(1 - A - 6)

Readout Aperture 조건에 따른 초해상 광디스크 신호특성

곽금철*, 이창호, 임정식, 김일환, 김효중, 송기창
LG Electronics Institute of Technology

이장교, 변석주
InsideOptics

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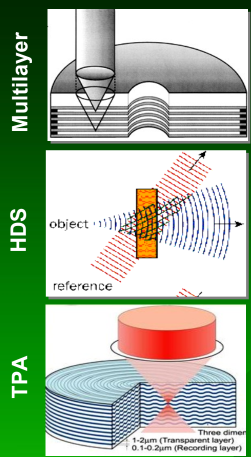
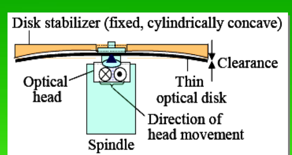
❑ Optical Disc Roadmap





Flexible disc

3-dim

Multi-layer Disc
- Interlayer X-talk, Transparency
- Servo
- Throughput

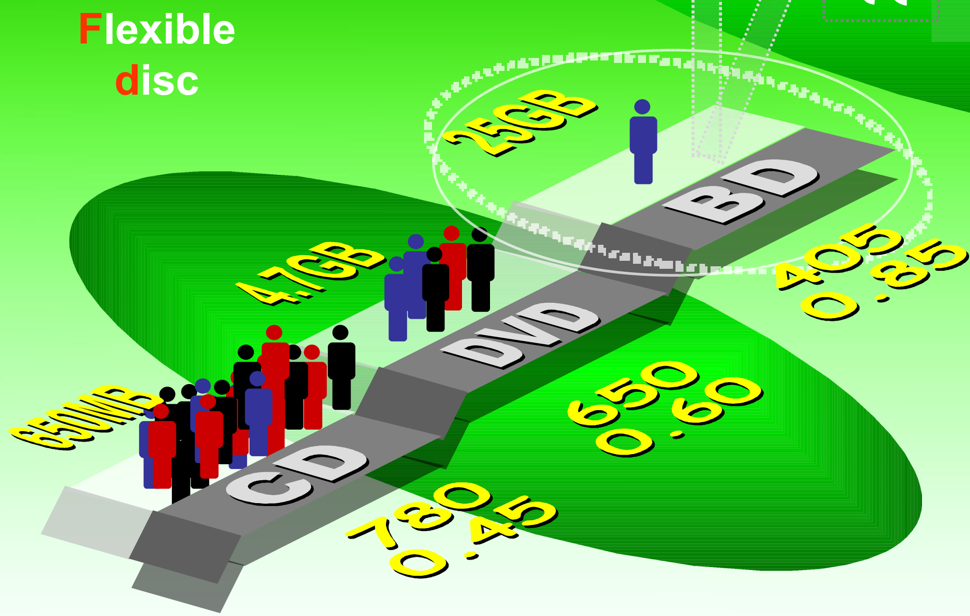
Holographic memory
- Material stability
- Signal processing
- Servo, Multiplexing

Two Photon Absorption
- Transparency, Low absorption
- Servo
- High power laser, Detector

2-dim

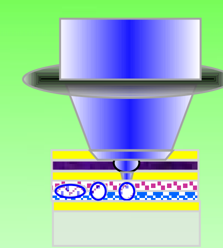
Super-RENS
- Signal processing
- Stability
- High readout power

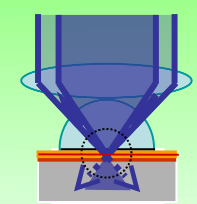
NFR
- Head Disc Interface prob.
- Servo
- High NA lens, High index cover



?
- **Laser**
- **Lens**

$$\sim \frac{\lambda}{NA}$$





Capacity Target

200GB / single layer → **500GB / dual layer**

37.5 *nm* min.pit.length

Land & Groove Rec.

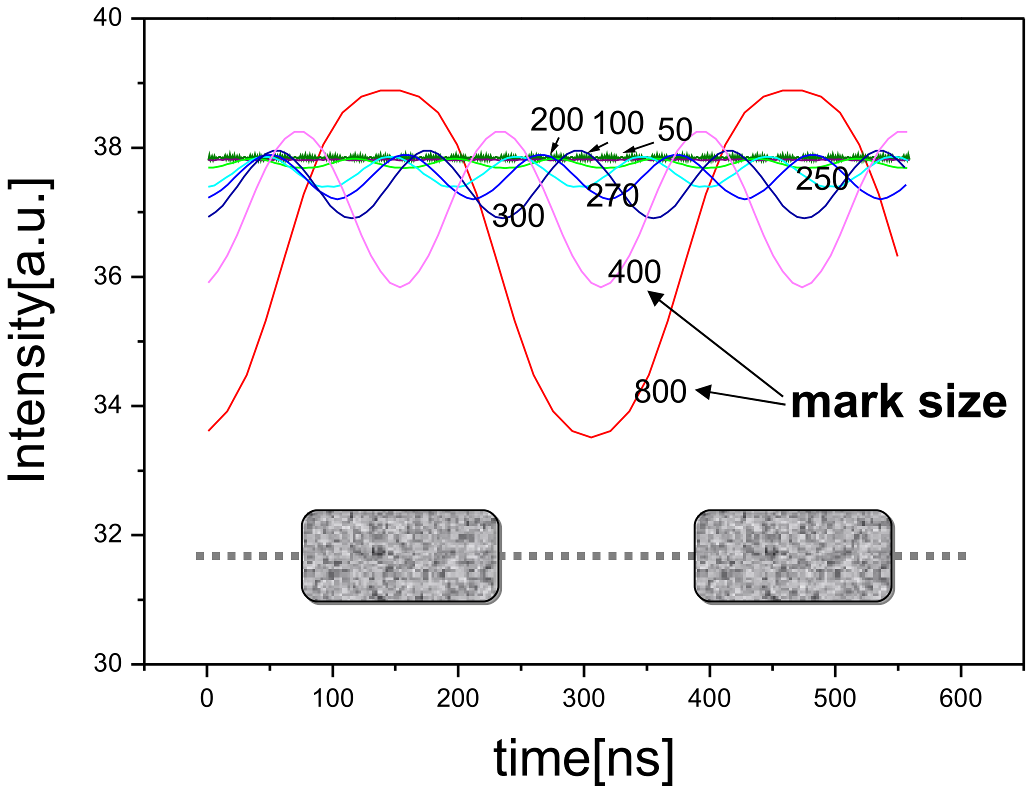
BD Pickup & Disc

- ✓ 405 nm wavelength
- ✓ 0.85 NA
- ✓ 320nm track pitch

Introduction --- "Diffraction limits Resolution"

