TOSHIBA

TOPCON

Mask Inspection Technology for 65nm (hp) node and beyond

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3. Possibility of transmitted light and reflected light concurrent inspection logistics (TREFOIL)
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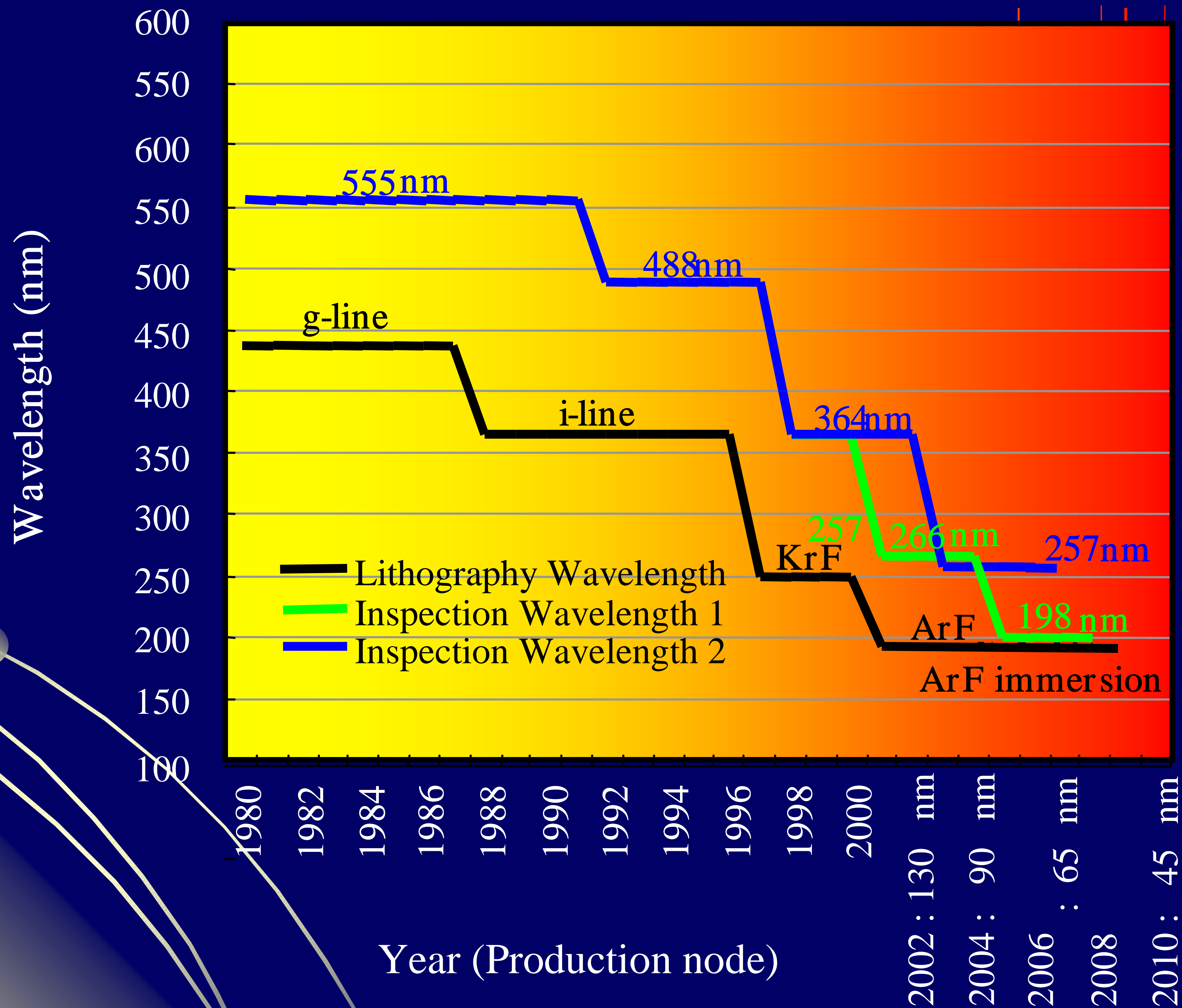
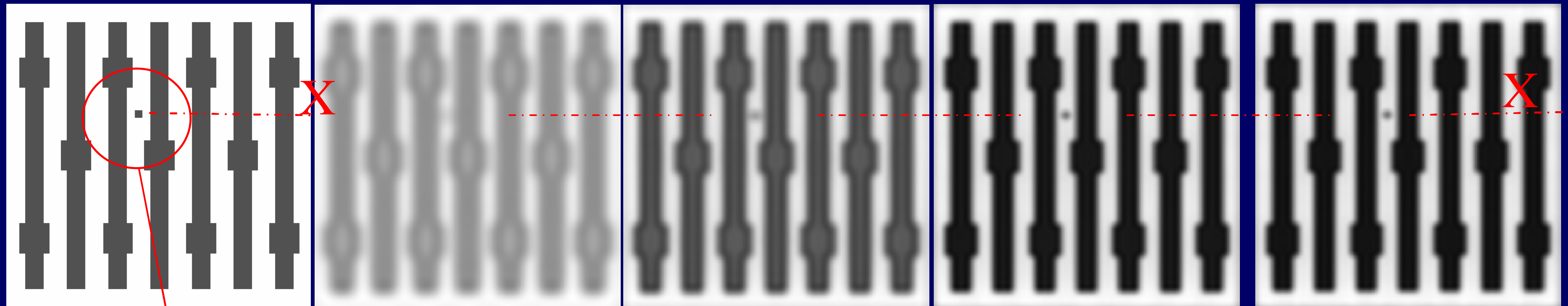
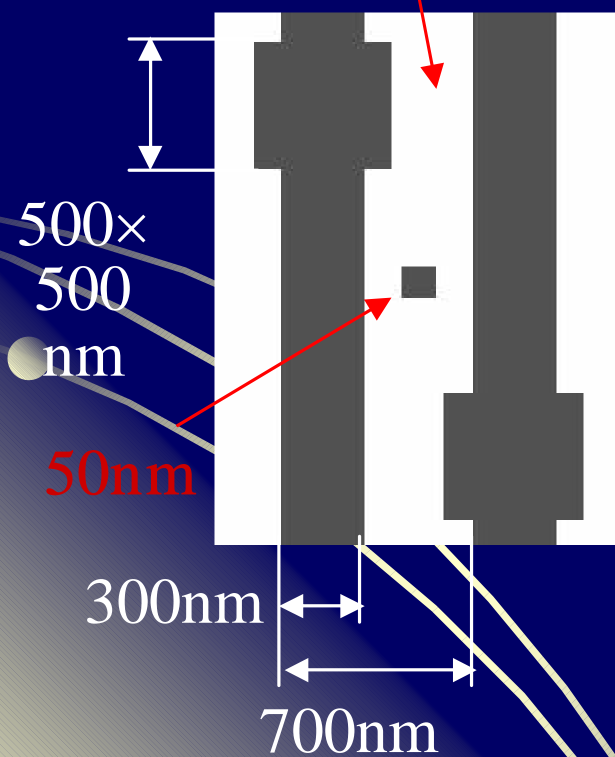
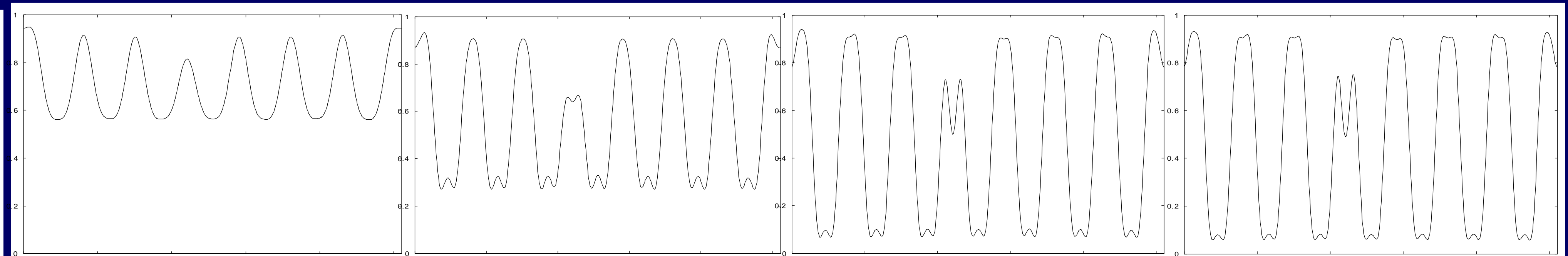
History of wavelength gap between inspection and lithography



Comparison of defect pattern fidelity for different inspection wavelength λ







T=54.6%	T= 29.0%	T= 7.5%	T= 6.1%
R=12.8%	R=16.6%	R= 21.3%	R=21.0%
RI(R)=2.300	RI(R)=2.373	RI(R)=2.483	RI(R)=2.300
RI(I)=0.190	RI(I)=0.299	RI(I)=0.553	RI(I)=0.190

6% ArF-HT PSM

Intensity profile at X-X cross section and parameters for simulations
T: transmittance, R: reflectance, RI: Refractive index (real part, imaginary part)
Inspection optics: NA=0.75, σ =1.0

