Die-Database Defect Inspection of Sub-30nm HP Pattern by a DUV Mask Inspection System

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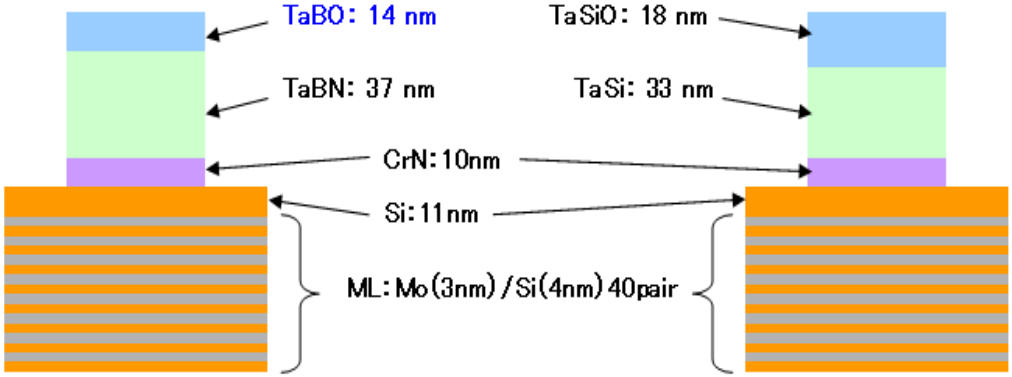
Motivation

- Development of pattern inspection tool is expected to realize EUV lithography. So far, the possibility of DUV (199nm) inspection tool for Sub-hp30nm Die-Die (DD) inspection was confirmed by NPI-7000α with image contrast enhancement technique.

- Die-Database (D-DB) inspection has difficulty as follows;
  Low image contrast,
  Image contrast reversal phenomena,
  And these are changed dramatically by pattern size, pitch, shape, absorber reflection rate and so on.

- Realizability of sub-hp30nm D-DB are obtained for 2 kinds of mask (R4, R19) with different polarized illumination method.



R19: absorber reflectivity 19% R4

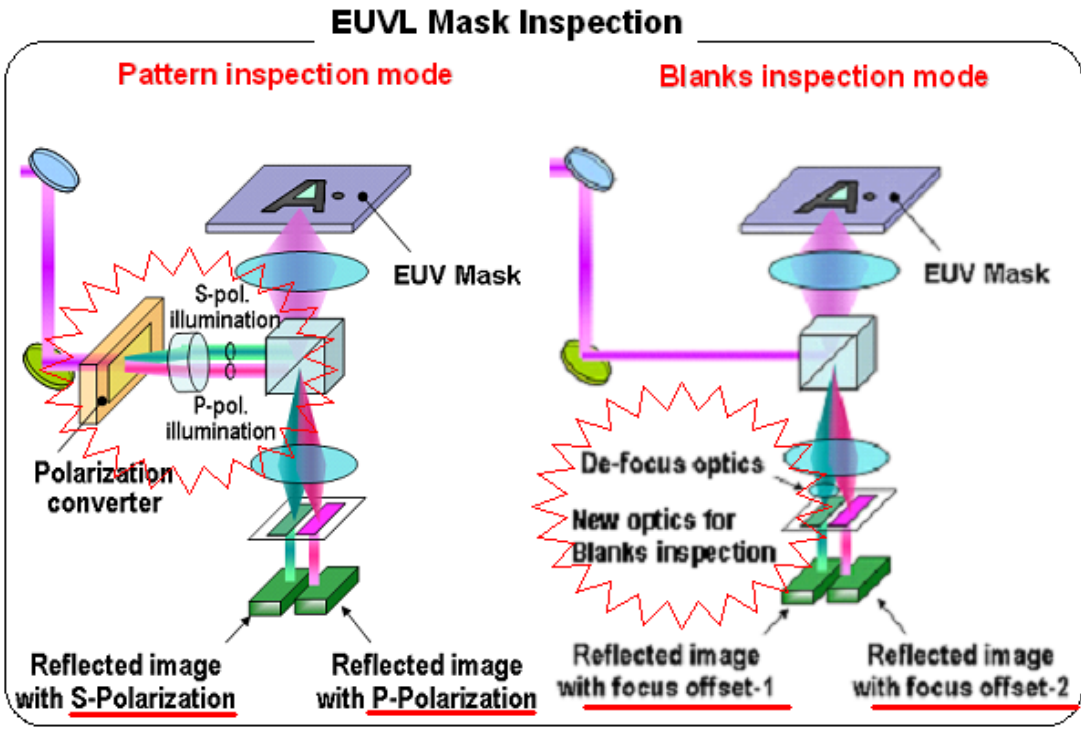
NPI-7000EUVα Overview

Targets;

- EUVL mask pattern inspection for sub-hp30nm
- EUVL mask blanks inspection (TBD)

Feature;

- 199nm pulsed laser source
- High resolution image scanner with newly developed TDI
- Two types of concurrent-
  EUV mask inspection mode