Life's Good

Reflected light intensity

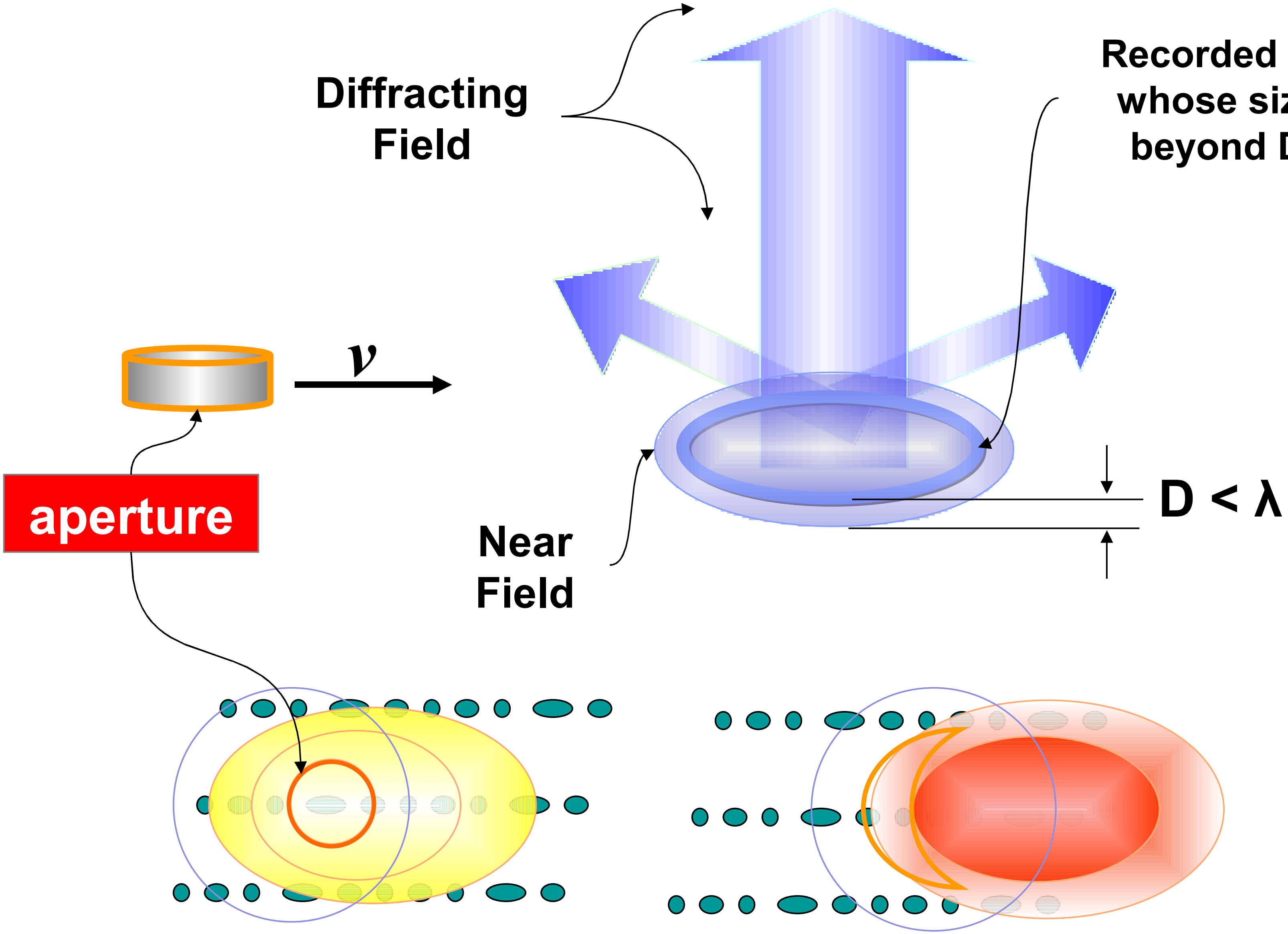


Diffraction thru. aperture

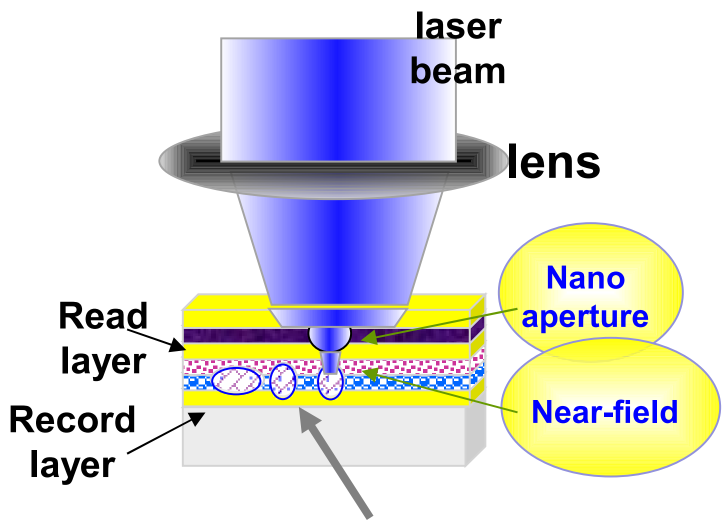
(650nm, 0.65 NA)

$$D.L.: \ \frac{\lambda}{4NA} = \frac{650nm}{4 \quad 0.65} = 250nm$$

Aperture ---- strong & weak points



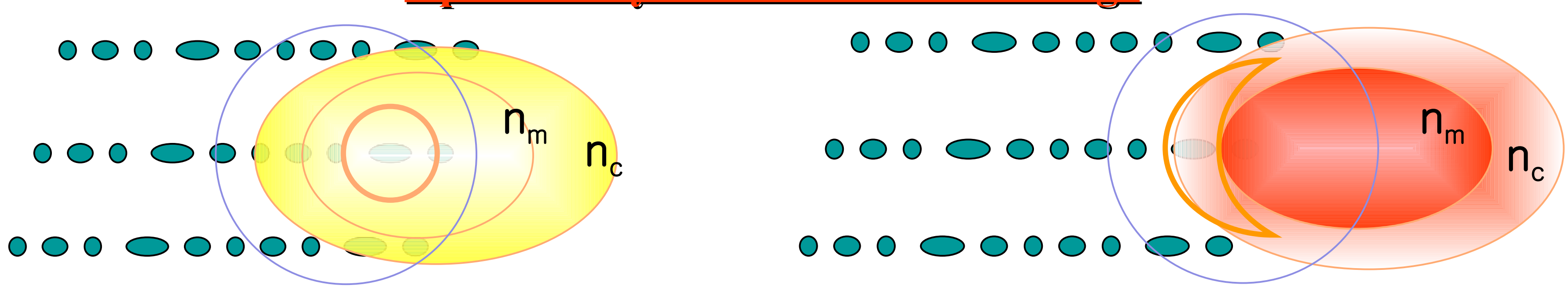
Super-RENS Technology ?



By { **Nano size Aperture** and **Near-field**

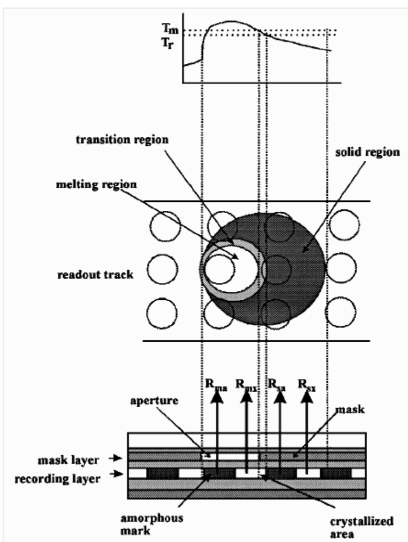
We can afford to read the marks whose size are much smaller than the optical diffraction limit.