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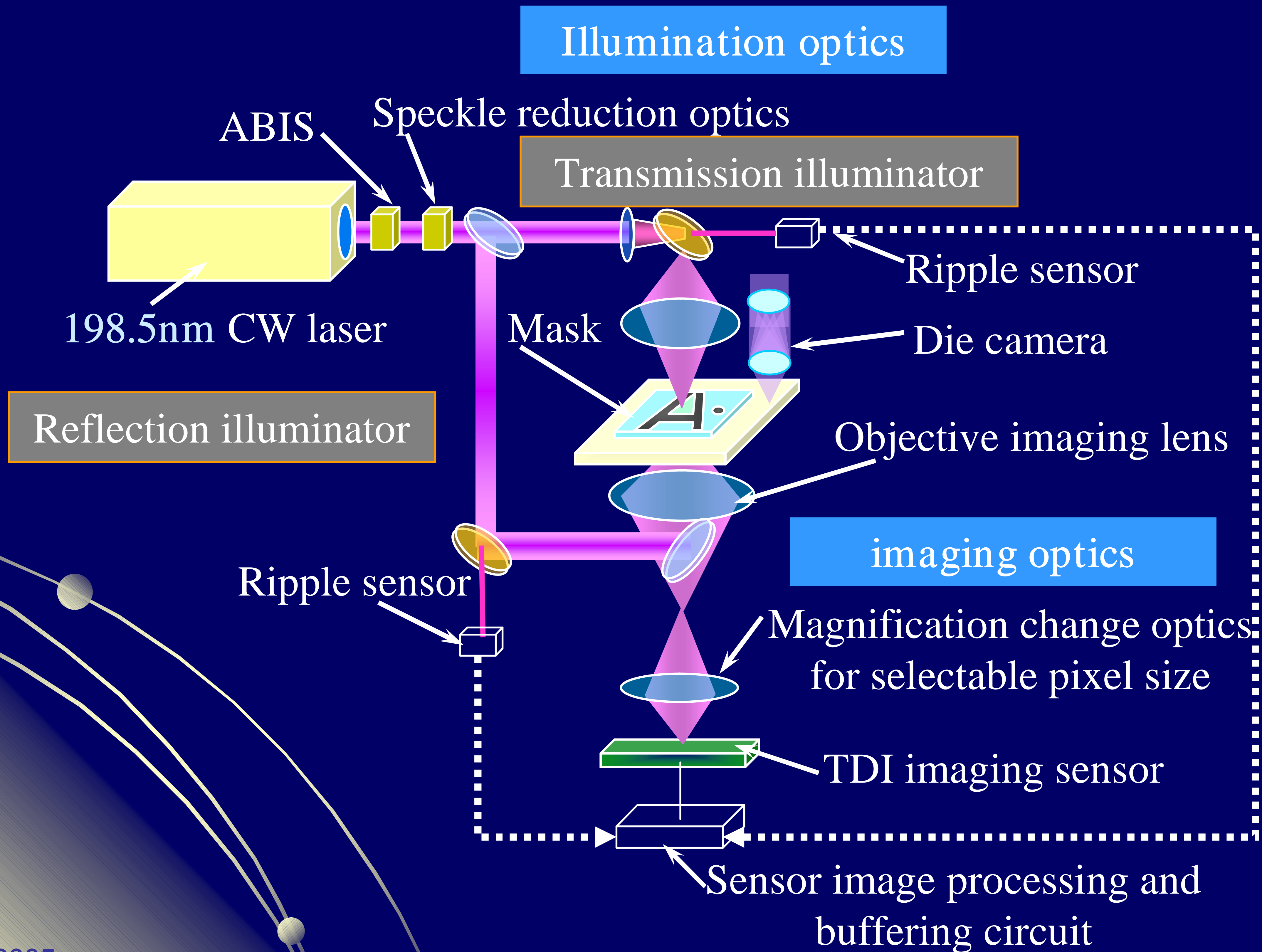
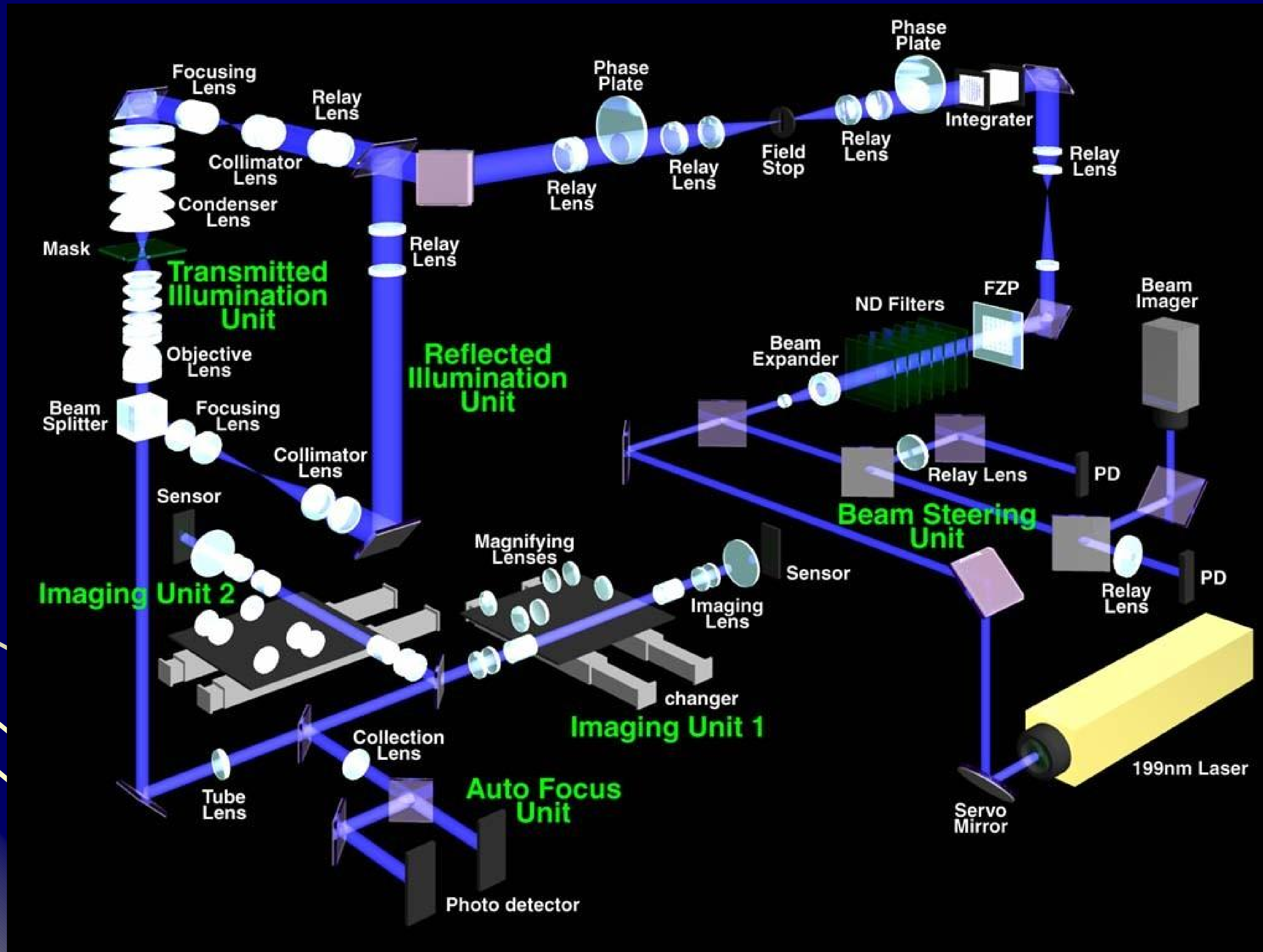
Overview of advanced mask inspection optical system (AMOS)