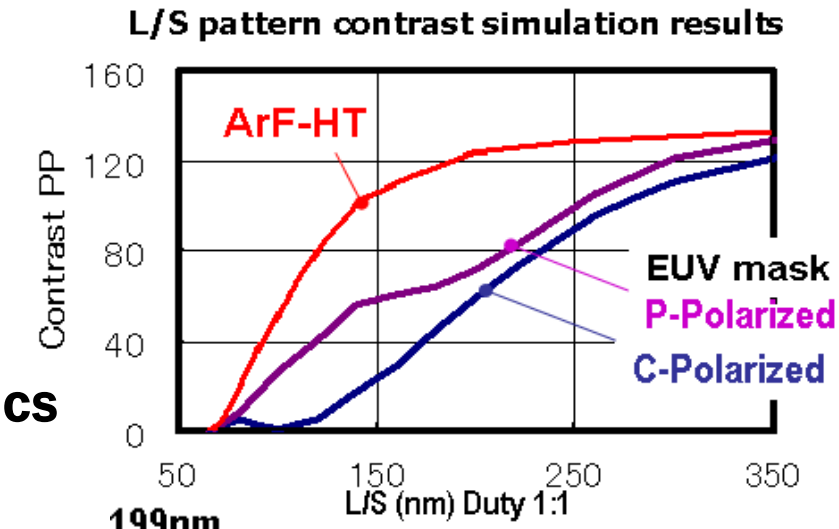


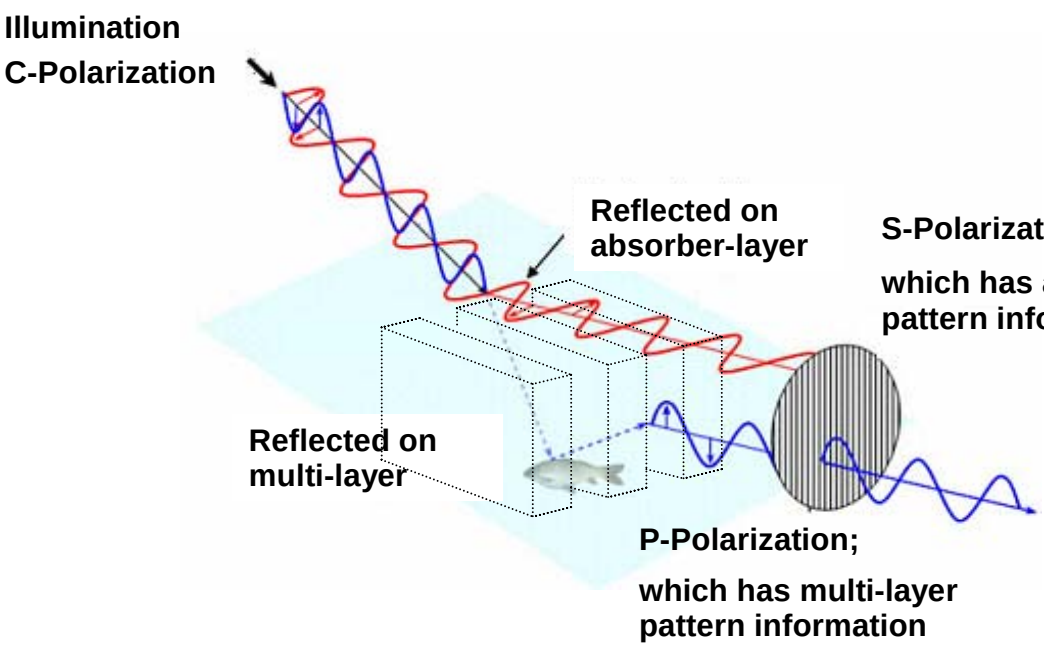
Pattern inspection technologies for sub-hp30nm

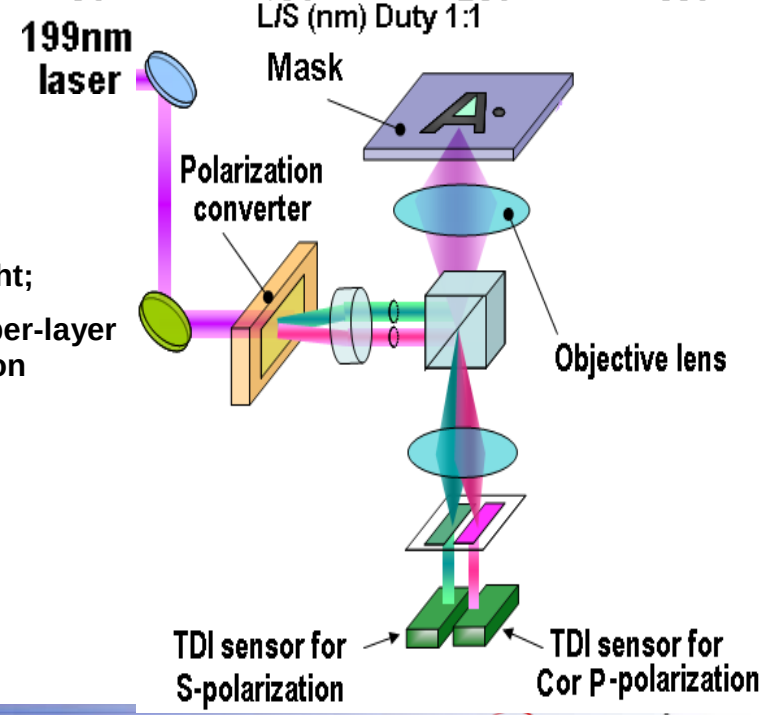
Technological difficulties are;

- **-Only reflected light images are available.**
- **-Difficult to get sufficient image contrast.**

Installation of P and S polarization optics is effective for sub-hp30nmTN.

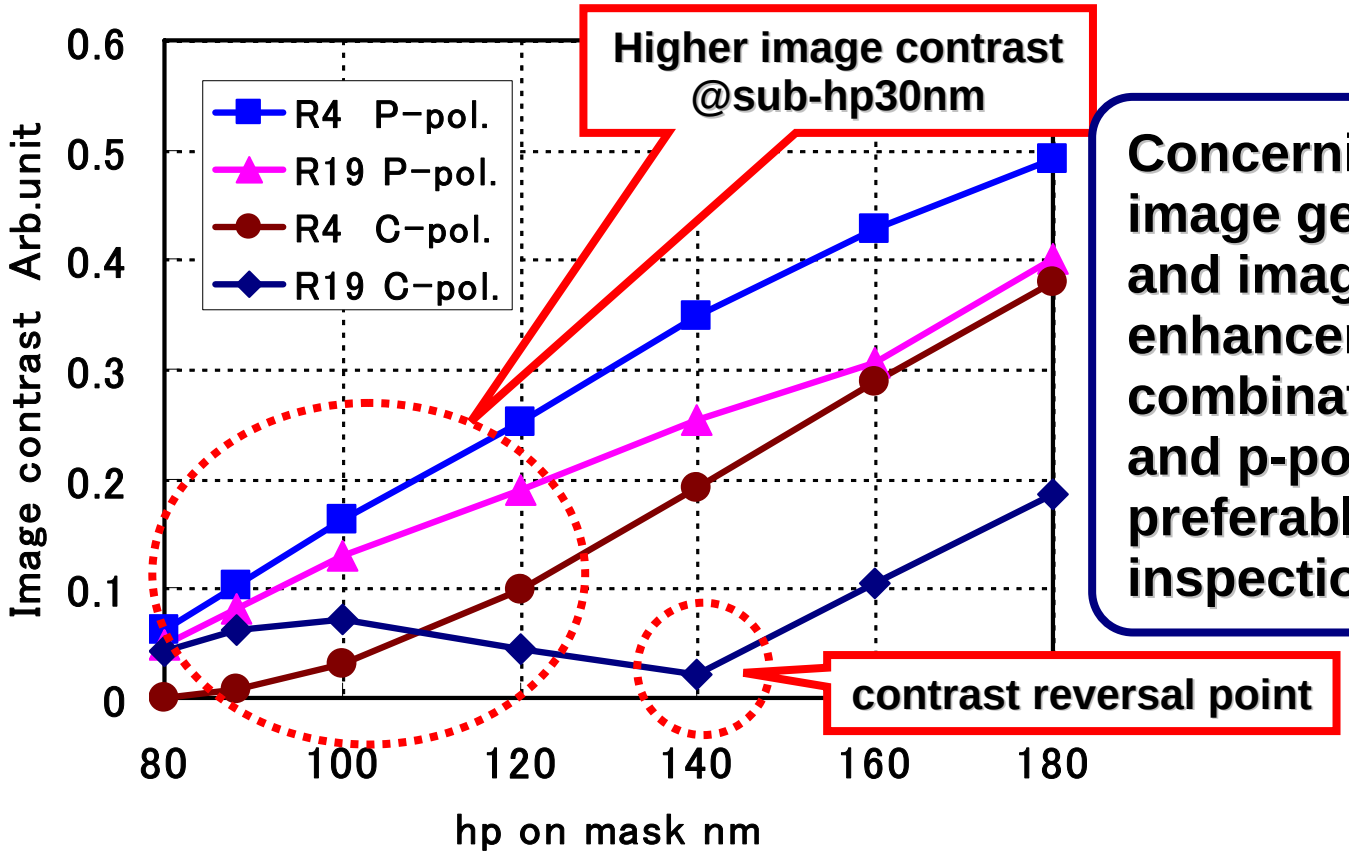






Preferable mask structure

Effectiveness of absorber reflectivity and illumination type



Concerning D-DB reference image generation difficulty and image contrast enhancement, the combination of R4 mask and p-pol. illumination is preferable for sub-hp30nm inspection.