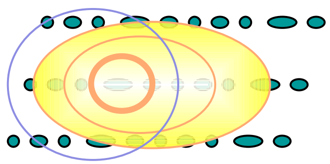
Aperture by refractive index change



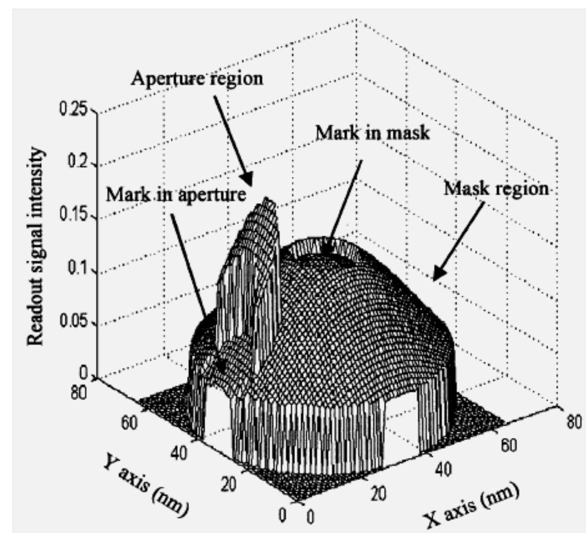
Motivation

1. Complete masking (aperture quality)?
2. Enough resolving power for the marks of 37.5nm length for 500GB capacity?

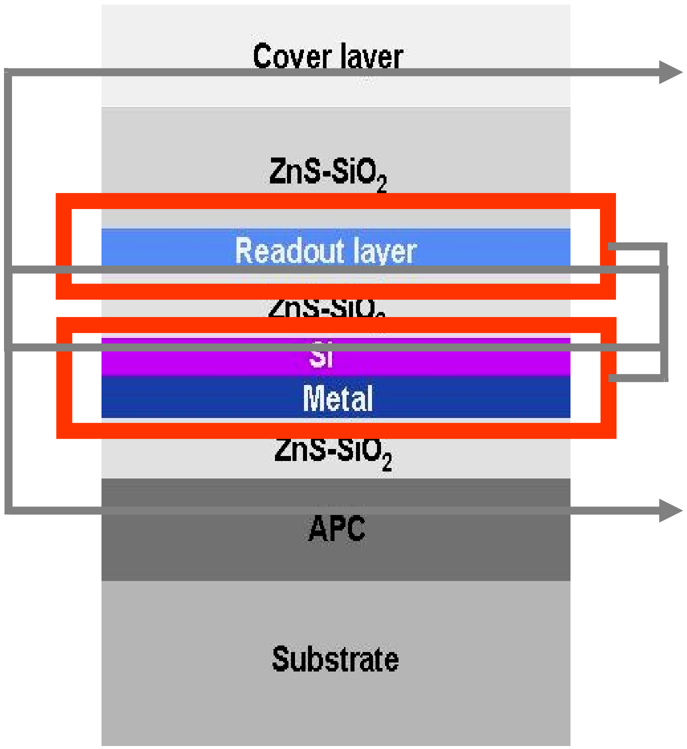




Readout signal



Design of Super Resolution Film Structure



Readout layer

- Optical contrast change (GST)
- Readout stability (~ISOM07, 10^5)
- Sharp aperture boundary
- Low noise

Recording layer

- Readout stability
- Reasonable modulation
- Low recording power

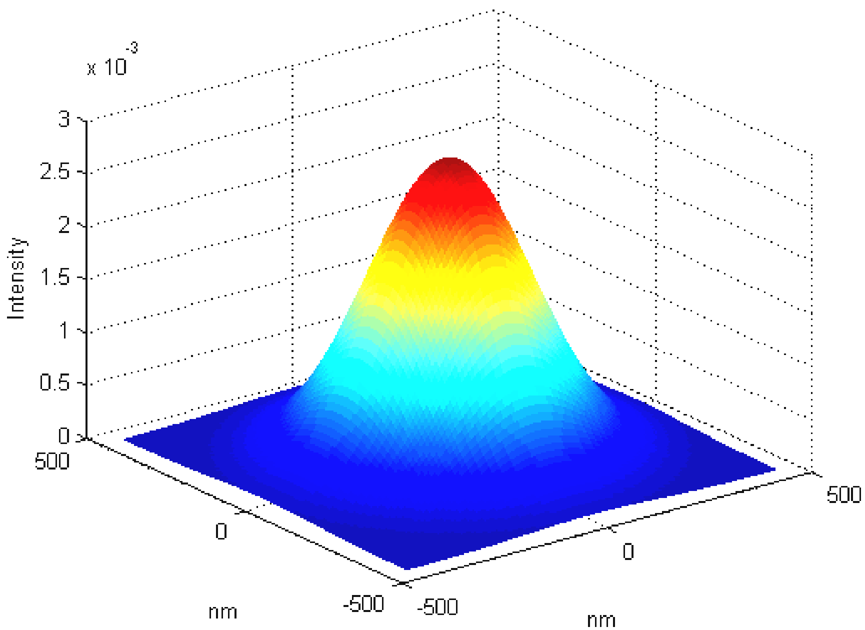
Stable material structure ➔ Silicide

Silicide

- Appropriate thermal conductivity (Mark Shape) ➔ Metal + Si
- Readout stability after recording ➔ Noble Metal
- Low melting temperature ➔ N.M. + Additive metal

Experimental setup (simulation)

- Readout Laser Power: 5.5mW
- Wavelength: 650nm
- NA: 0.6
- FWHM: 640nm

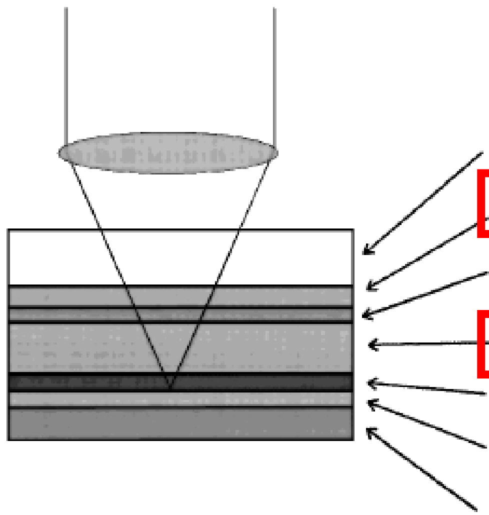


Input Beam

	DVD	BD
Wave.length (nm)	650	405
NA	0.6	0.85
D.L. (nm)	250	119
Min.mark.length (nm)	400	150
Track.pitch (nm)	740	320
Min.mark.length (nm)	100	37.5
Capa. (GB)	18.8 (=4.7x4)	500 (L&G/DL)

"200GB/SL - equivalent condition"

Simulation Background



substrate

top dielectric layer
$ZnS\text{-}SiO_2$ (92 nm) — **2.17573+0.00162i**

mask layer
$GeTe_7Sb_4$ (3 nm) — **5.6+3.5i (Solid), 4.35+2.875i(Wall), 3.0+2.25i(Melt)**

middle dielectric layer
$ZnS\text{-}SiO_2$ (336 nm) — **2.17573+0.00162i**

recording layer
$Ge_{21}Te_{53}Sb_{26}$ (25 nm) — **3.82067+1.66755i (A), 3.40605+3.54229i(C)**

bottom dielectric layer
$ZnS\text{-}SiO_2$ (30 nm)

reflective layer
Al (90 nm) — **1.32+5.573i**

Wavelength: 650 nm
Velocity: 5 m/s

- **Reflectance, Transmittance, and Absorption were calculated by 4X4 Berreman Matrix method.**