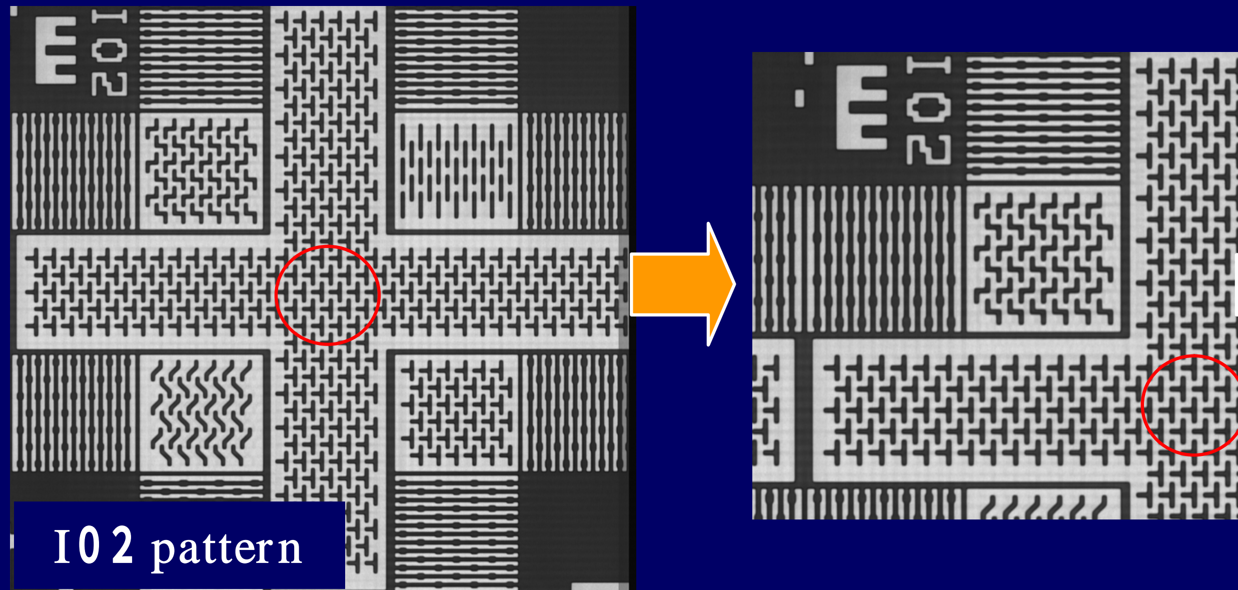
Optical block diagram of AMOS

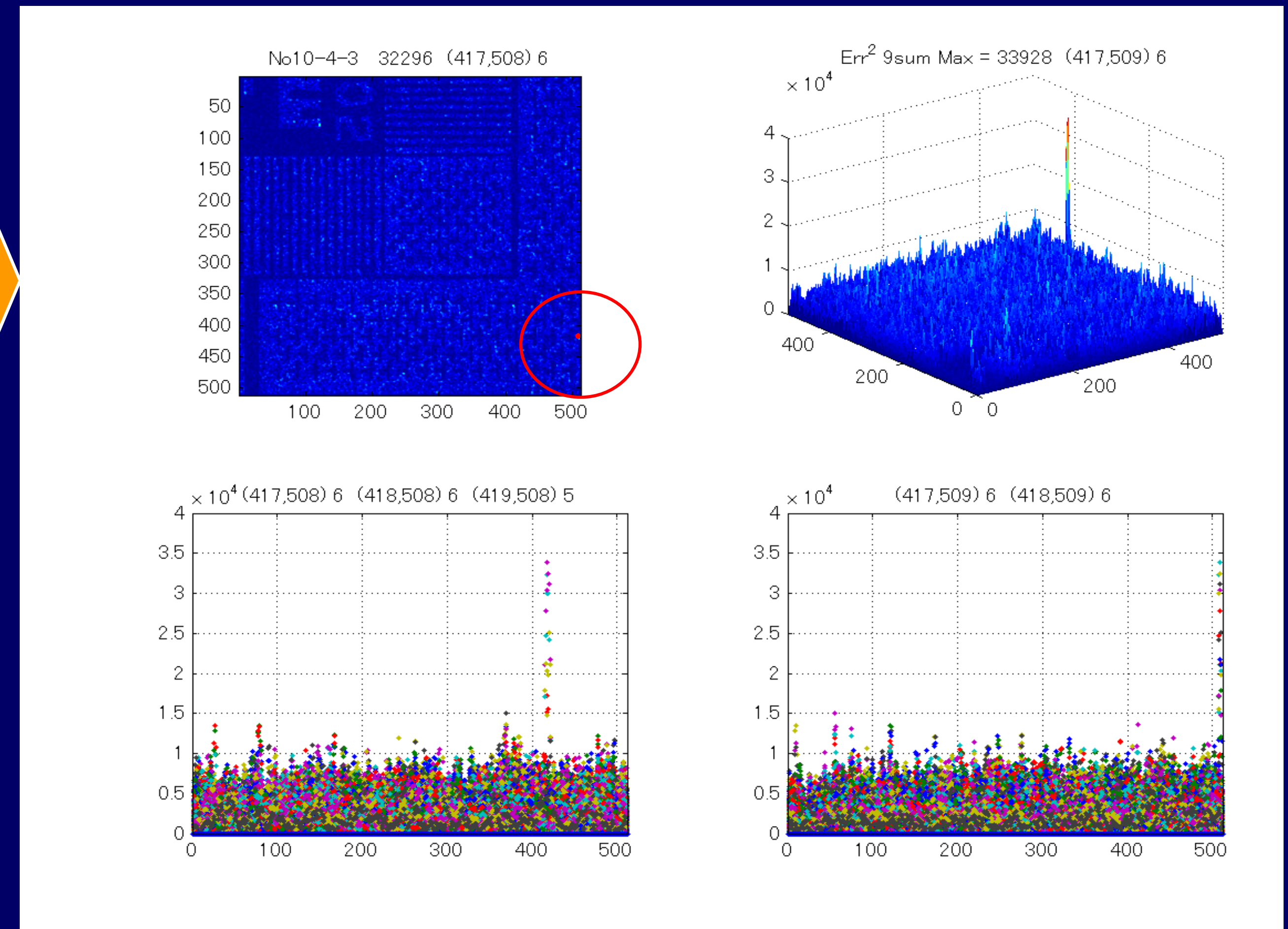


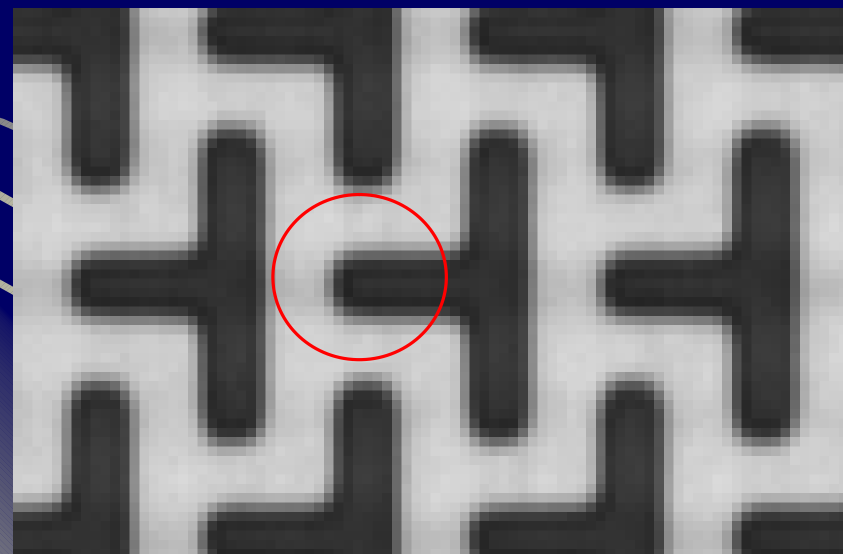
198.5nm wavelength mask inspection optics of AMOS



29nm length defect of detection by D-to-D inspection
15% ArF-HT PSM with 420nm wire, 70nm pixel, 400M pixel/s