There is a possibility to realize D-DB inspection for under 22nmTN.

Comparison between Inspection Modes (R19)

RI-P08

experimental results

Base Pattern	Defect Type	Inspection Mode	DEfect Size(nm)															
			80	75	70	65	60	55	50	45	40	35	30	25	20	15	10	5
32nm TN	Edge Extrusion	D-D(C)																
		D-D(P)																
		D-DB(C)																
		D-DB(P)																
	Edge Intrusion	D-D(C)																
		D-D(P)																
		D-DB(C)																
		D-DB(P)																
27nm TN	Edge Extrusion	D-D(C)																
		D-D(P)																
		D-DB(C)																
		D-DB(P)																
	Edge Intrusion	D-D(C)																
		D-D(P)																
		D-DB(C)																
		D-DB(P)																
22nm TN	Edge Extrusion	D-D(C)																
		D-D(P)																
		D-DB(C)																
		D-DB(P)																
	Edge Intrusion	D-D(C)																
		D-D(P)																
		D-DB(C)																
		D-DB(P)																

defect unformed

R19 Mask, with buffer

C and P have weak defect type respectivily.

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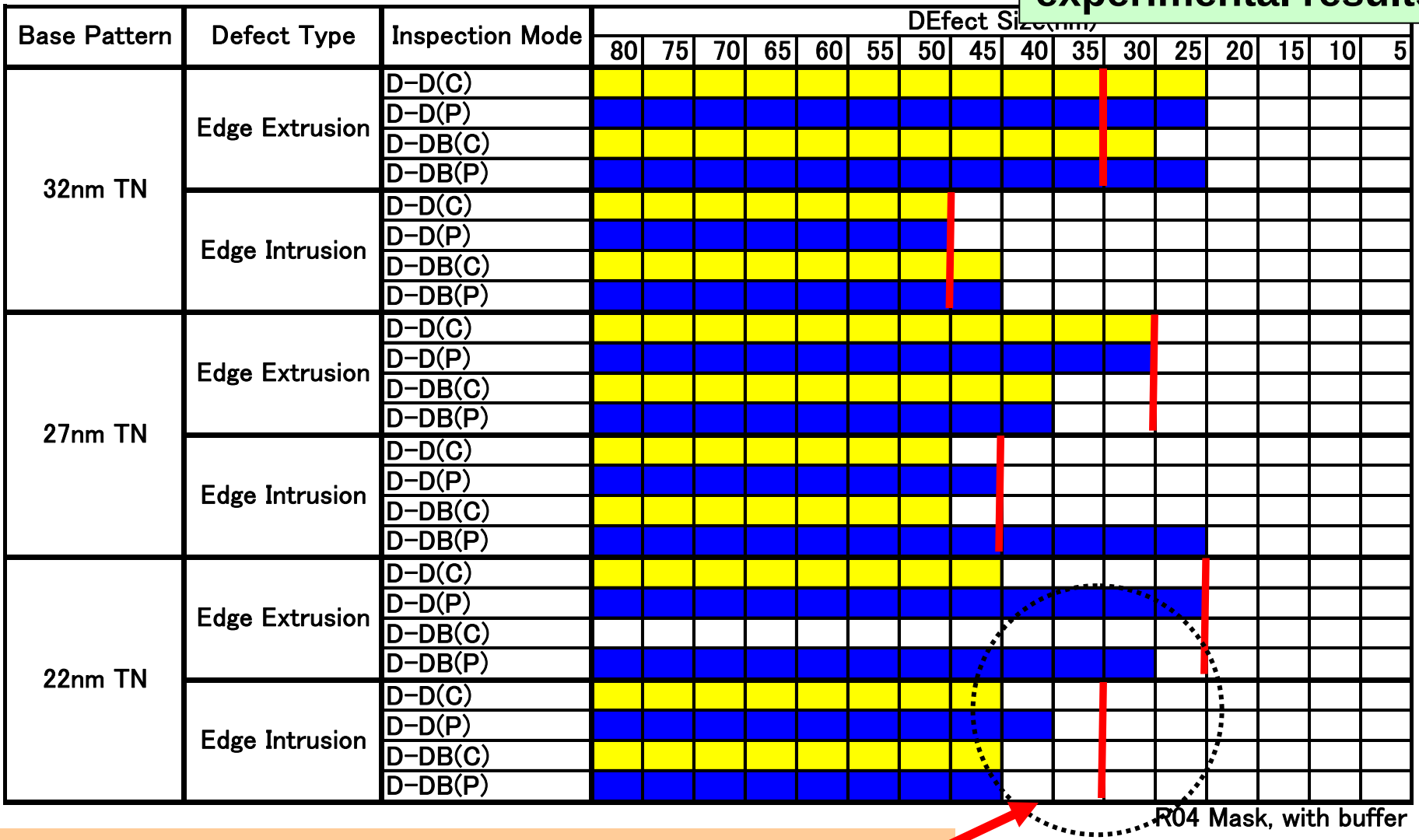
Comparison between Inspection Modes (R4)

RI-P08

experimental results



Achievable goal using digitizing rate change of imaging sensor and new image generator

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Comparison between R4 and R19