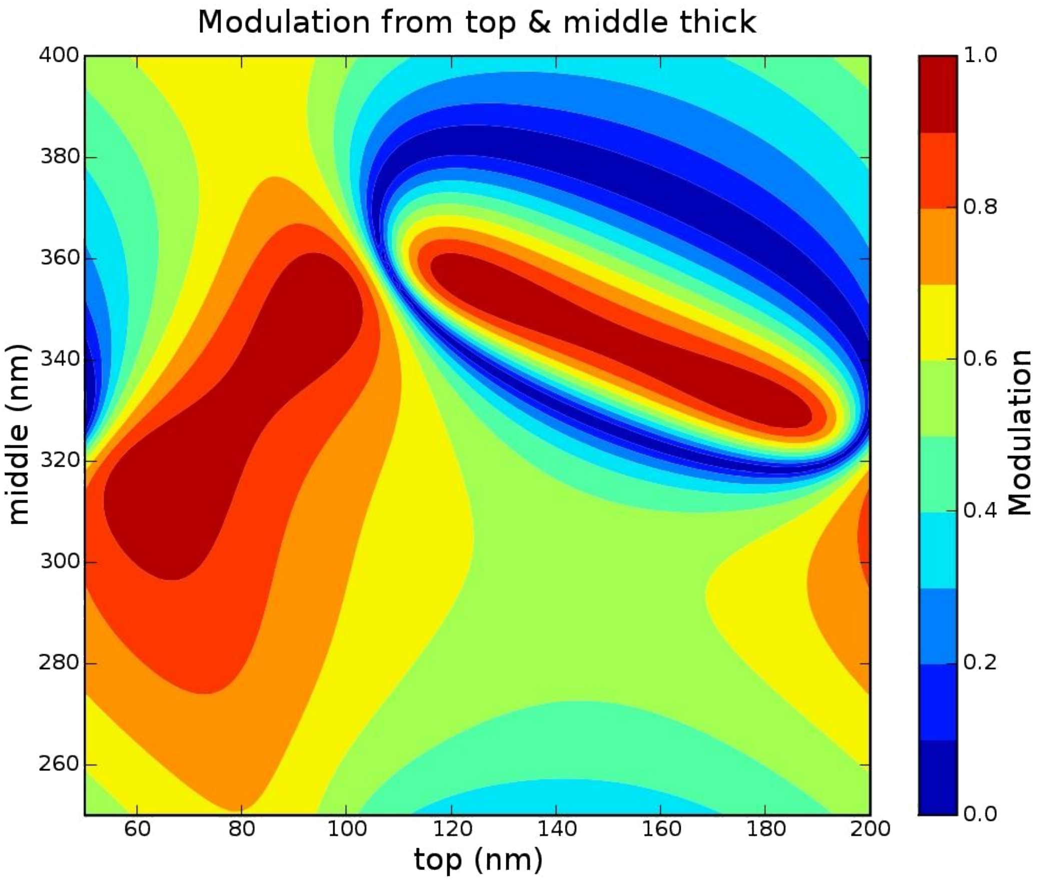
- **Read-out signal was calculated by 2D-convolution method.**

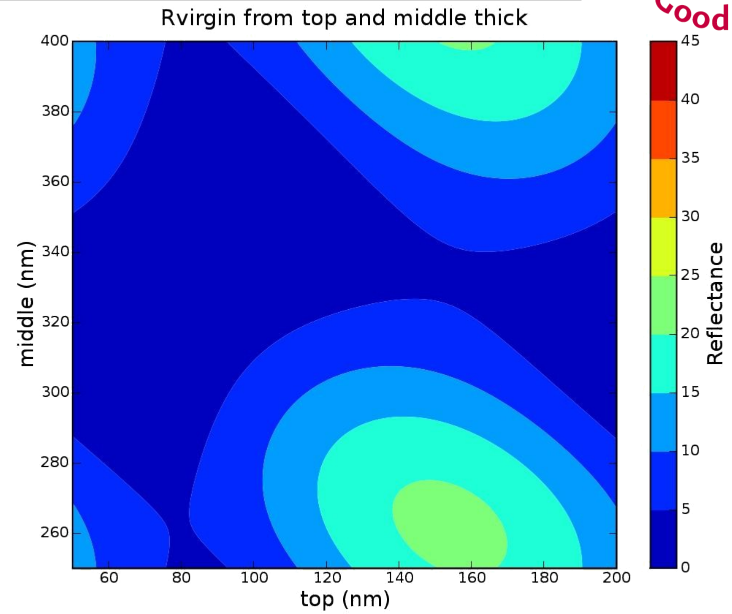
Motivation

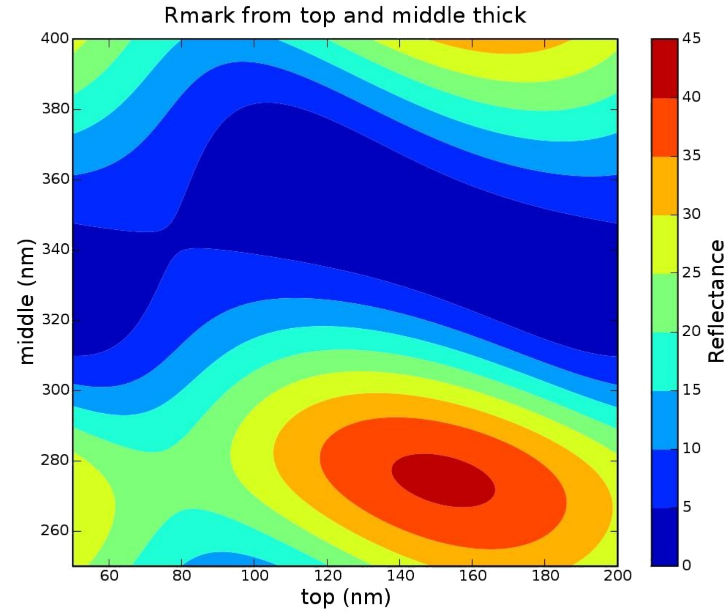
1. Complete masking (aperture quality)?

2. Enough resolving power for the marks of 37.5nm length for 500GB capacity?

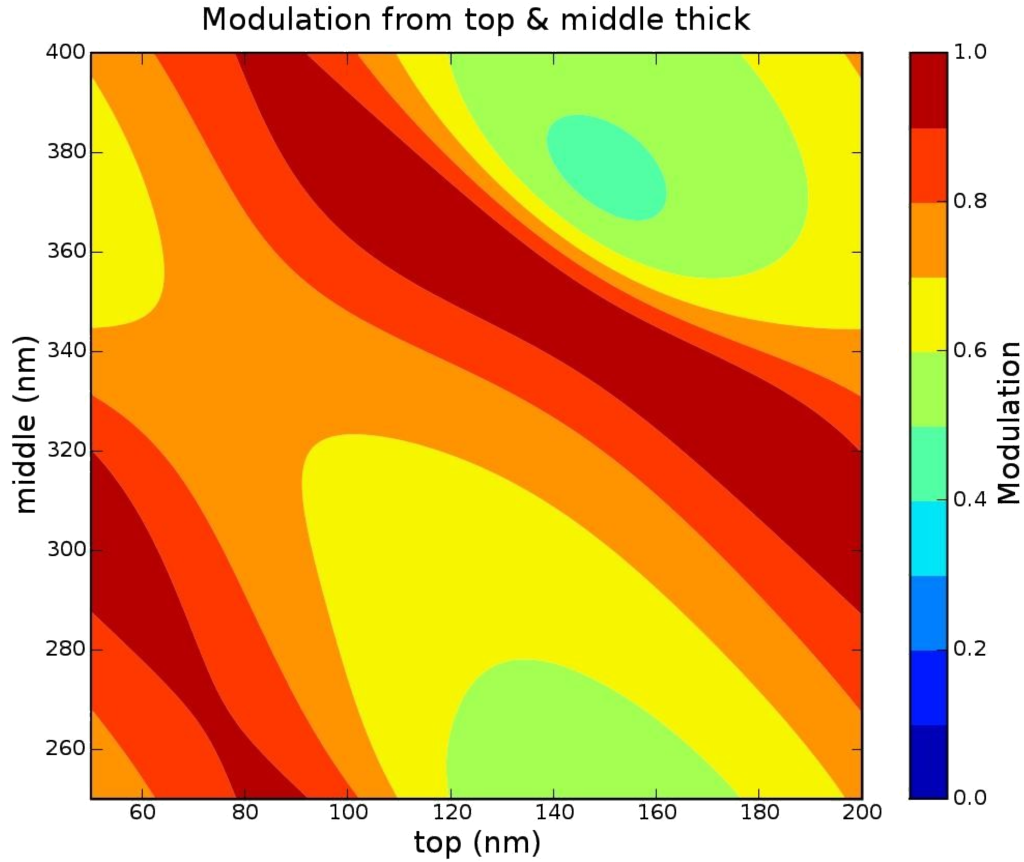
Modulation (solid)

