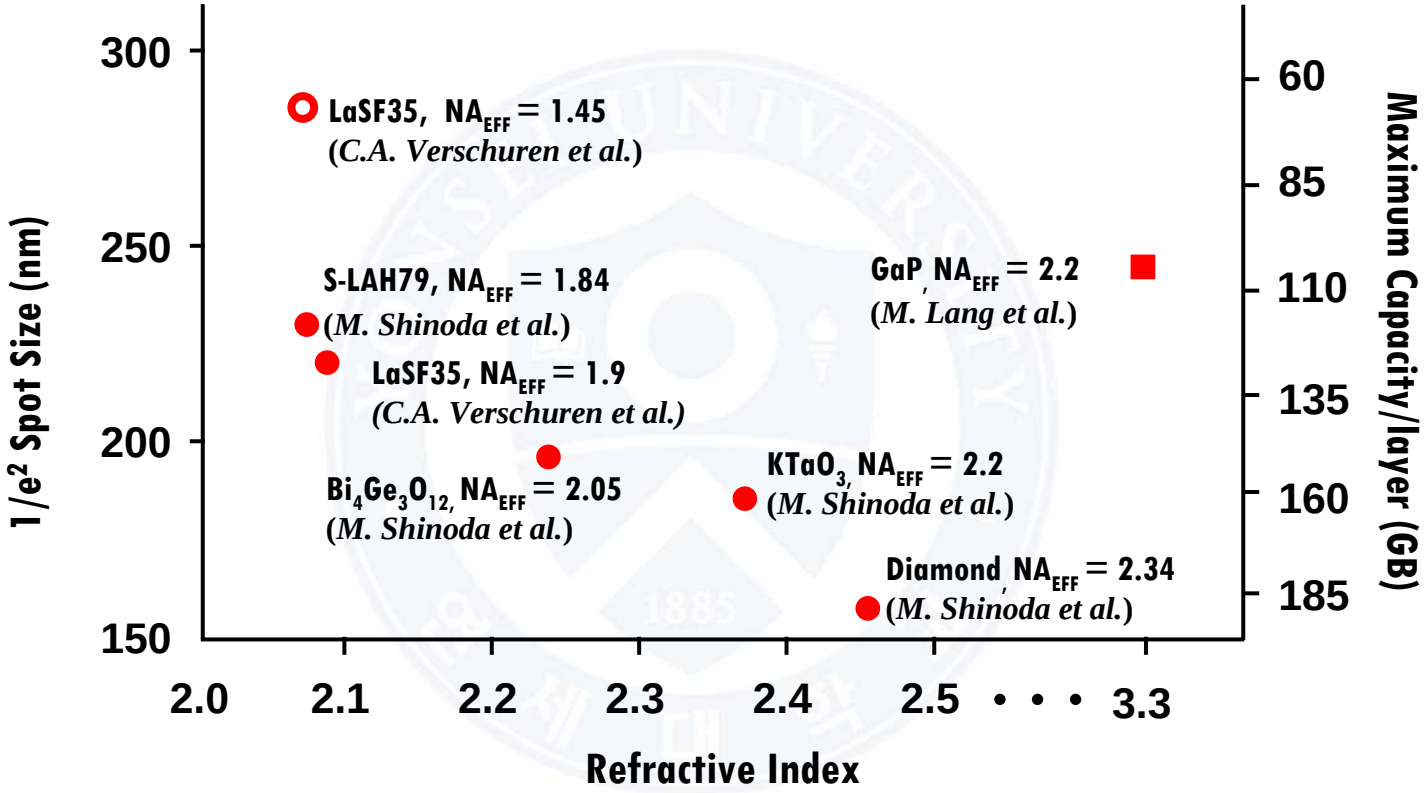
Tolerance of SIL

NA	1.82
SIL thickness (μm)	10
Replicated lens thickness (μm)	6
Chromatic aberration (nm)	401~412
SIL off-axis (μm)	2

Various SIL Materials has been used up to now

Requirements for SIL material candidates

➔ High refractive index/ High transmittance @ short wavelength/ Good manufacturability