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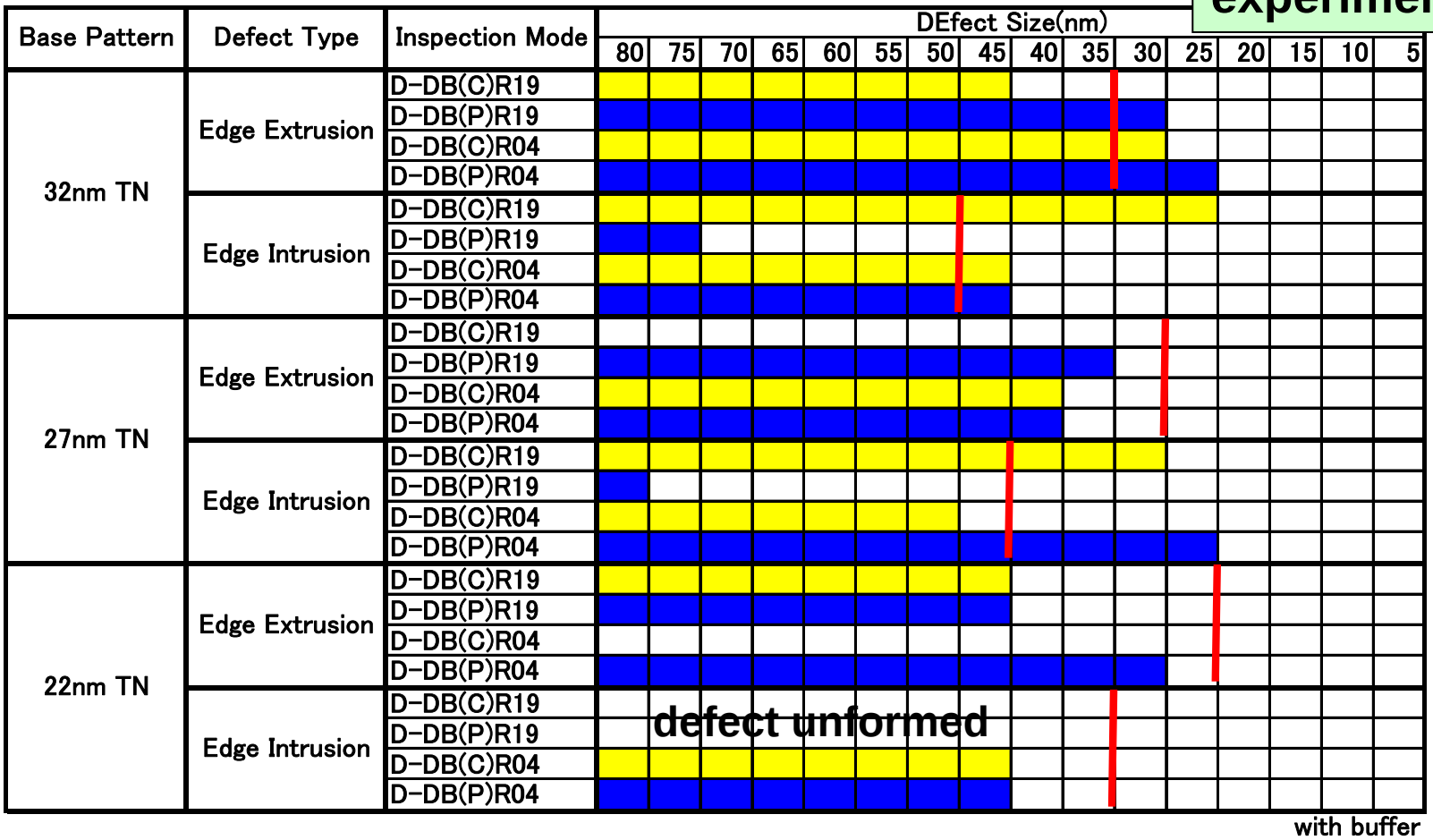
experimental results



	R19						R04					
	DD			DB			DD			DB		
	C	P	PS	C	P	PS	C	P	PS	C	P	PS
32	○	○	○	×	○	○	○	○	○	○	○	○
27	×	○	○	×	△	△	○	○	○	×	○	○
22	×	○	○	×	×	×	×	△	△	×	△	△

R4 is more suitable than R19 for DB inspection.

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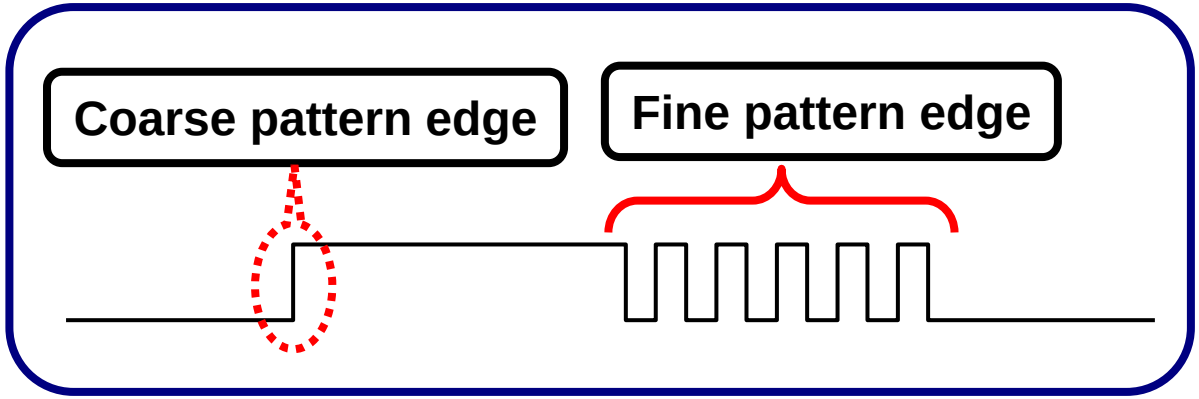
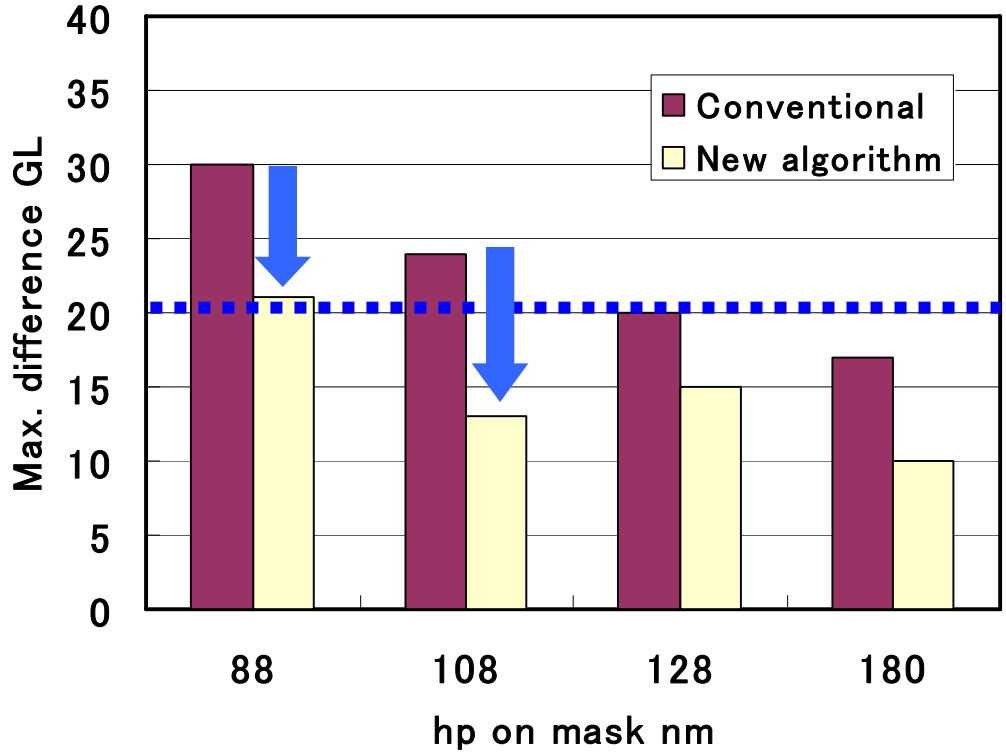
New reference image generator concept



New reference image generator concerns the 3D effect difference between coarse and fine pattern.



<20GL difference is achieved with new algorithm for D-DB inspection requirement.