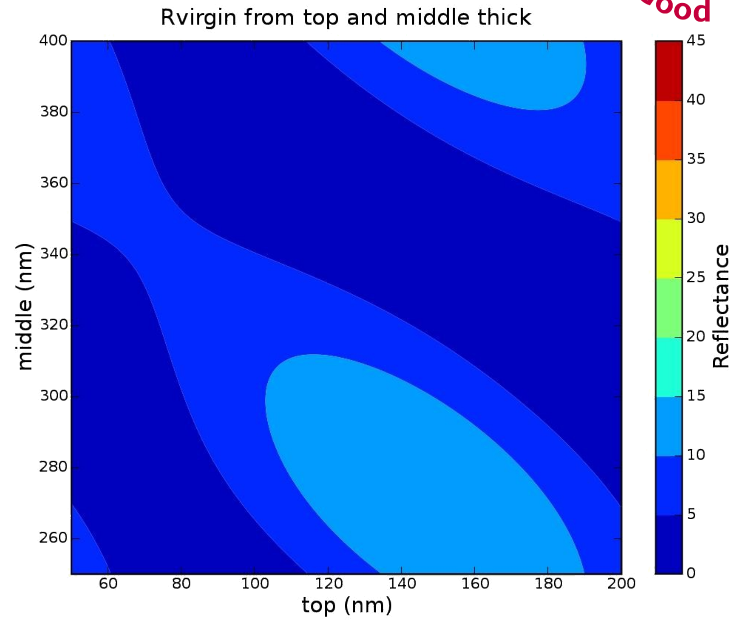


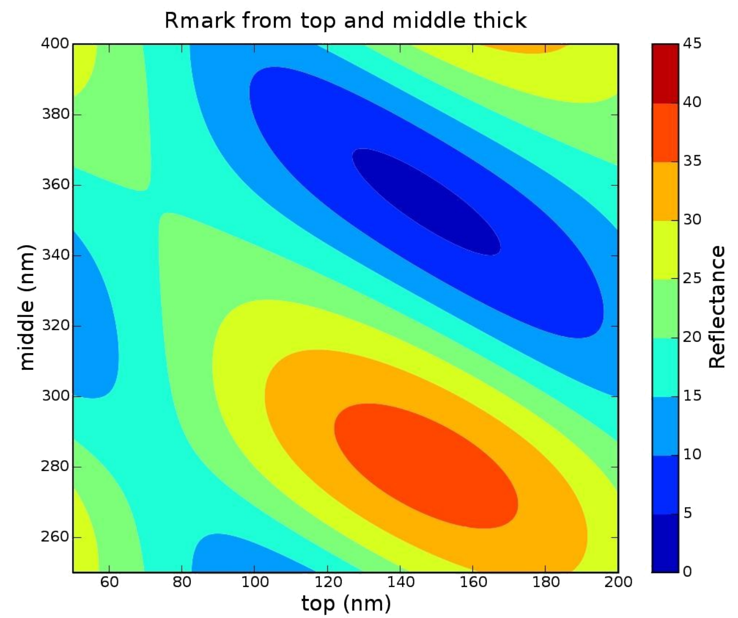




Modulation (molten)

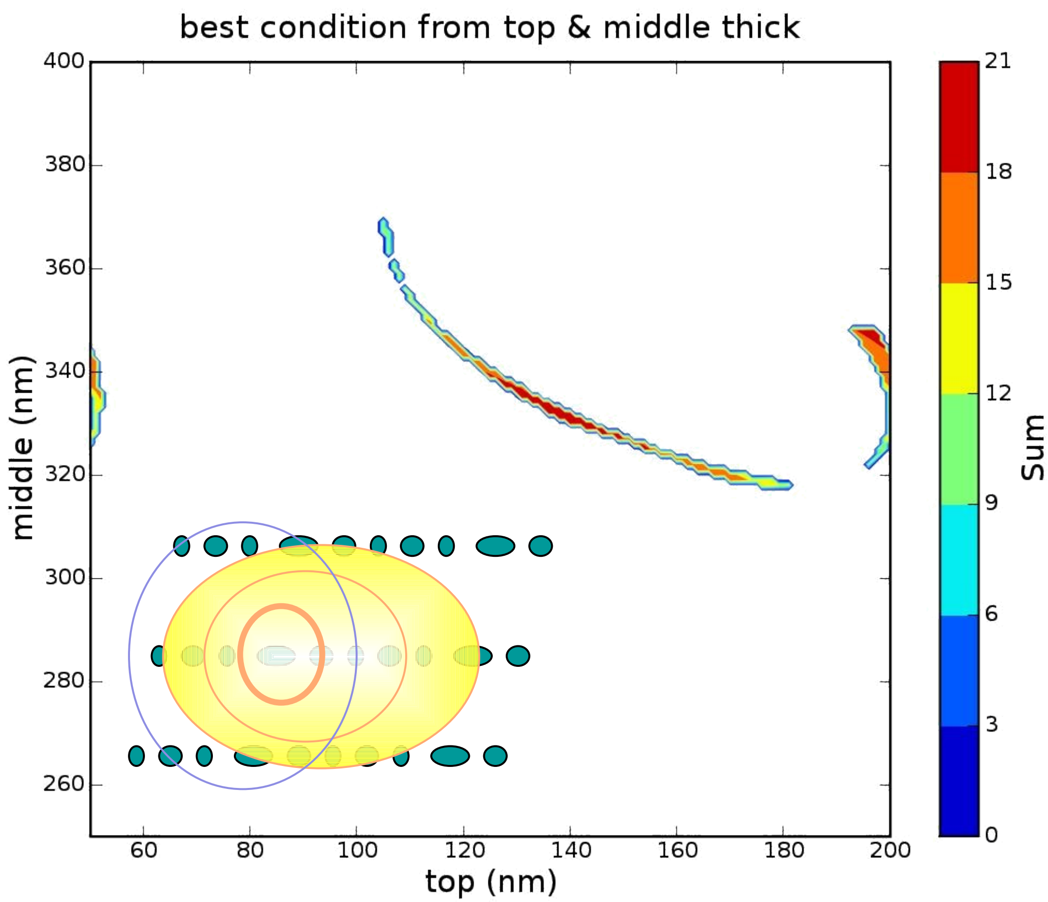






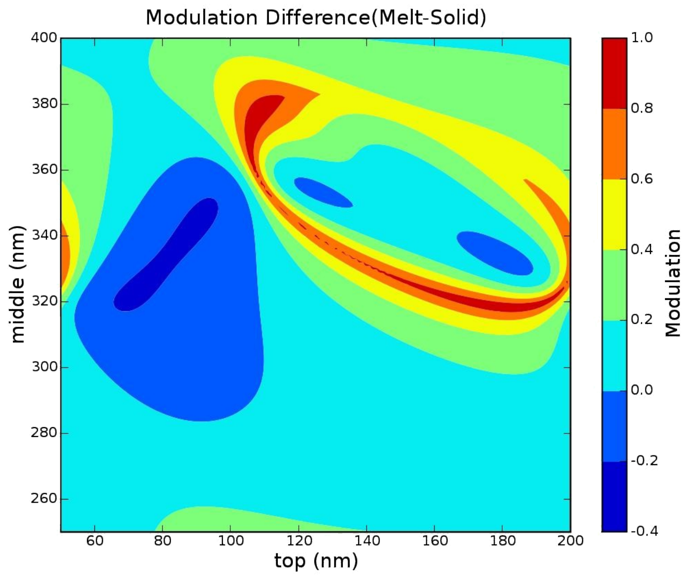
(Modulation of whole area is over 40%)