● Wavelength=405nm, disk 1st surface NFR optics

■ Wavelength=530nm, disk 1st surface NFR optics

○ Wavelength=405nm, cover-layer incident NFR optics

Development of Near Field Air-Gap Controller

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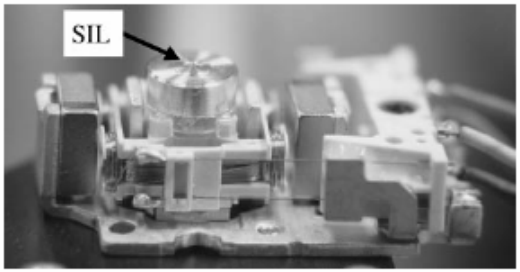
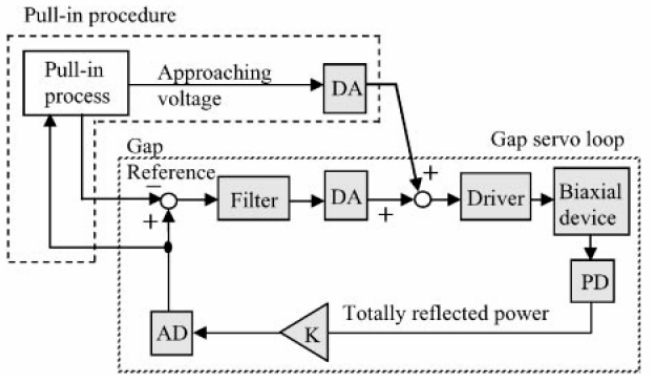
Sony, Philips, LG, and CISD have achieved in near-field air gap servo with mode switching control method
Optical characteristic of total internal reflection at head media interface is used to obtain gap error signal

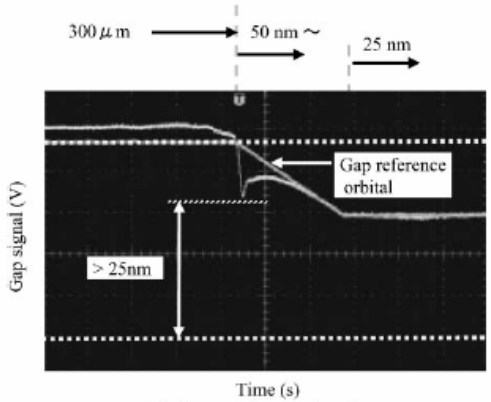
Sony



SIL on a conventional DVD actuator

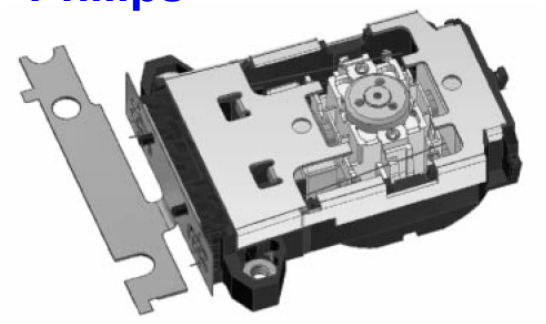


Gap servo block diagram of Sony

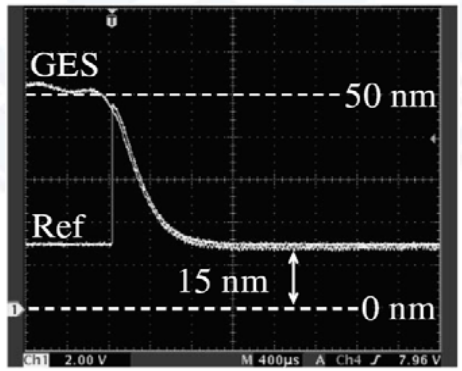


The Result of Gap servo control of Sony (stable control of 20nm air gap)