New reference image generator result

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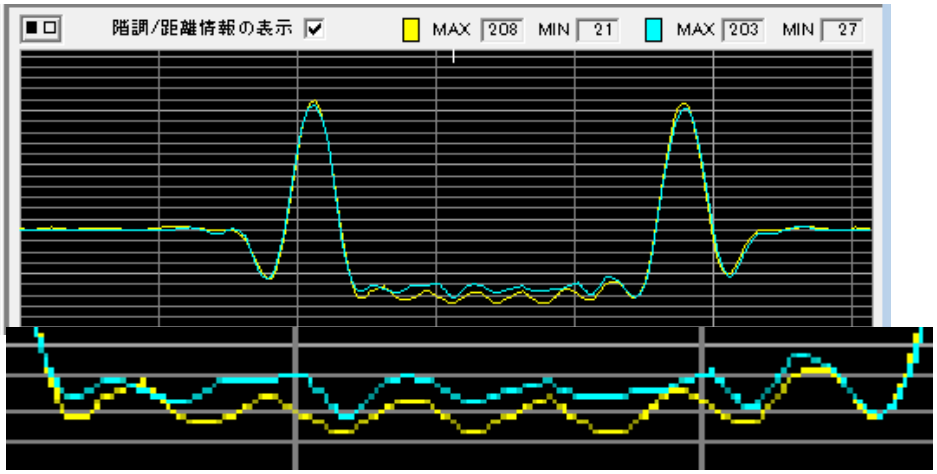
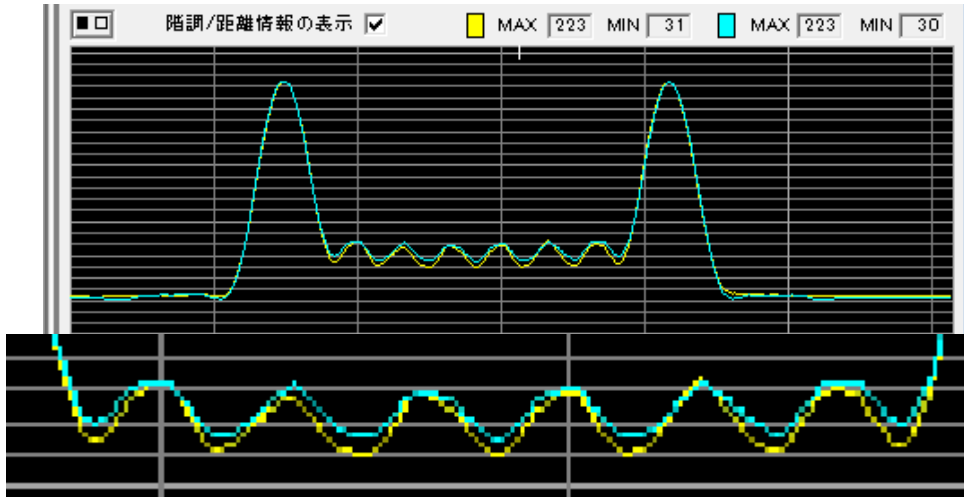
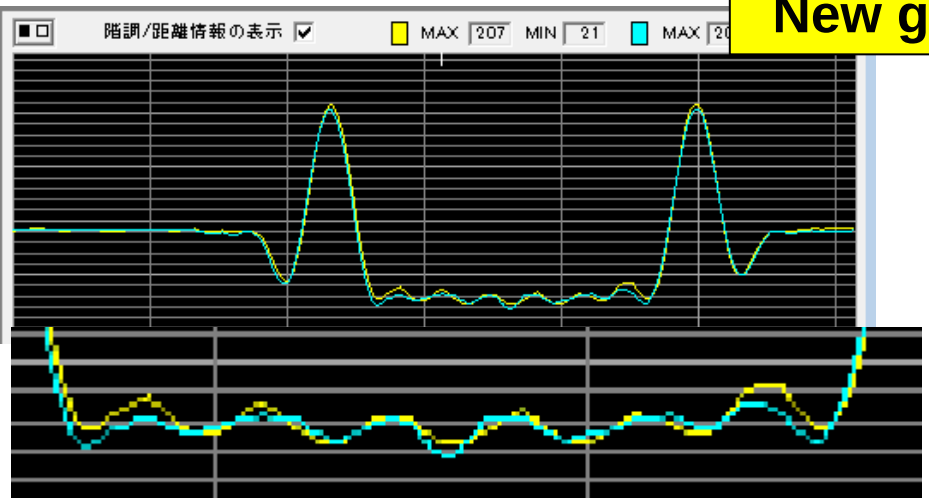
21nm L/S