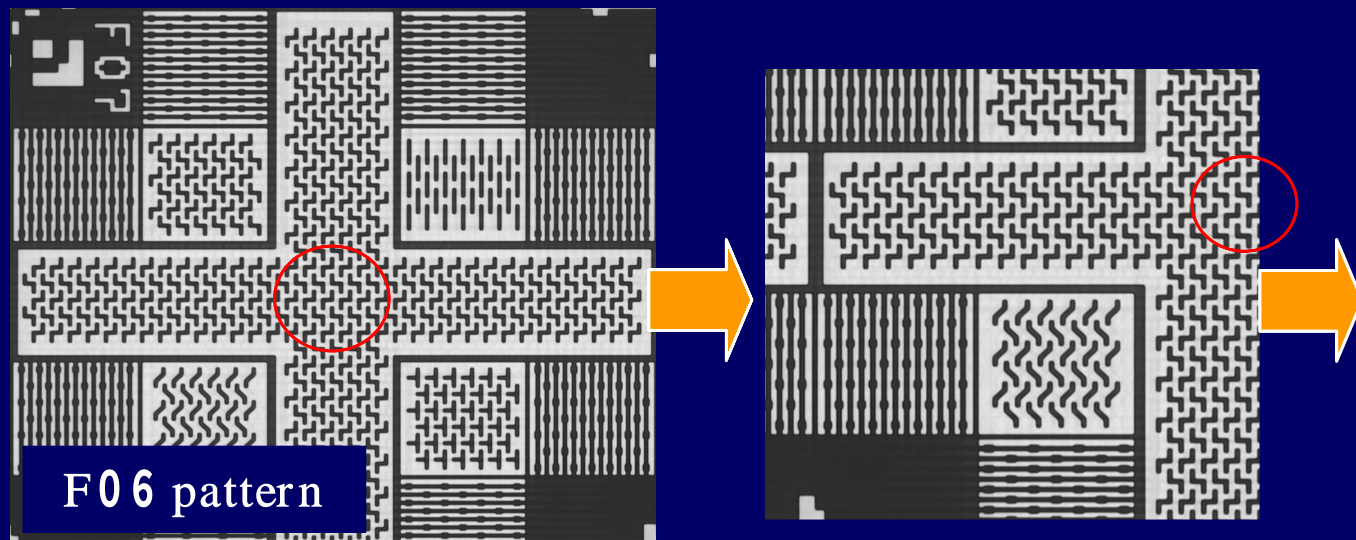


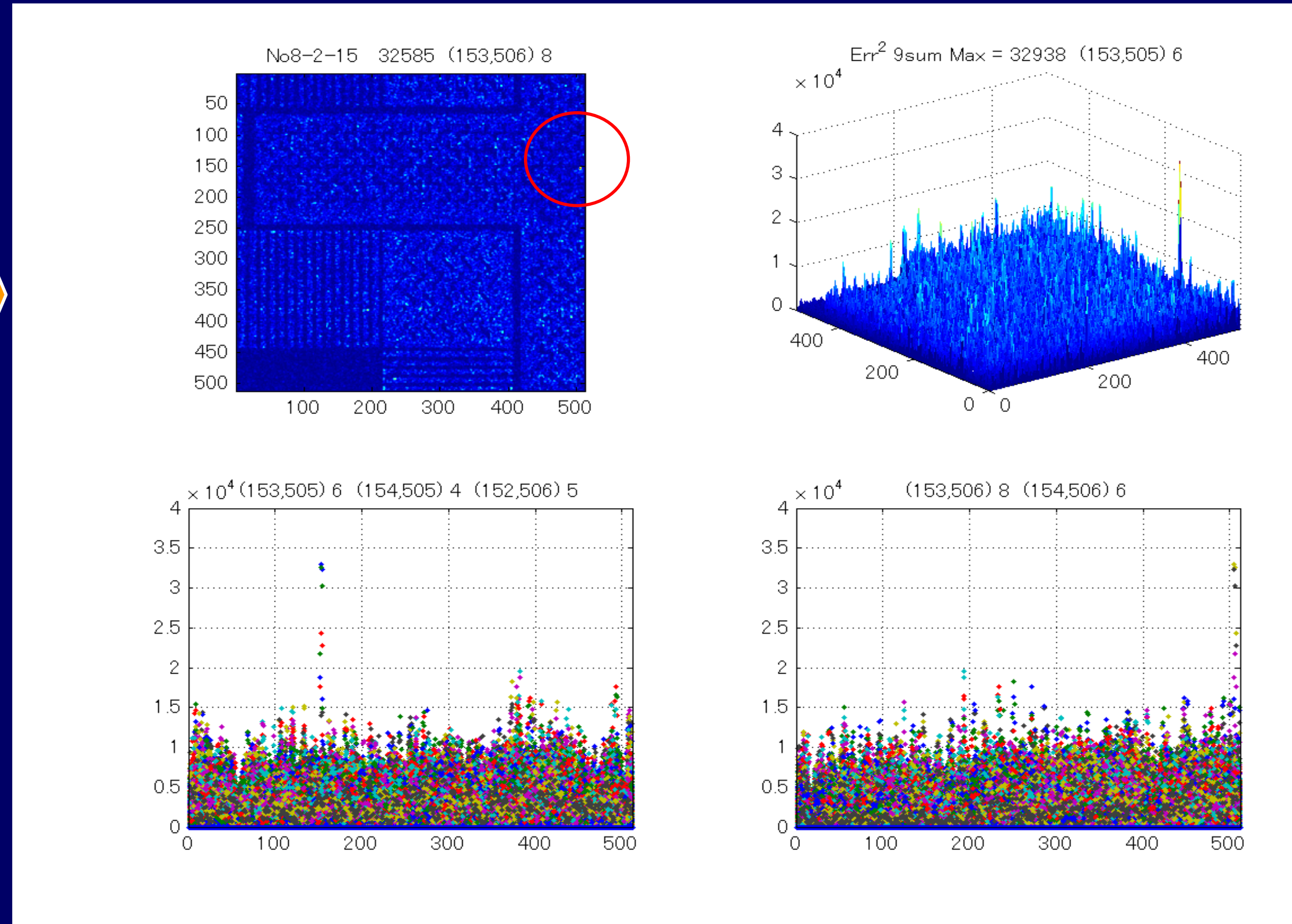


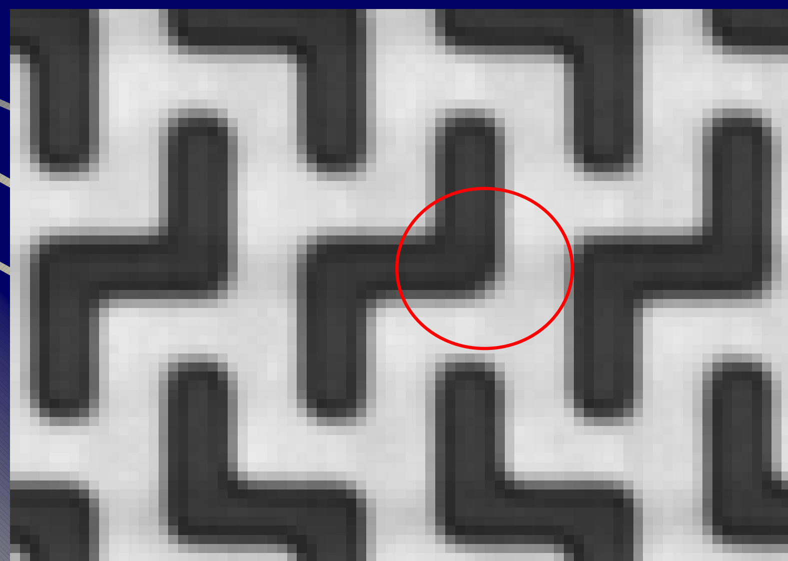
Magnified defect pattern

Upper left: Top-down view of simulation area
Upper right: 3D image of defect signal
Lower right/left: X and Y side view of defect signal

22nm corner defect detection by D-to-D inspection
15% ArF-HT PSM with 420nm wire, 70nm pixel, 400M pixel/s







Magnified defect pattern

Upper left: Top-down view of simulation area
Upper right: 3D image of defect signal
Lower right/left: X and Y side view of defect signal

Die-to-die inspection sensitivity of 15% ArF-HT PSM with 420nm wire pattern, 70nm pixel, 400M pixel/s

No	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1							16	11	12	24		22					
2							35	23	29	36	27	27					
3			12	12	11		51	38	42	54	40	48					
4			27	27	11		62	58	42	66	56	54	23	23	12		
5			20	31	11	11	80	75	59	87	67	66	20	23	20	8	
6			36	40	25	22	88	87	83	84	79	88	27	23	36	27	
7			44	44	42	40	113	100	95	113	91	101	40	40	40	31	
8			64	60	62	40	125	117	111	125	104	117	60	44	60	56	
9			79	67	65	59	134	133	119	138	115	131	75	56	71	67	
10			91	95	81	73	151	149	131	149	135	144	100	67	95	75	
11			123	123	101	81	166	166	149	163	147	154	111	100	108	95	
12	40		127	135	104	113	176	183	170	179	158	168	127	100	115	111	
13	75		147	139	132	118	194	193	179	196	175	185	139	131	135	147	
14	100	48	163	167	140	135	208	214	188	204	187	206	158	143	158	150	
15	131	127	187	175	166	157	222	232	202	221	206	207	191	175	187	183	
16	147	154	198	191	185	172	242	246	218	233	210	227	206	191	198	191	
17	171	206	222	222	196	191	254	269	229	246	235	237	210	210	202	210	
18	193	238	231	242	233	213	265	283	236	262	250	258	235	231	227	238	
19	210	262	254	258	242	224	280	306	262	280	258	271	254	258	250	258	
20	227	285	266	281	264	263	294	338	258	292	281	286	258	281	266	274	

Standard algorithm (transmitted light)

CD algorithm (transmitted light)

Standard algorithm (reflected light)