Film structure optimization result



1. Mod_solid < 0.1
2. Mod_melt > 0.4
3. (Rmark_melt > 10) && (Rmark_solid< 5)

```
If (1 & 2 & 3)
  {
     Color = Mod_solid
                 + Rmark_melt
                 + Rmark_solid
  }
  else    Color = 0;
```



Complete Masking, OK !!

Motivation

1. Complete masking (aperture quality)?

2. Enough resolving power for the marks of 37.5nm length for 500GB capacity?

Enough Resolving Power ?

1. Aperture Noise

- Sharp aperture boundary (aperture wall)

1. material ➔ GeSbTe !

(abrupt change of refractive index regarding temperature change)

2. readout layer thickness ➔ the thinner, the better

3. film structure

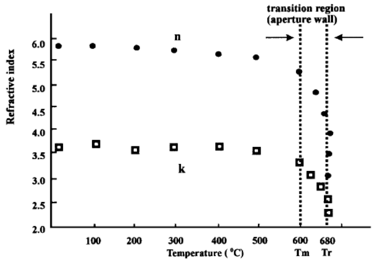
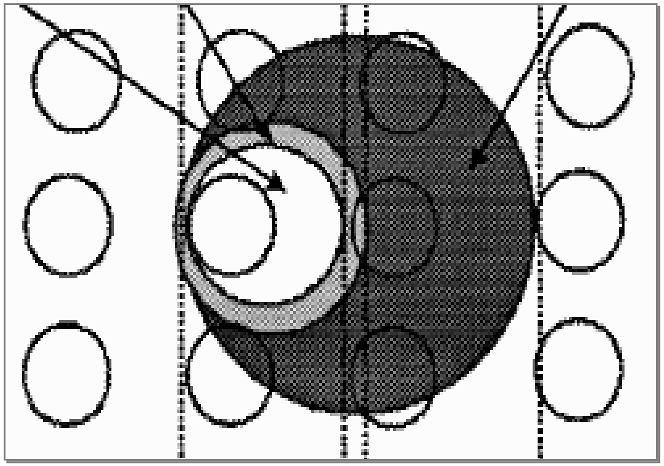


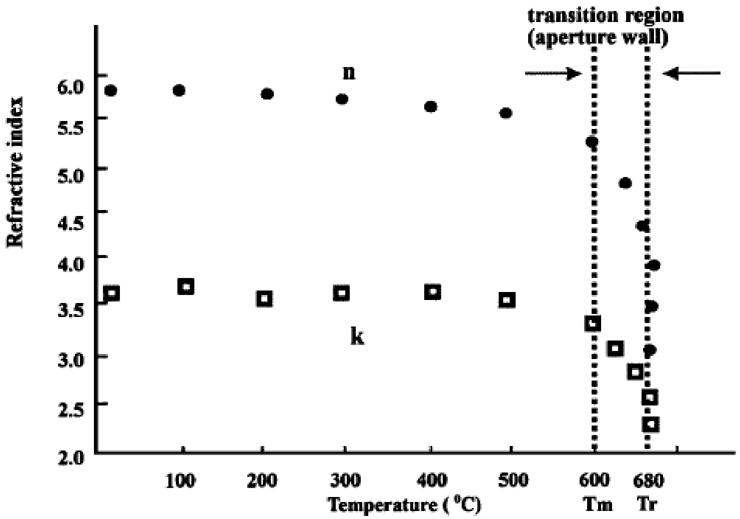
Fig. 5. Temperature gradient from melting point T_m to readout temperature T_r results in the gradient of the refractive index of the mask layer.

2. Aperture Size vs. Mark Size issue

3. Inter-track X-talk for Land & Groove Records/Readout

Aperture wall





Aperture boundary effect

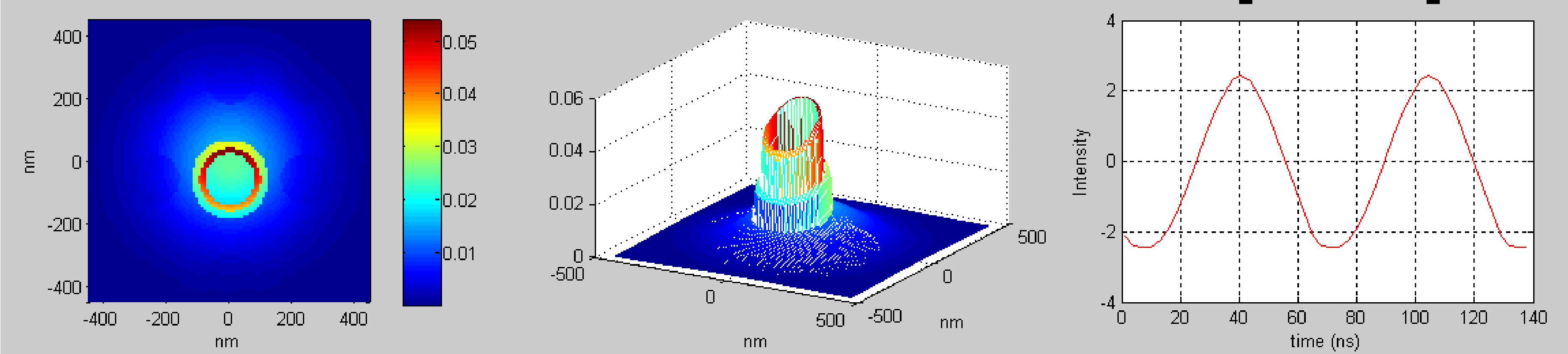
(nearly completely masked)

Mark size: 160nm, Period: 320nm

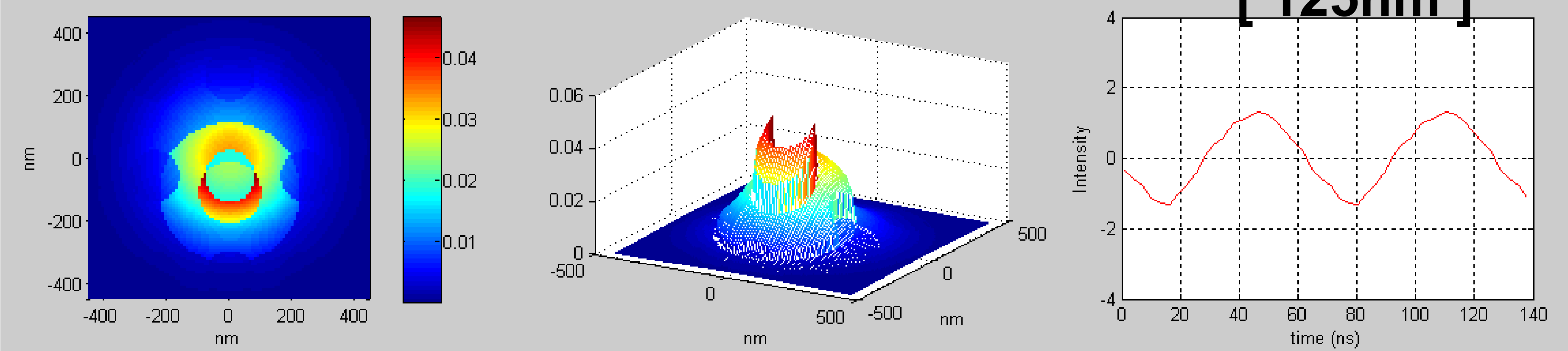
Top dielectric thickness [92nm]