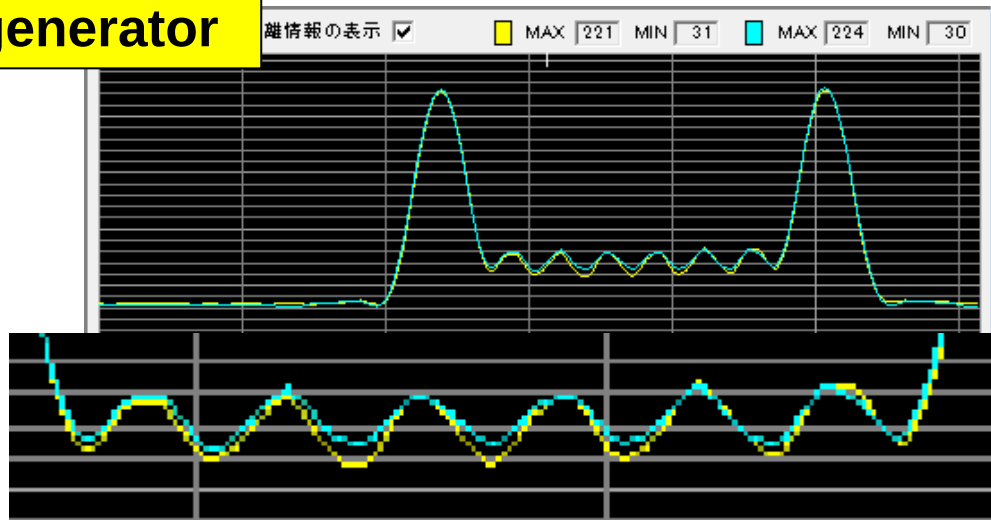
Conventional generator





New generator





R19 P

R04 P

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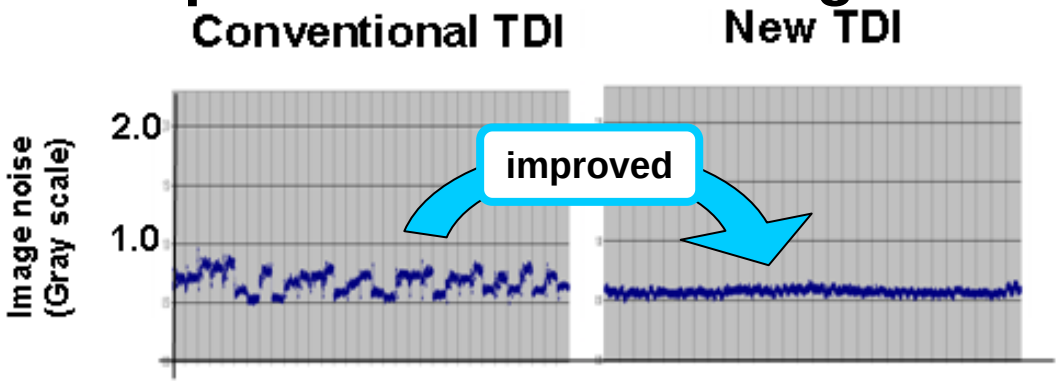
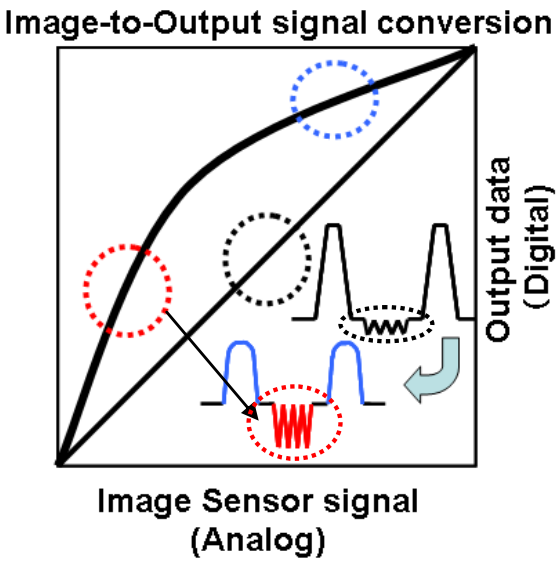
Image contrast enhancement technique

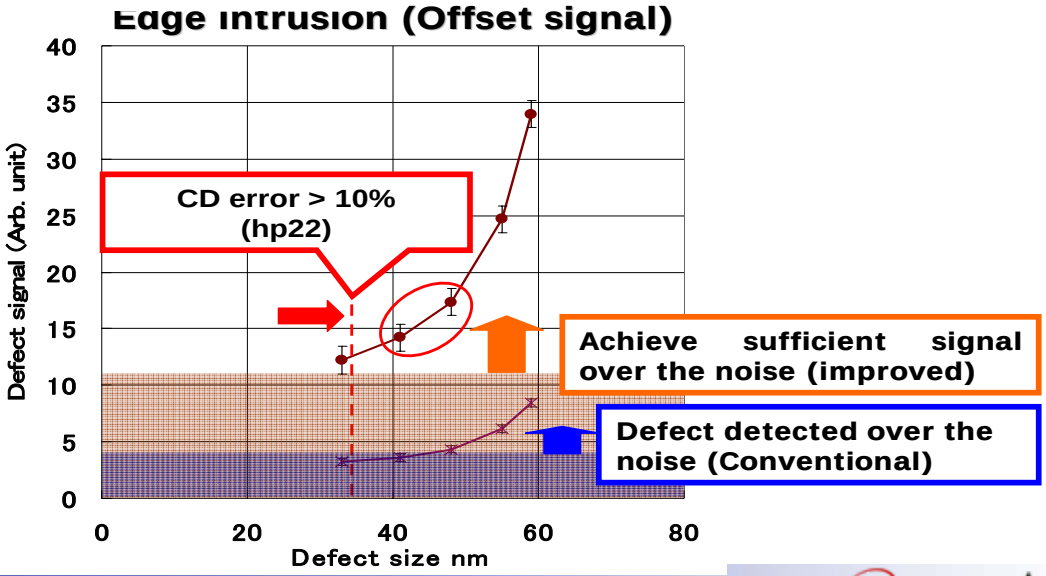
1. Low noise New TDI sensor installation.
2. Digitizing rate change of imaging sensor in correspondence with the signal level.



New TDI noise evaluation

Low noise sensor and signal enhancement function are installed for D-DB inspection sensitivity improvement.





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Influence of absorber reflectivity simulation