Philips

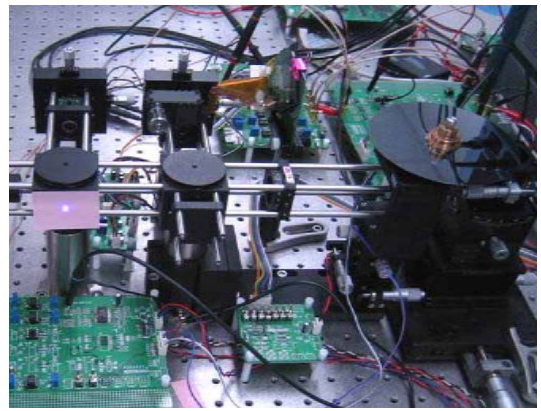


SIL on a conventional High Speed DVD actuator



The Result of Gap servo control of Philips (stable control of 15nm air gap)

LG



Technology Development on Media Fabrication

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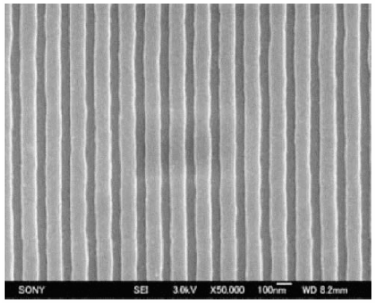
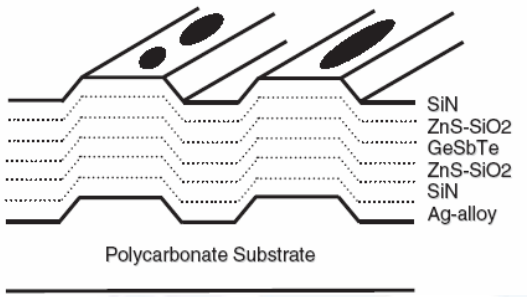
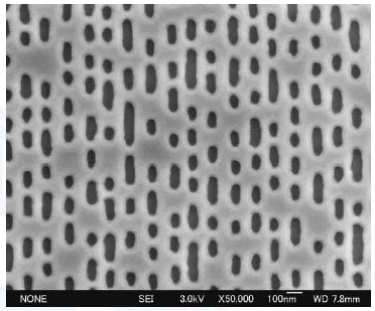
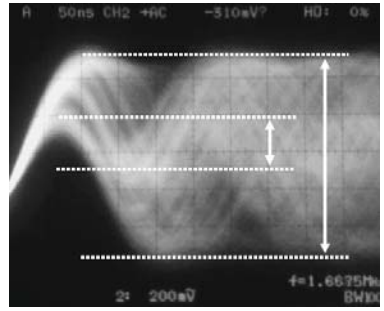
Sony evaluated read/write characteristic with100GB PC Disk and 150GB ROM disk (Sony)







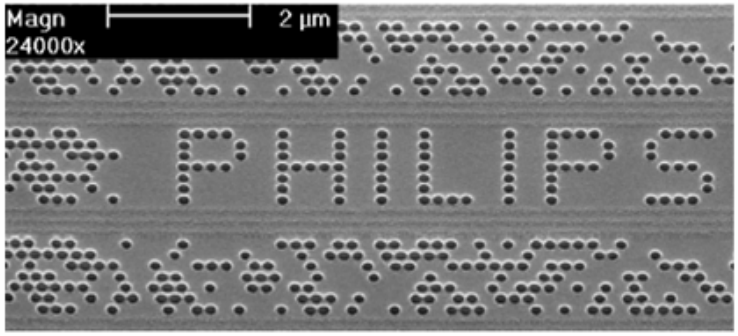


Electron beam recording mastering
Track pitch =160nm

Electron beam recording mastering
Track pitch: 130nm
Bit length: 47.6nm.