Wall thickness

[25nm]



[125nm]



Aperture boundary effect

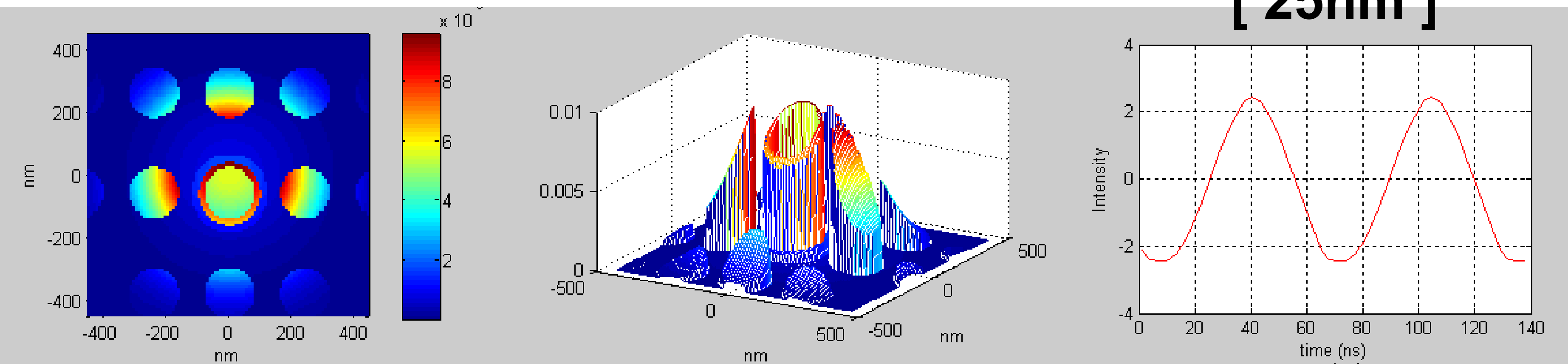
(not nearly completely masked)

Mark size: 160nm, Period: 320nm

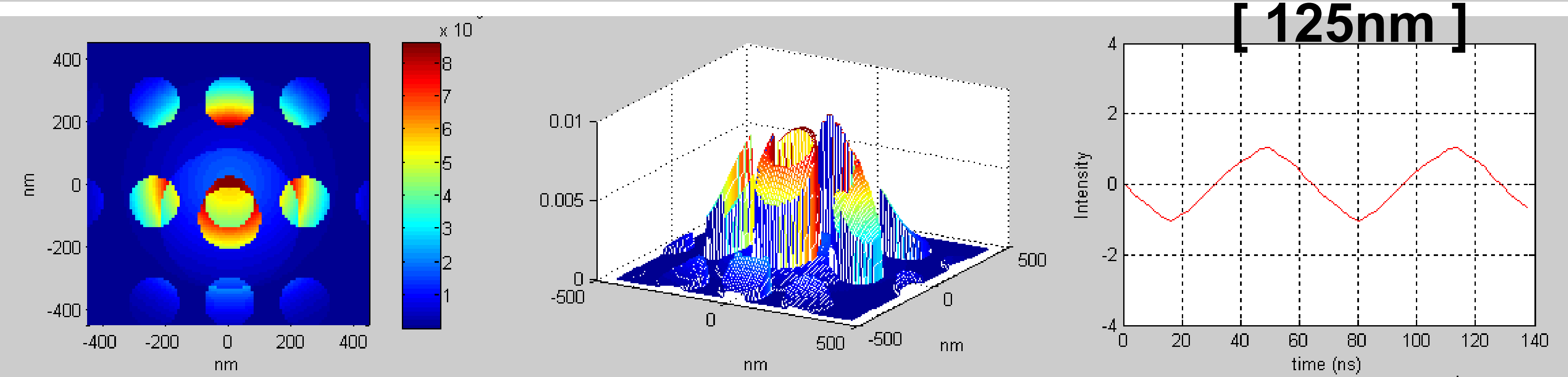
Top dielectric thickness [184nm]

Wall thickness

[25nm]



[125nm]



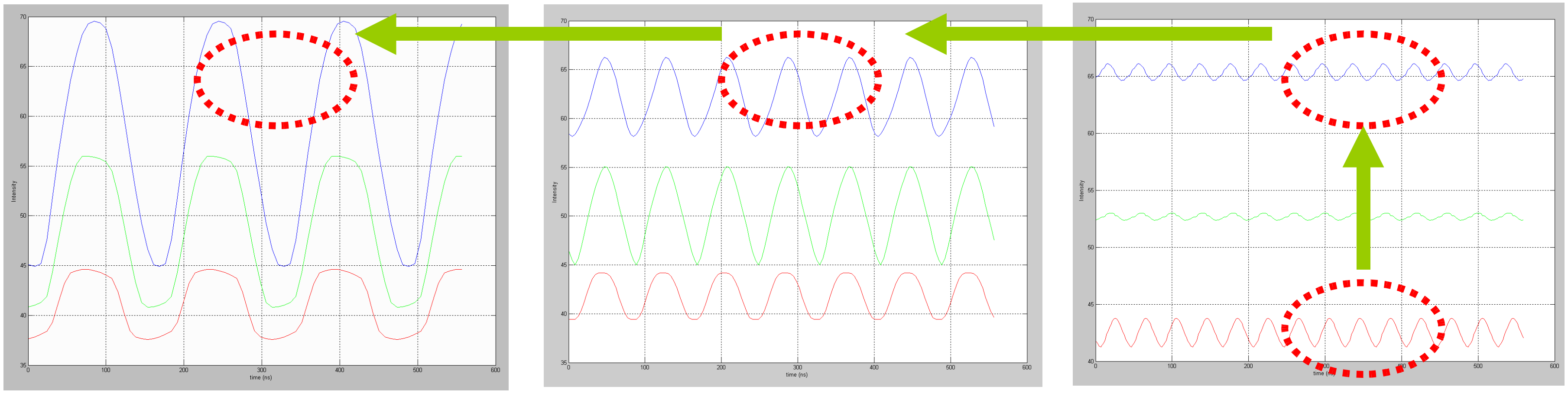
Wall effect can be controlled by structure optimization !

200GB/SL, OK?