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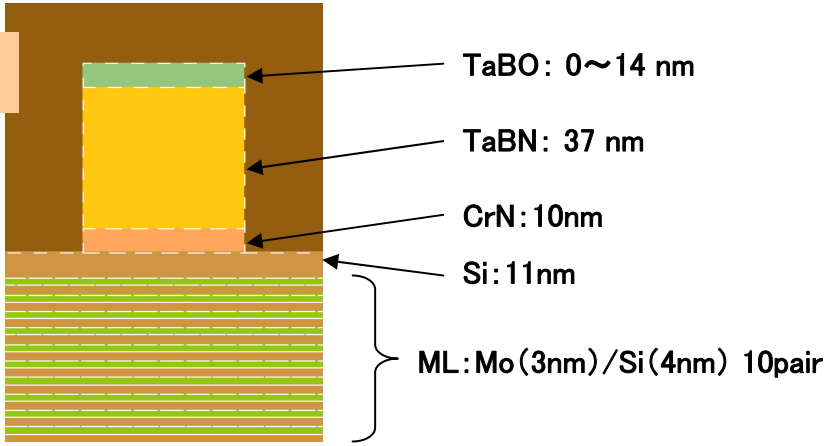
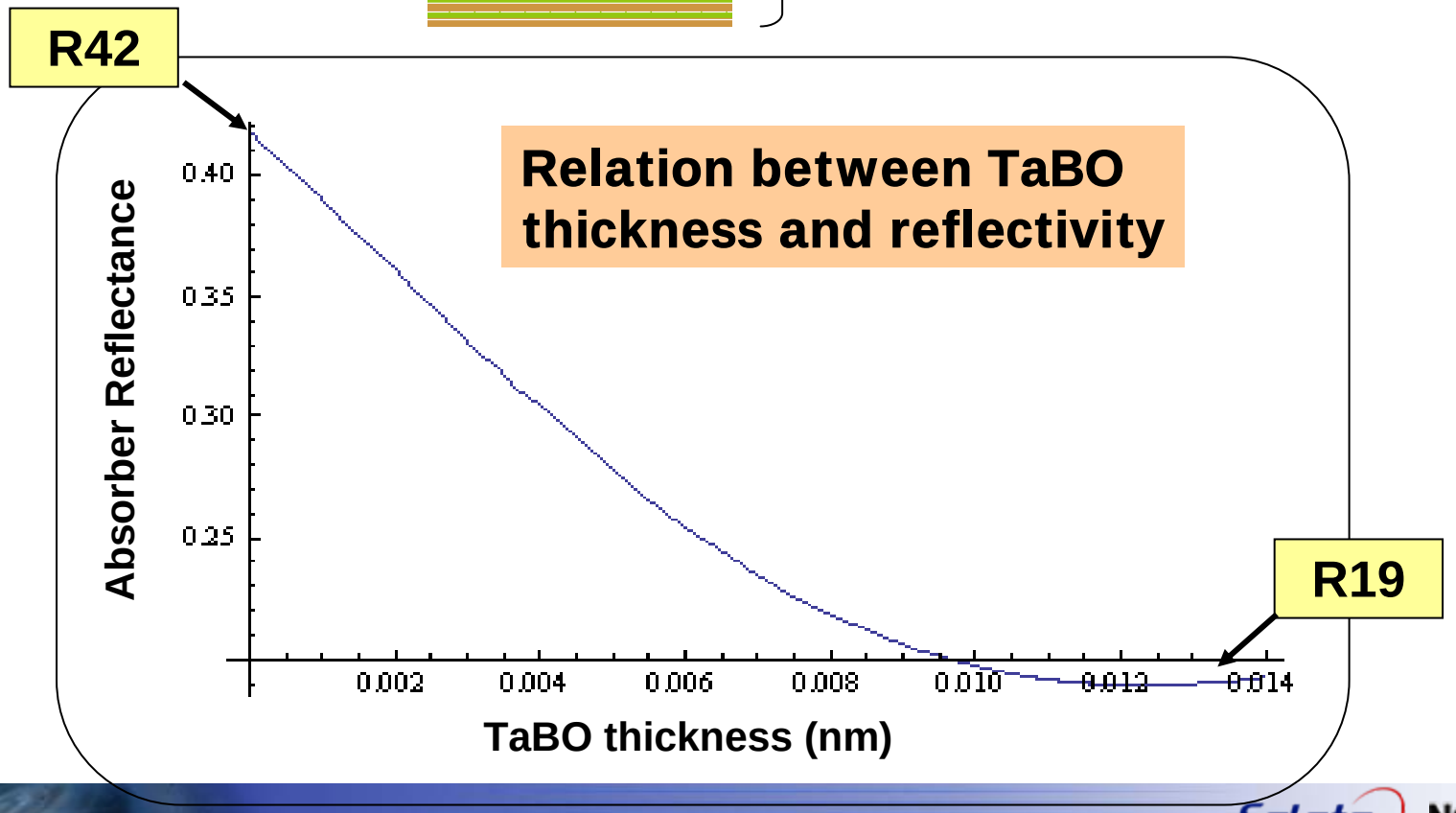
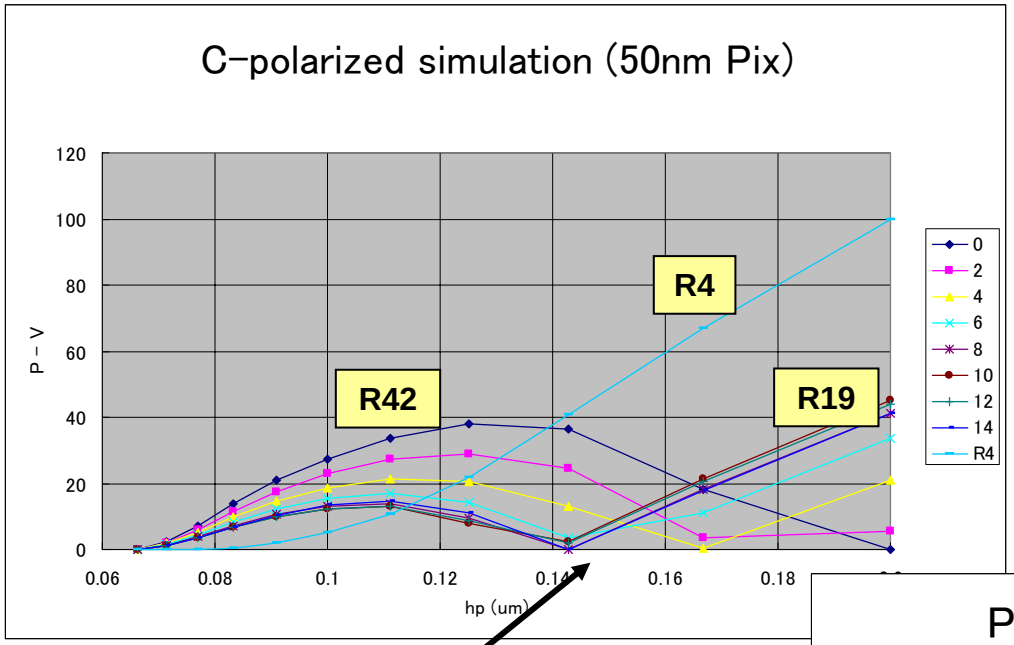
Simulation model





Simulation results （C&P-polarized）

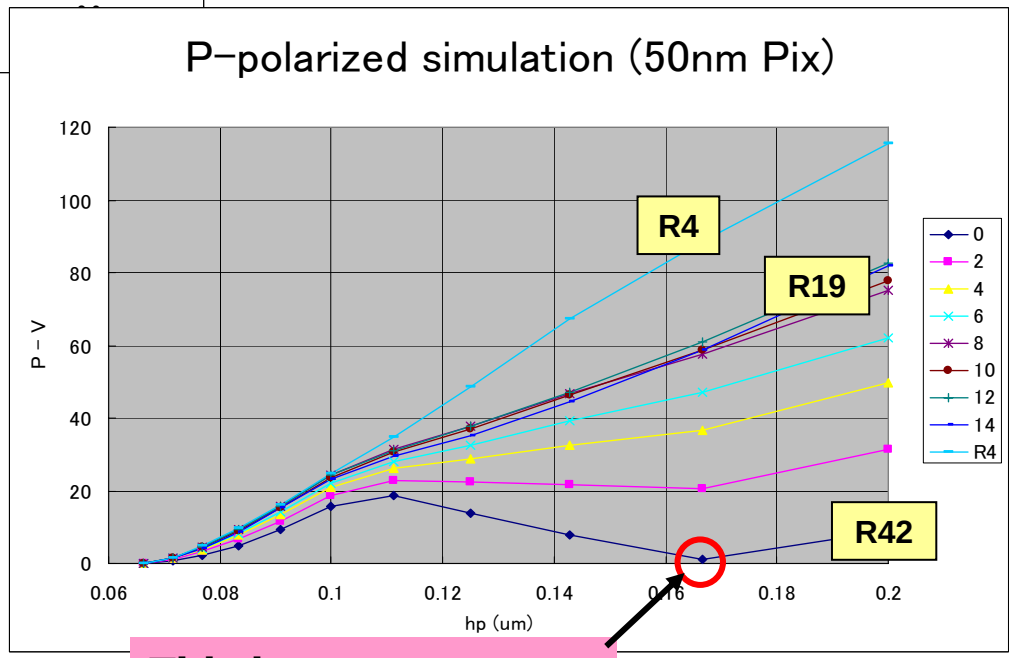


	R4	R19	R42
C	N/R	R	R
P	N/R	N/R	N/R

N/R:Not reverse B/W phase

R: reverse B/W phase

Around the contrast reversal point, contrast and inspect sensitivity go down.



This is not contrast reversal point.