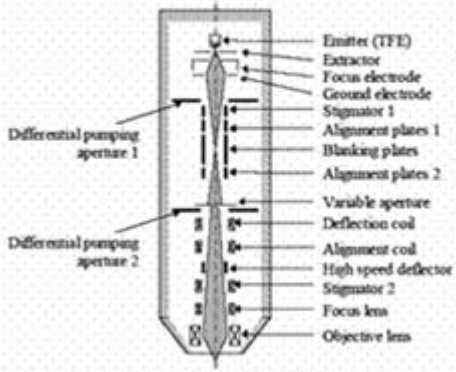
3μm thick Cover-layer incident NFR ROM Media (Philips)

-Liquid Immersion mastering
-ROM disc with 3 μm cover-layer
-Track pitch = 170 nm

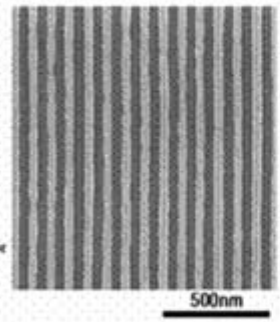


The EBR setup and fabrication result of 300 GB RE disk by Pioneer

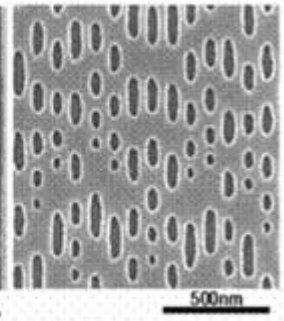
-Electron beam recording mastering
-Track pitch: 90 nm (Phase Change Disk)
-Pit length: 45nm (ROM Disk)



Schematic diagram of the electron beam column.



90 nm-pitch line and space.



Modulated pit pattern
(Capacity: 300 GB/layer)

Dual-Channel NFR System For Higher Data Transfer Rate

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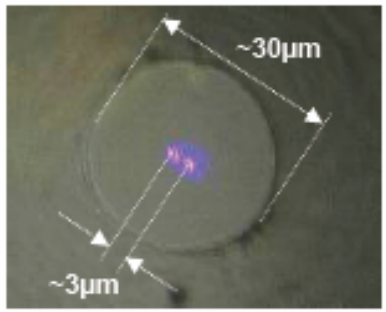
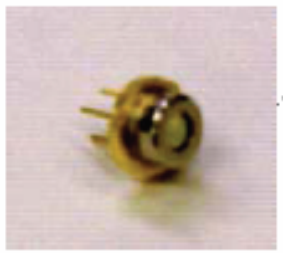


NA 1.84
SIL Objective Lens

Independent APCs by pinholes

PD-IC for multi-channel

Dichromatic prism
Expander lens
Beam monitor
Detector I
BS
QWP
RF signal
Tracking error (Push-Pull)
Pin hole
PBS
QWP
HWP
Detector II
Anamo. prism
BS
PBS
Beam monitor



A cathode common 2beam AlGaInN laser diode

2-beam BlueLD (412nm)

35 mW (CW)
65 mW (Pulse)

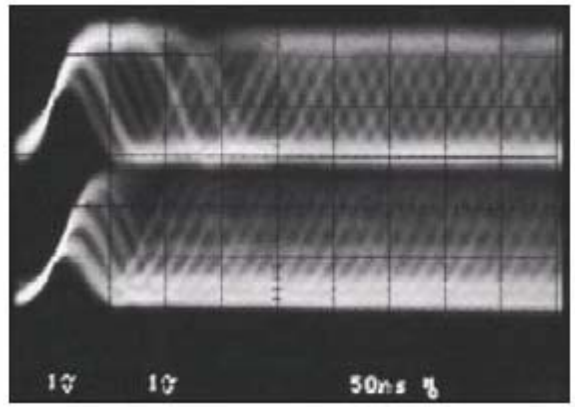
Red LD (660nm)

Separated optics for Gap Servo

Eye pattern

Ch1

Ch2



Test conditions

Wavelength: 412nm
NA: 1.84
Air gap: ~20nm
Channel clock: 66Mhz
Linear velocity: 3.1m/s
Recording power: 2.3mW
Modulation: 1-7 pp