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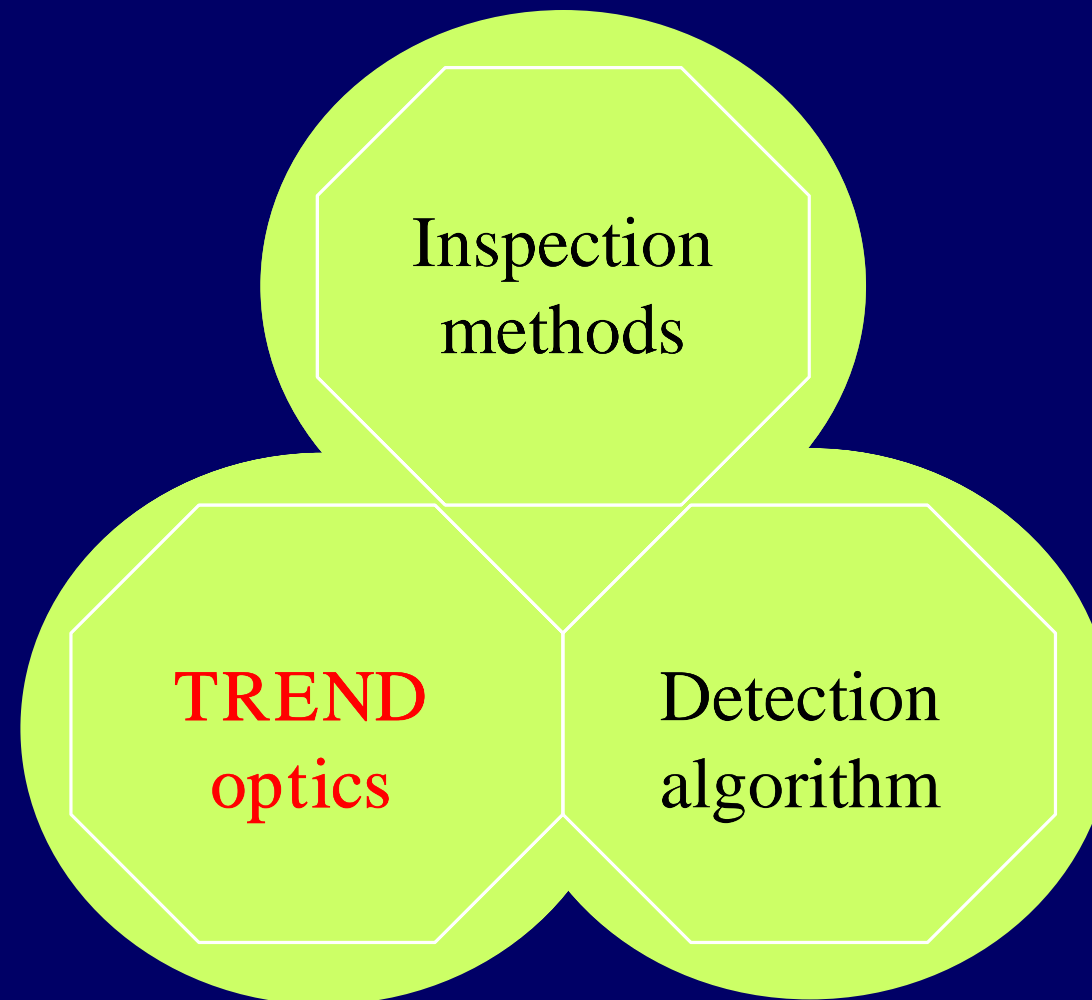
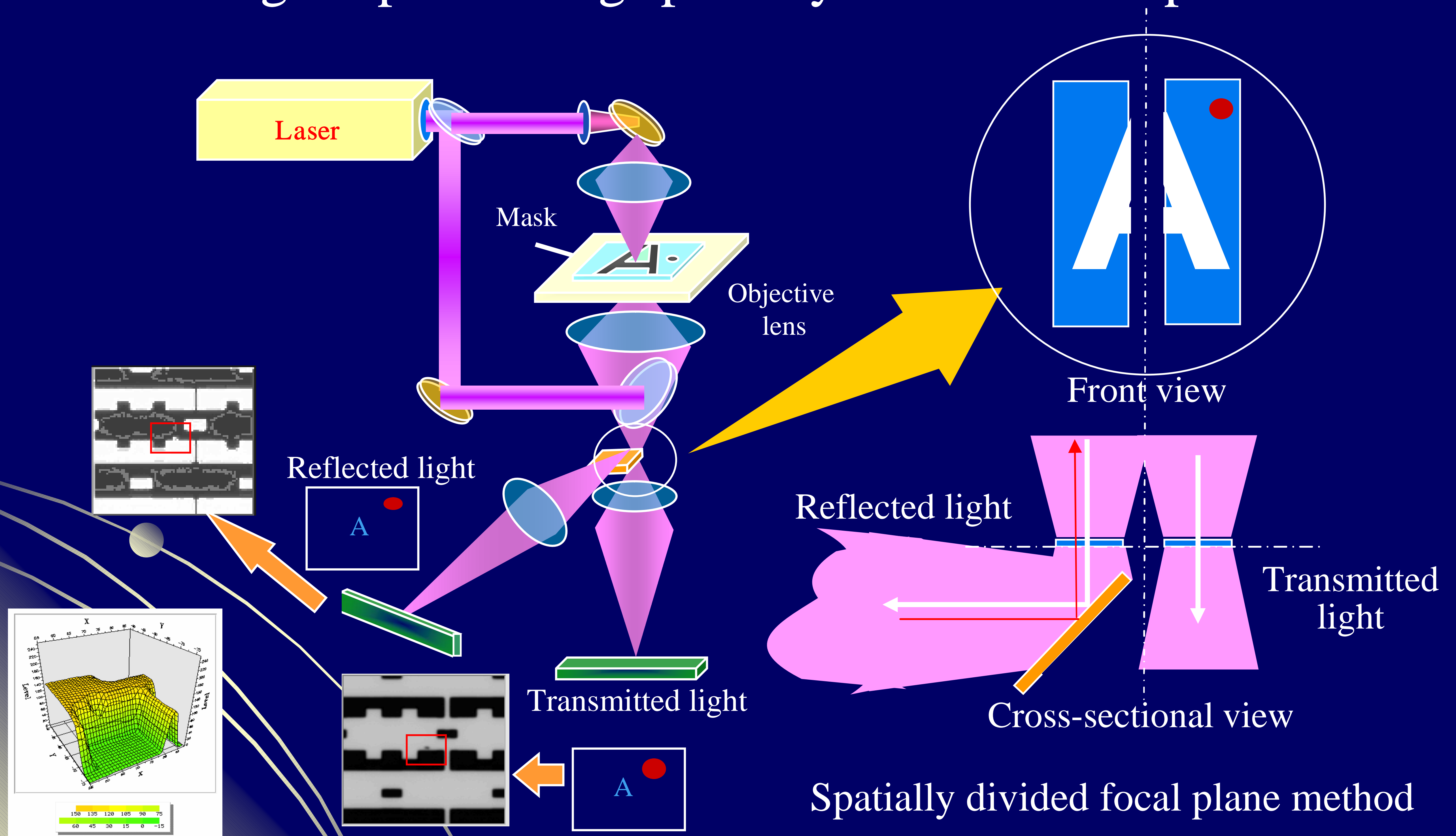
TREFOIL

TREFOIL:Transmitted light and REFlected light cOncurrent Inspection Logistics



TREND: Transmitted light and REflected light coNcurrent Detection

An example of TREND optics:
Reflected light optics using spatially divided focal plane method