Gray level（R42 & R19）C-polarized

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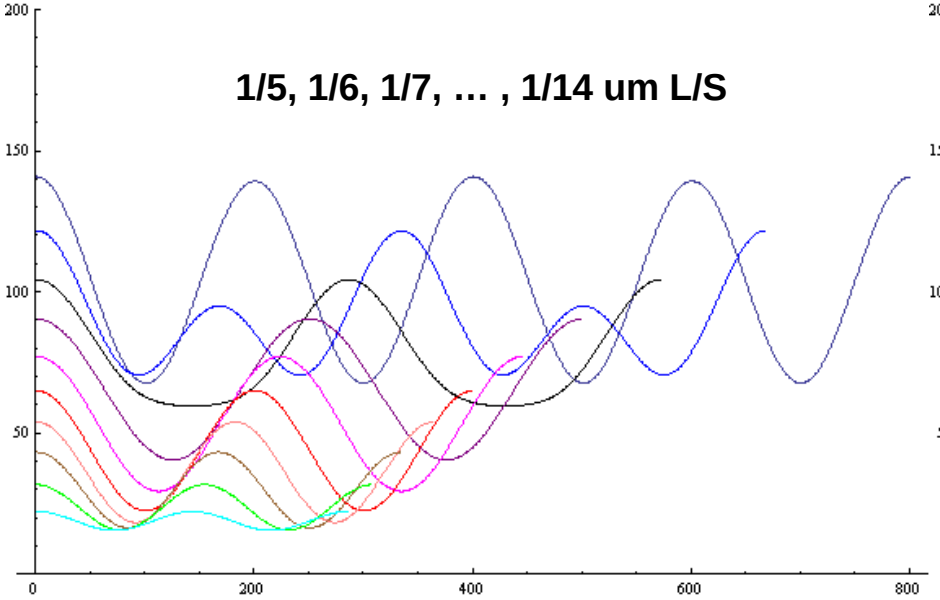
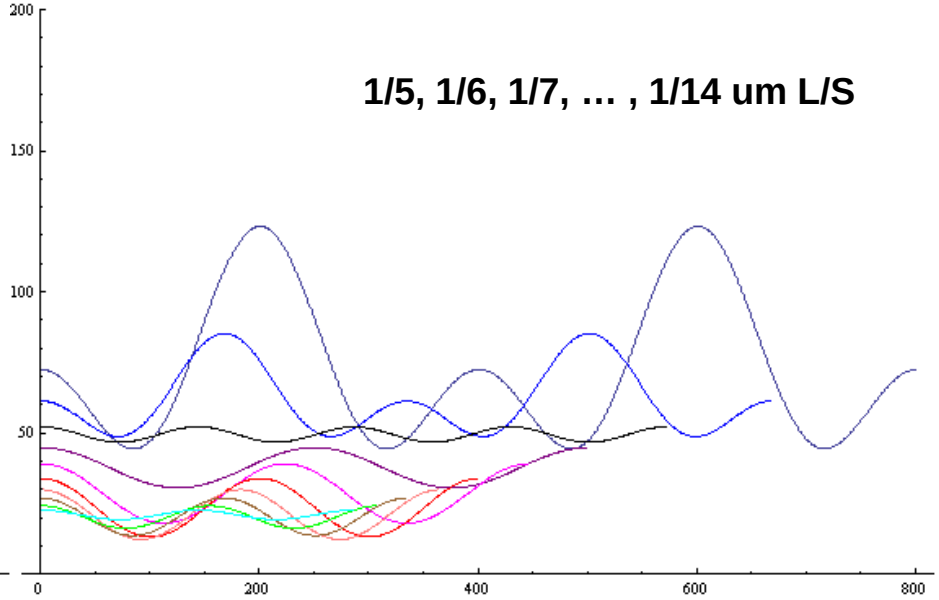


Reflectivity 42％



Reflectivity 19％

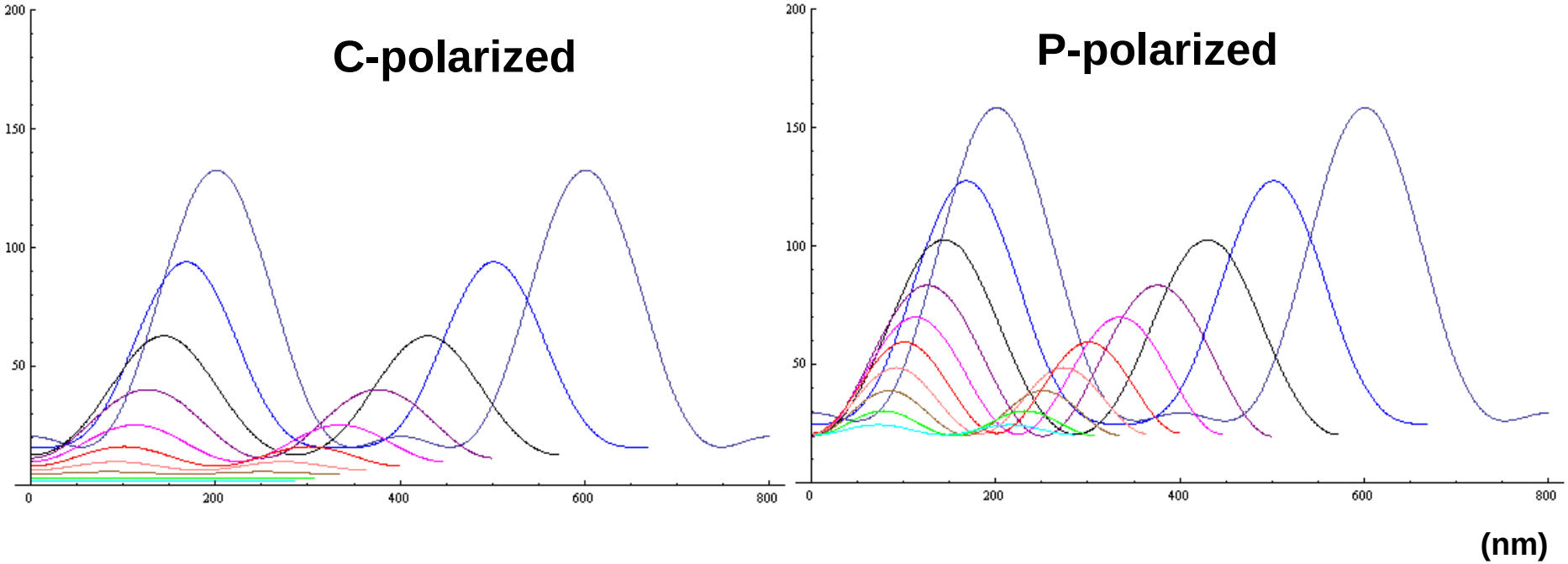
(nm)

In R42, contrast reversal appears from 1/5um(50x4nm) L/S.

In R19, contrast reversal appears from 1/8um(31.25x4nm) L/S.

Gray level（R4）C&P-polarized

RI-P08



In R04, contrast reversal does not appear both C&P-polarized.

Conclusion

D-DB inspection of sub-HP30nm pattern using C-polarized and P-polarized illumination was executed, and the domination of P- polarized light and R4 was confirmed.

- A new reference image generation algorithm was proven to be effective for hp30nm or less.
- It was shown by the simulation result that

1) For TaBO absorber type mask, If the contrast reversal is allowed, R42（TaBO thickness 0nm） with C-polarized illumination gives the best result near 22.5nm L/S. If the contrast reversal is not allowed, R19 with P-polarized illumination gives the best result.

2) For R4 type mask with P-polarized illumination, its resolution surpasses that for R19 and is almost identical to C-polarized R42 for smaller L/S patterns.

3) R4 mask is suitable for DB inspection.

Future Works

1. NPI-7000, based on alpha tool technology, will be realized for 22nm TN EUV inspection technologies.
2. A study of a defect inspection to 20 nm or less.

Acknowledgements

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