Sony

Progress of Near-Field Recording Technologies

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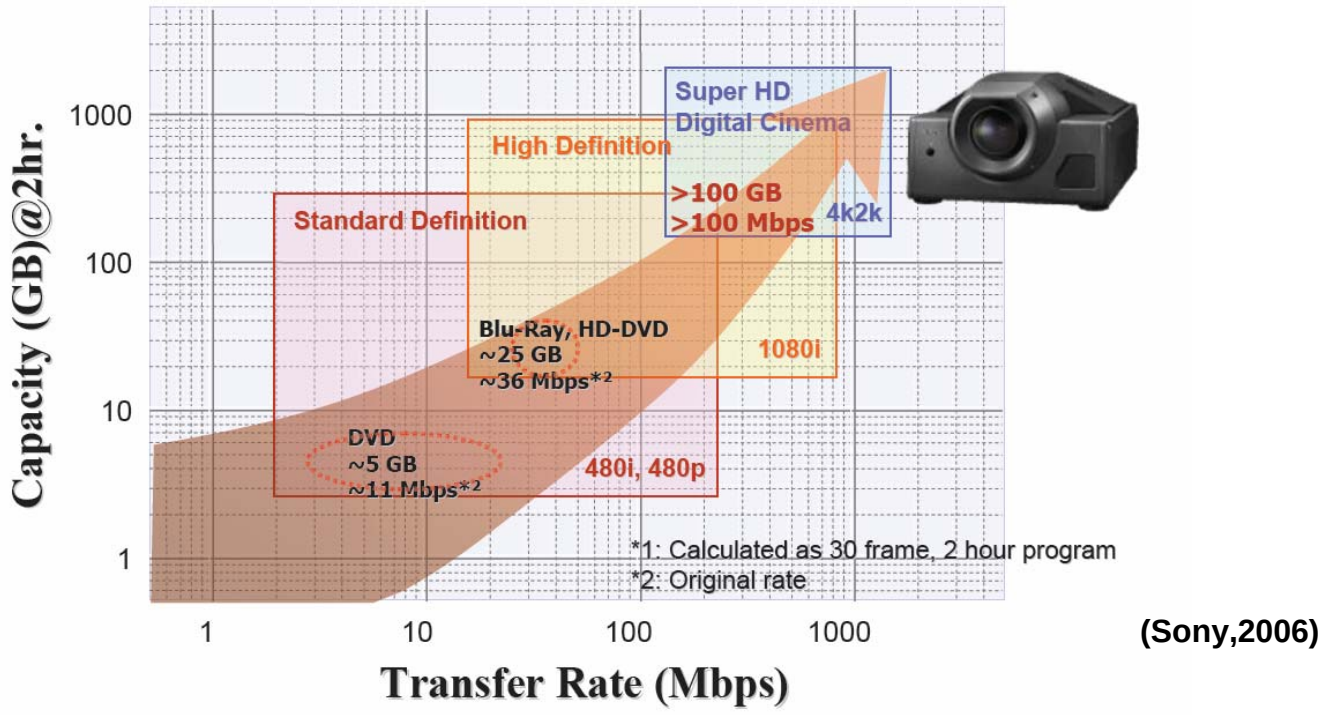
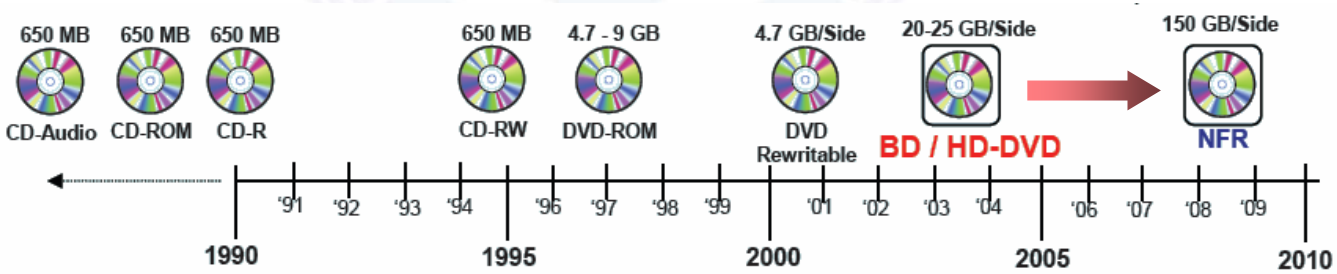
Technology steps for digital imaging Technology steps for digital imaging



(Sony,2006)



(LG,2006)

Target: Post-BD/HD-DVD consumer market

Application for Near-Field Recording Technology

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