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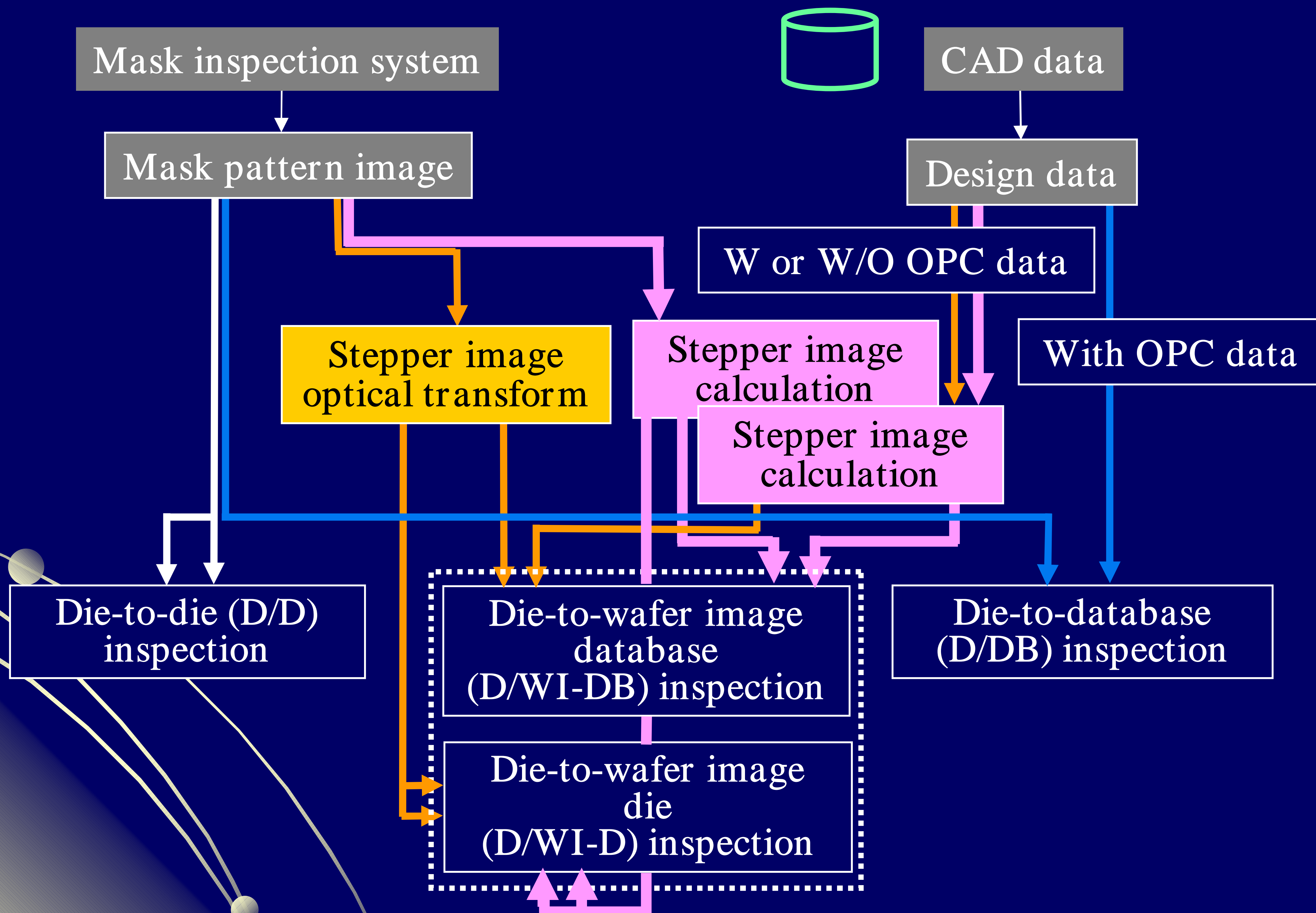
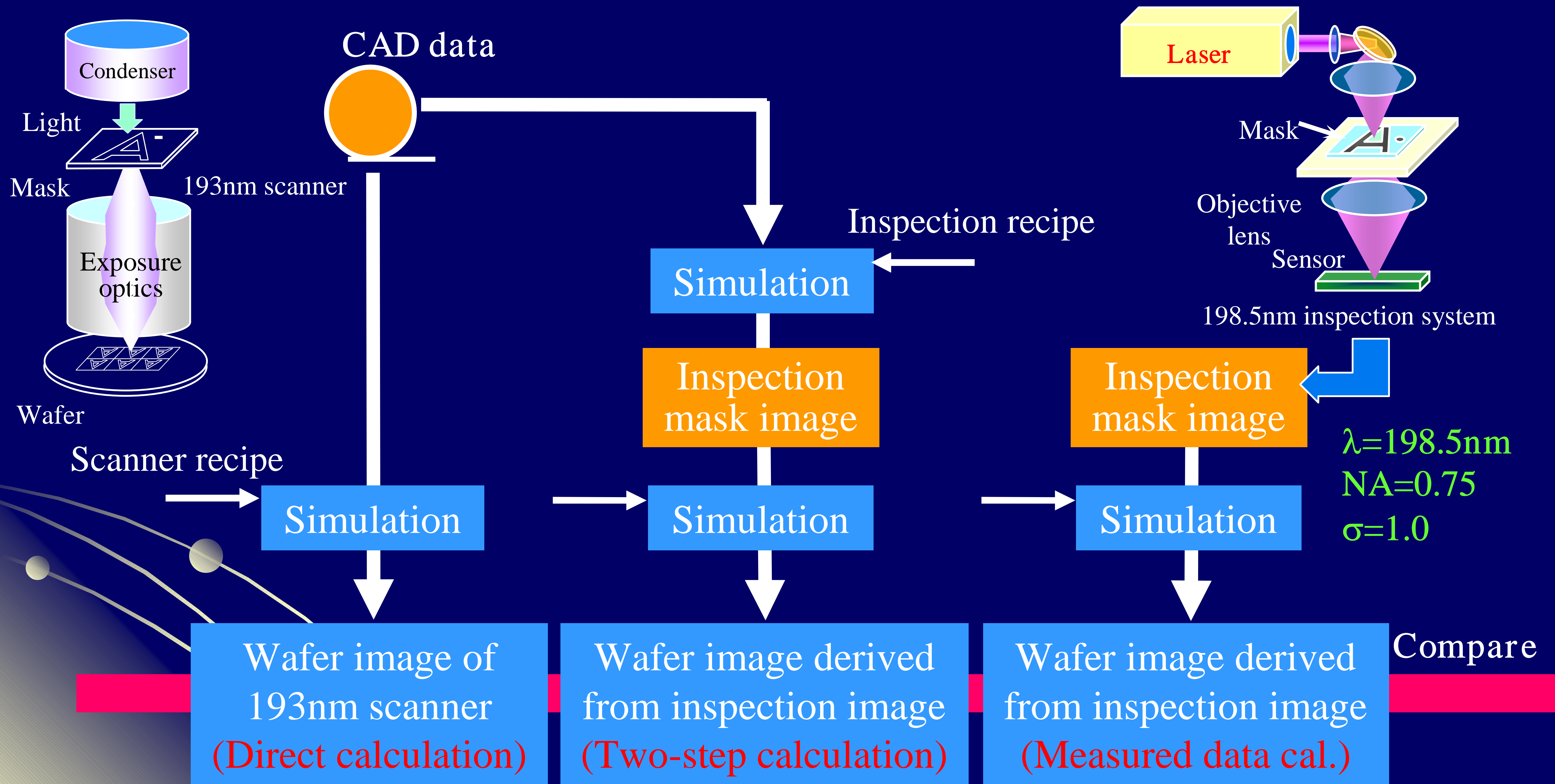
Concept of Die-to-wafer image inspection and this dataflow



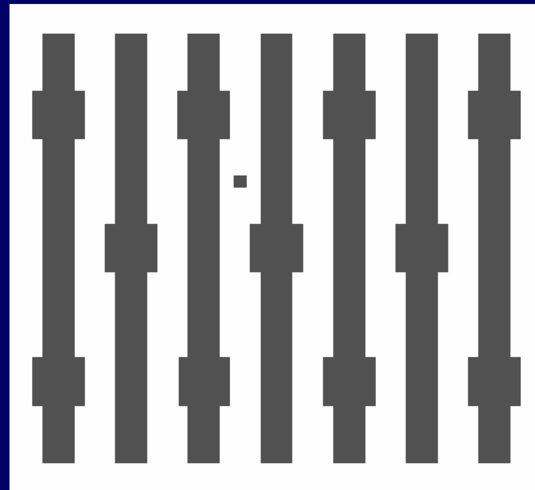
Verification of Die-to-wafer image inspection method



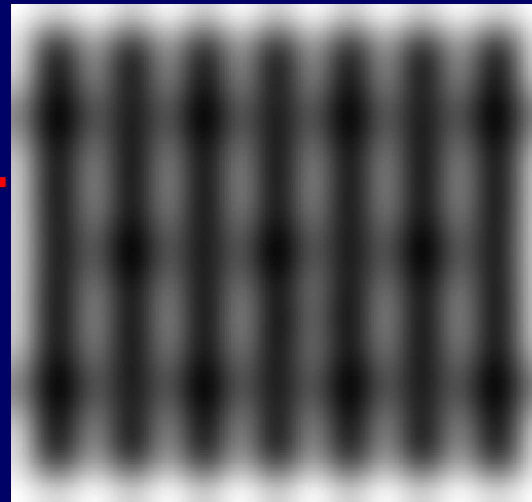
Calculation condition: λ=193nm, NA=0.75 / 0.9, σ=1.0, 2/3 annular illumination