Aperture size vs. pit size

> ➢ **Motive: appropriate aperture for each pit size ?**

Mark Size: 400nm **Mark Size: 200nm** **Mark Size: 100nm**



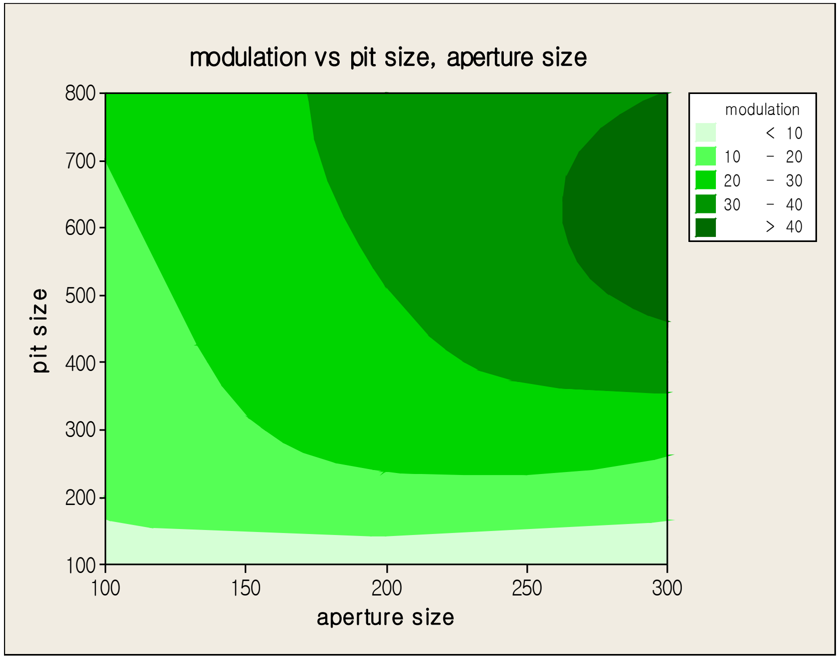
Aperture size:

Red: 100nm
Green: 200nm
Blue: 300nm

Aperture Wall Size: 25nm

- When aperture size > 300nm, OK!
- 100nm(37.5nm-equiv.), OK!

200GB/SL OK?



When 2T = 100 nm and 8T = 400 nm,

$$\frac{I_2}{I_8} = \begin{cases} 23.1\%, @100nm\ aperture\_size \\ 6.45\% @200nm\ aperture\_size \\ \boxed{8.33\% @300nm\ aperture\_size} \end{cases}$$

cf) > 4% for BD specification

1. **For large marks, Modulation maximum is @ Aperture_size ~ FWHM /2,**
2. **For small marks, Modulation maximum is @ Aperture_size ~ mark_size, the difference is small, though.**
3. **Even though the wall width reaches about 125nm, modulation can be feasible.**

Inter-track X-talk

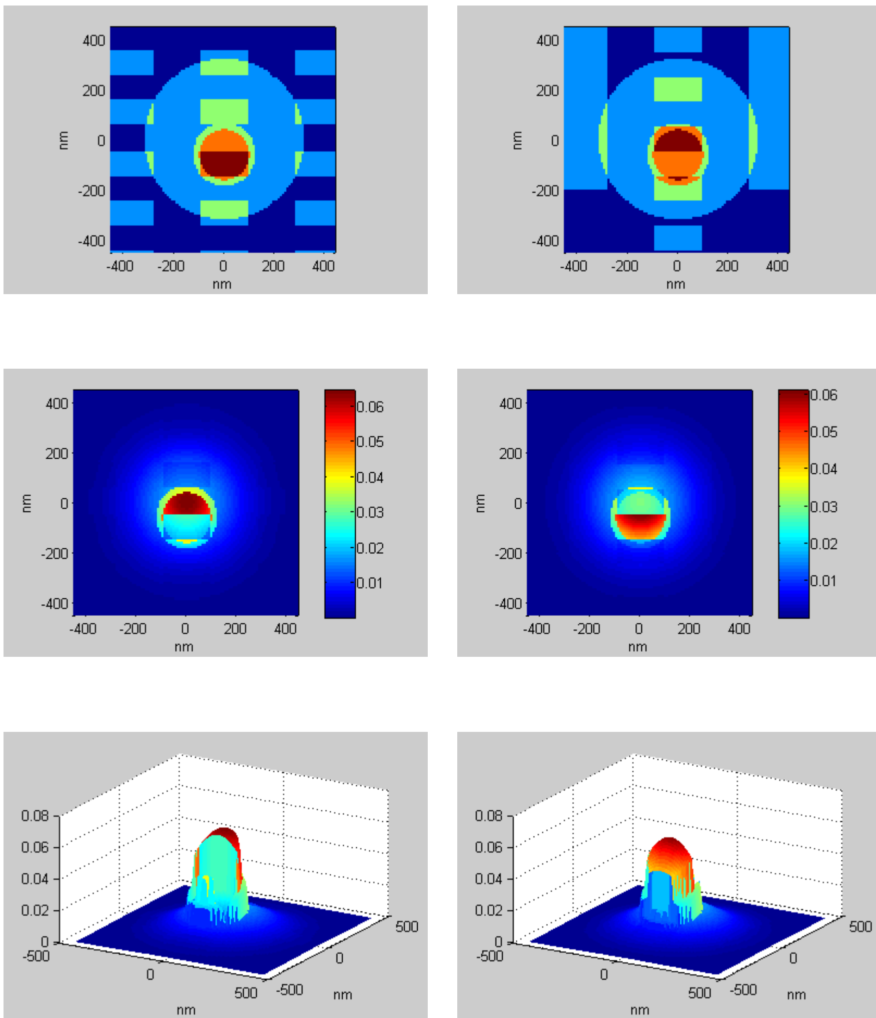
Mark Size: [100nm(Red), 100nm+800nm(Green)]

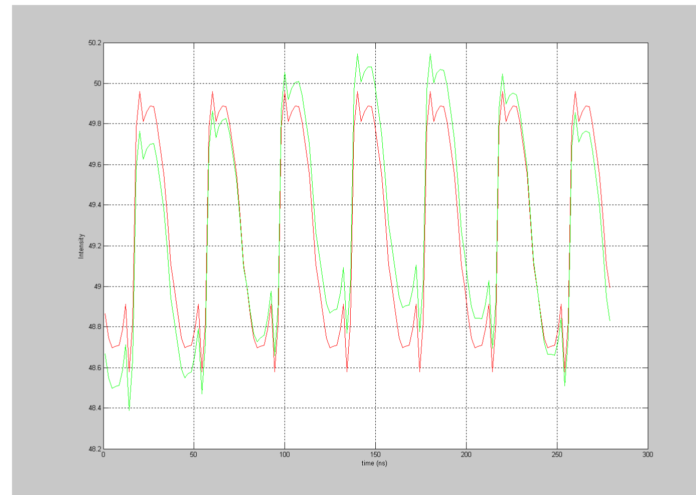
Aperture size: 200nm

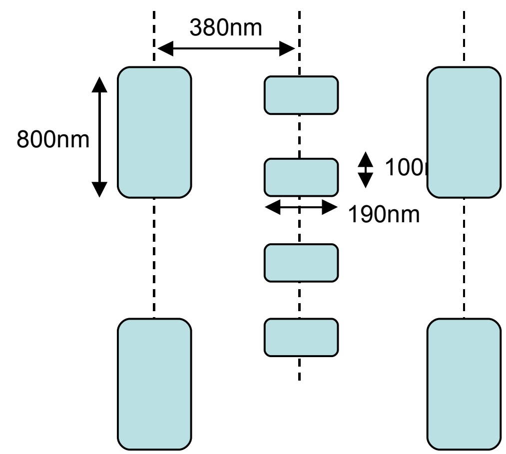
Geometry

Aperture

Readout







For R, x-talk can be controlled by pit_width

Summary and Discussion

1. Complete masking (aperture quality)? **OK!!**
2. Enough resolving power for the marks of 37.5nm length for 500GB capacity? **OK!!**

❖ Future works

1. Apply vector diffraction theory
2. Experimental proof