Wafer-like image comparison of direct calculation with two-step calculation

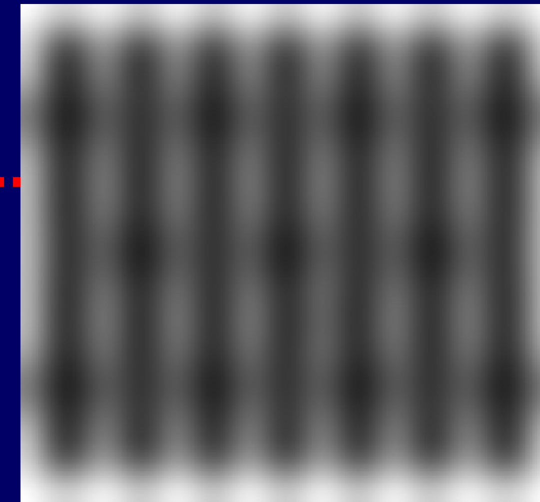
6% ArF-HT PSM



300nm wire pattern with 125nm pin-dot defect

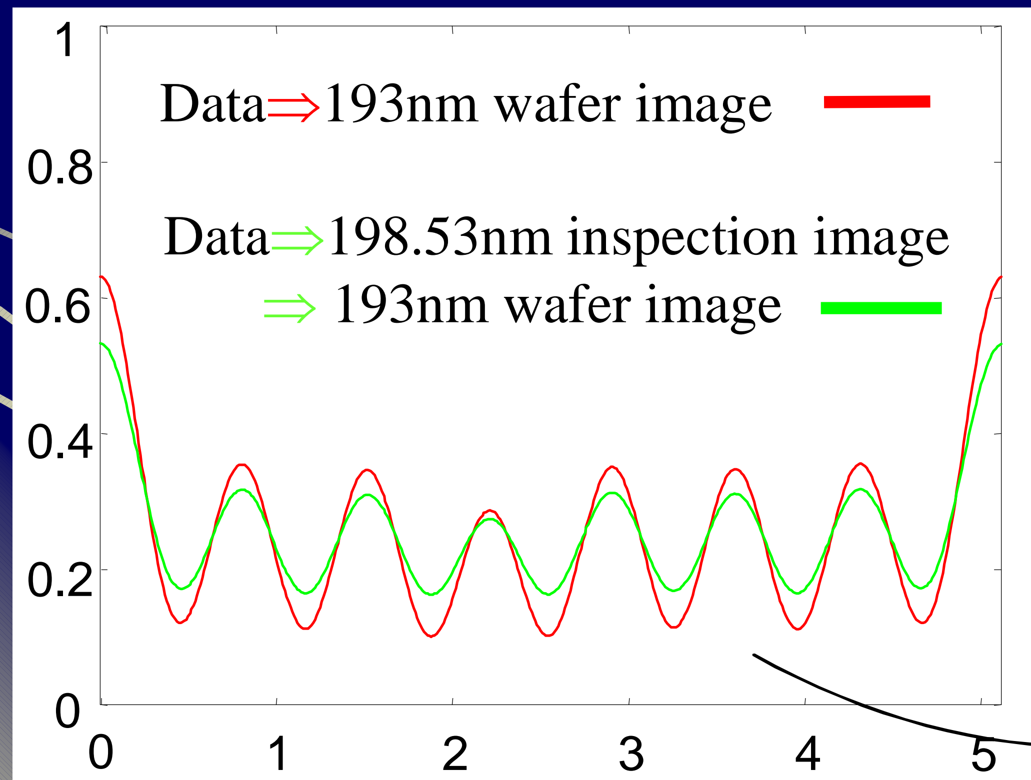


193nm wafer image from pattern data

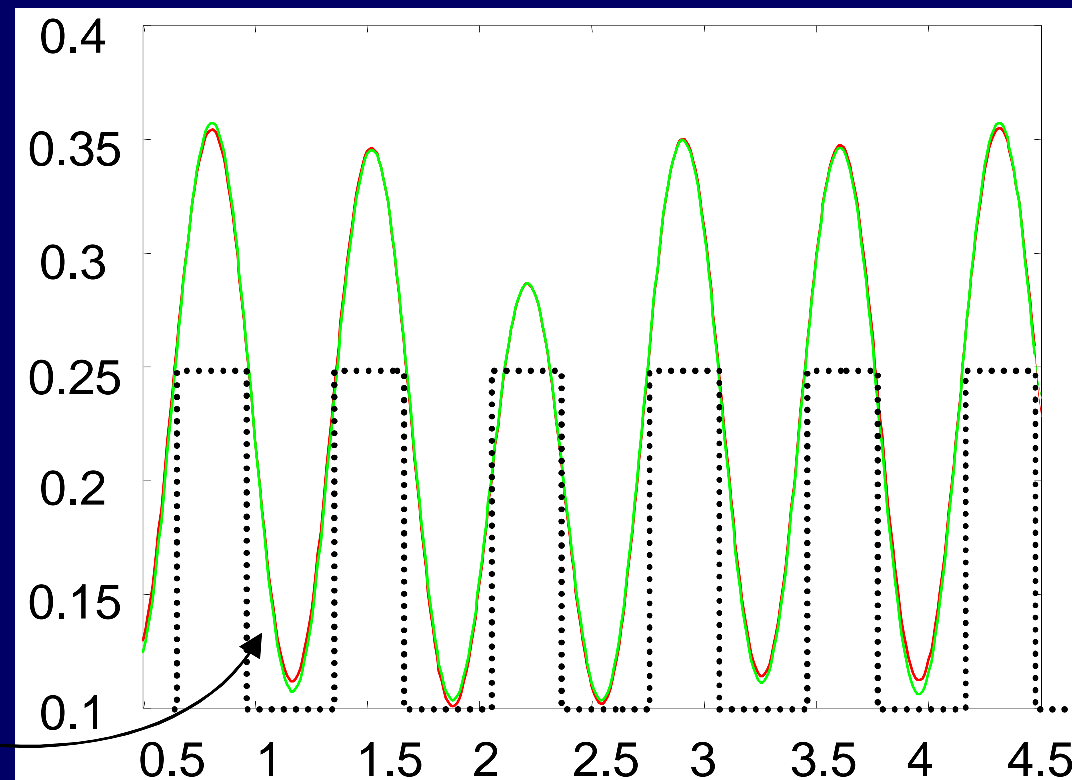


193nm wafer image from inspection image

X-X



Intensity profile at X-X cross section

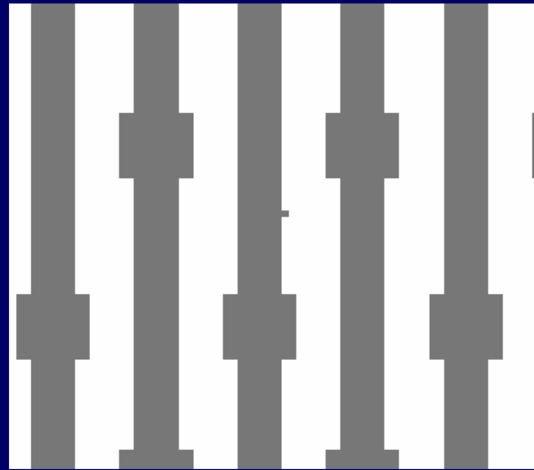


Enlarged intensity profile with correction

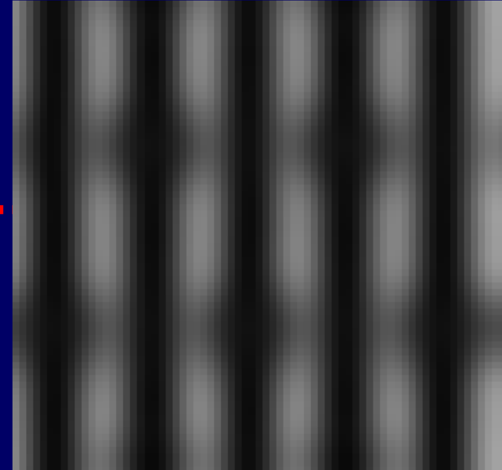
λ=193nm, NA=0.75, 2/3 annular illumination

Wafer-like image comparison of direct calculation with calculation from measured data

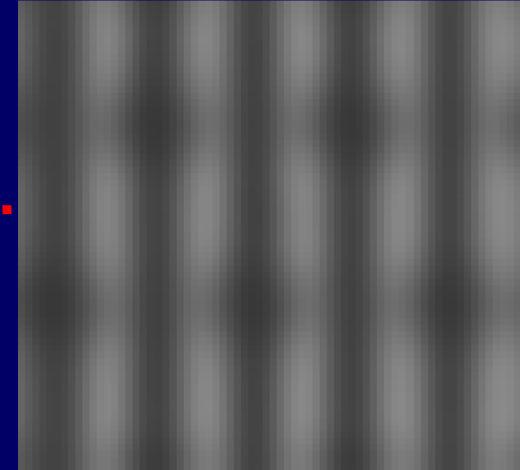
15% ArF-HT PSM



420nm wire pattern with 64nm edge defect



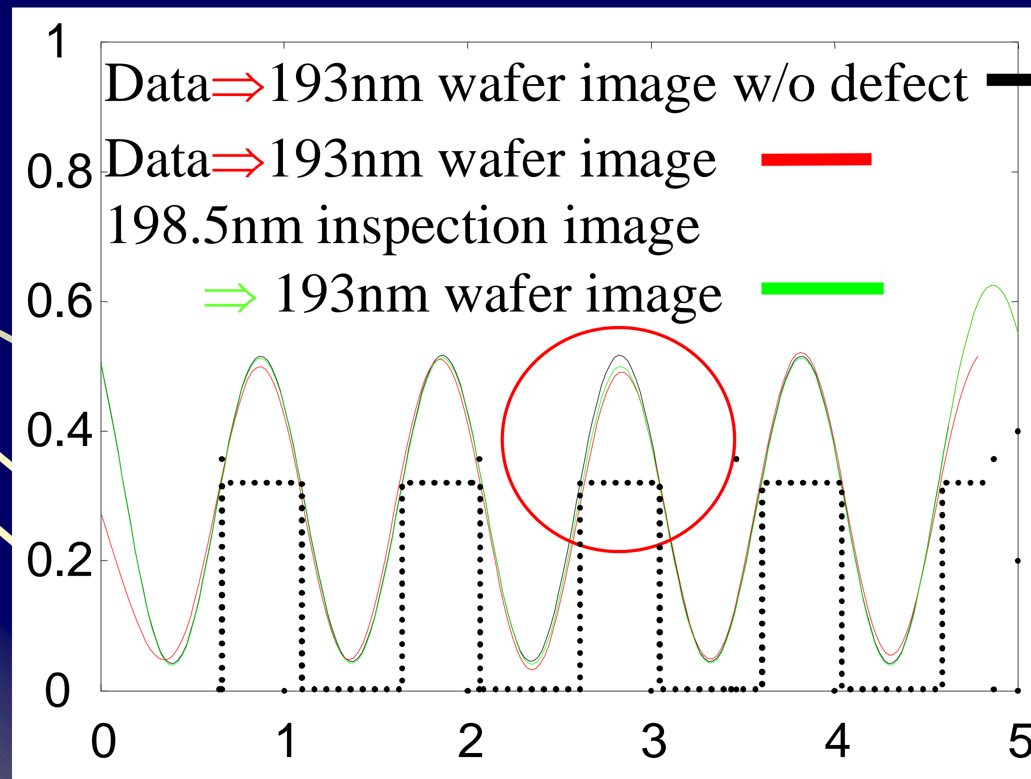
193nm wafer image from pattern data



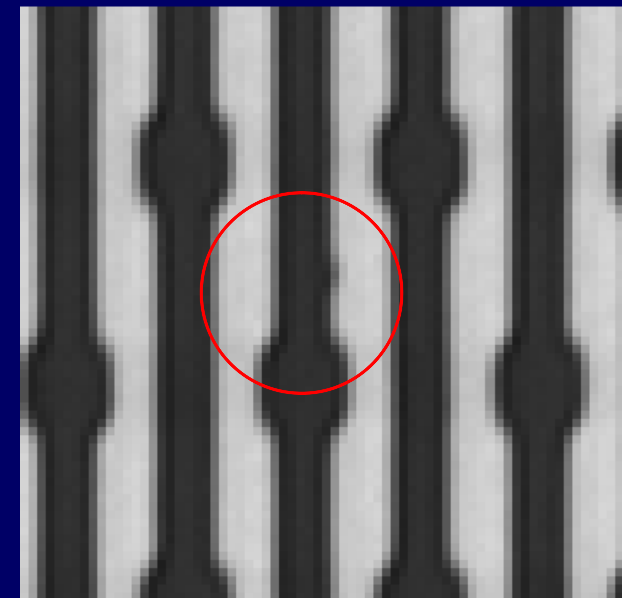
193nm wafer image from inspection image

X X

λ=193nm, NA=0.75 , 2/3 annular illumination



Intensity profile at X-X cross section



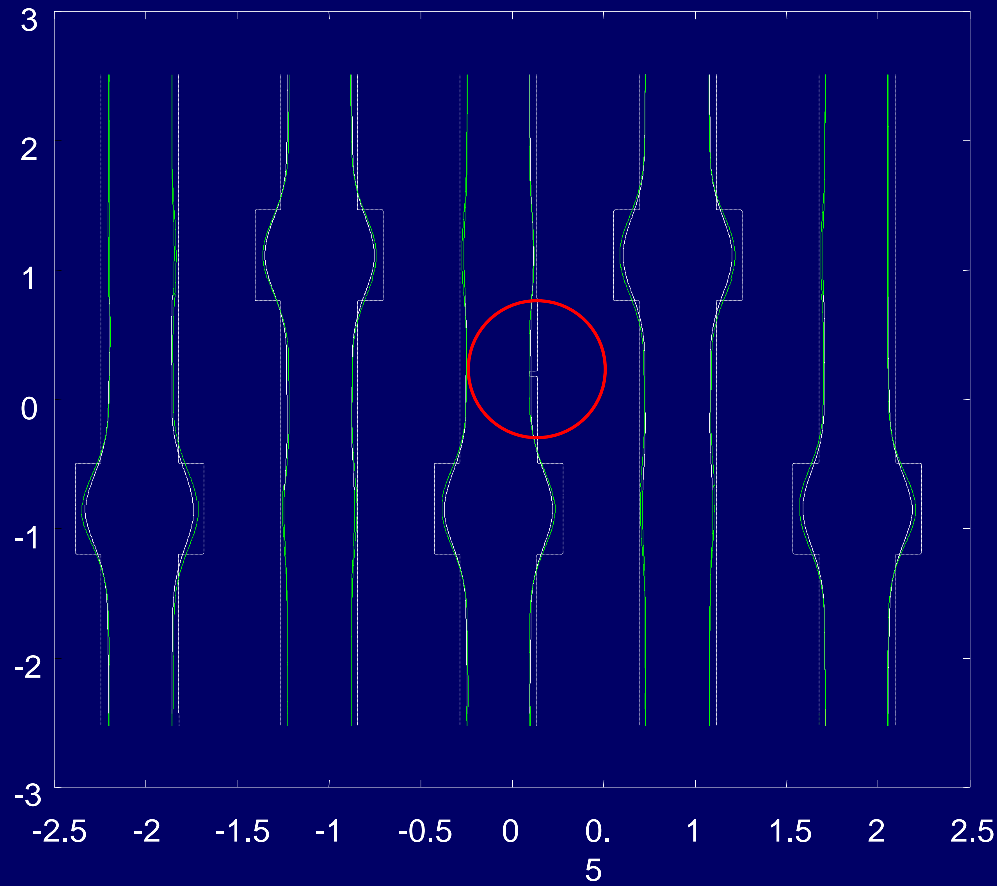
198.5nm AMOS inspection image

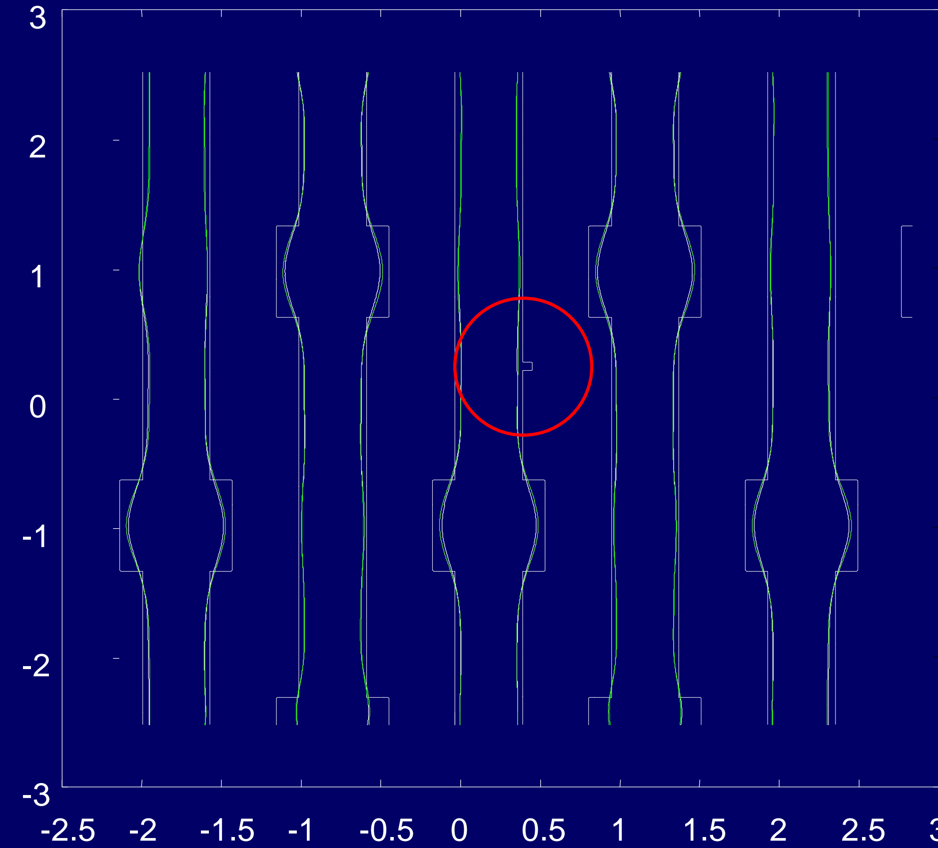
λ=198.5nm NA=0.75 σ=1.0

CD variation of wafer image due to defect when intensity level is set at 0.2

15% ArF-HT PSM

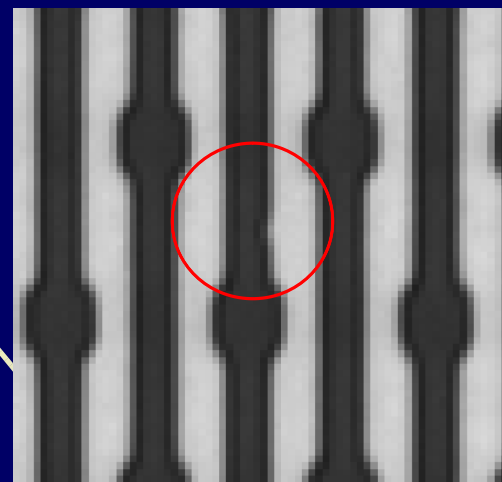
420nm wire pattern with 44nm edge defect

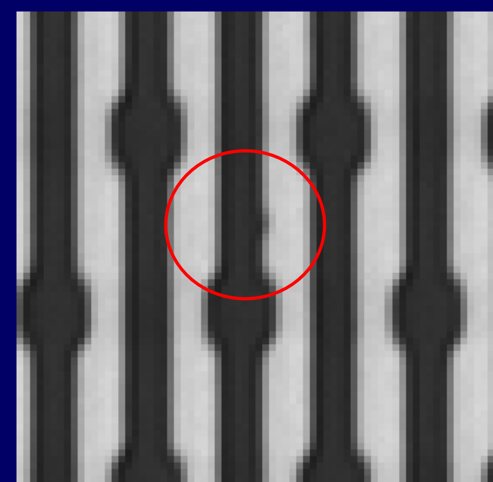




420nm wire pattern with 64nm edge defect

λ=193nm, NA=0.75 , 2/3 annular illumination

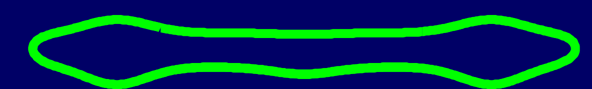




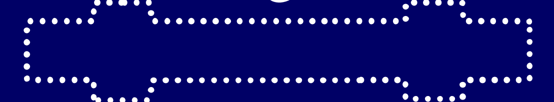
198.5nm AMOS inspection image

Direct calculation without defect

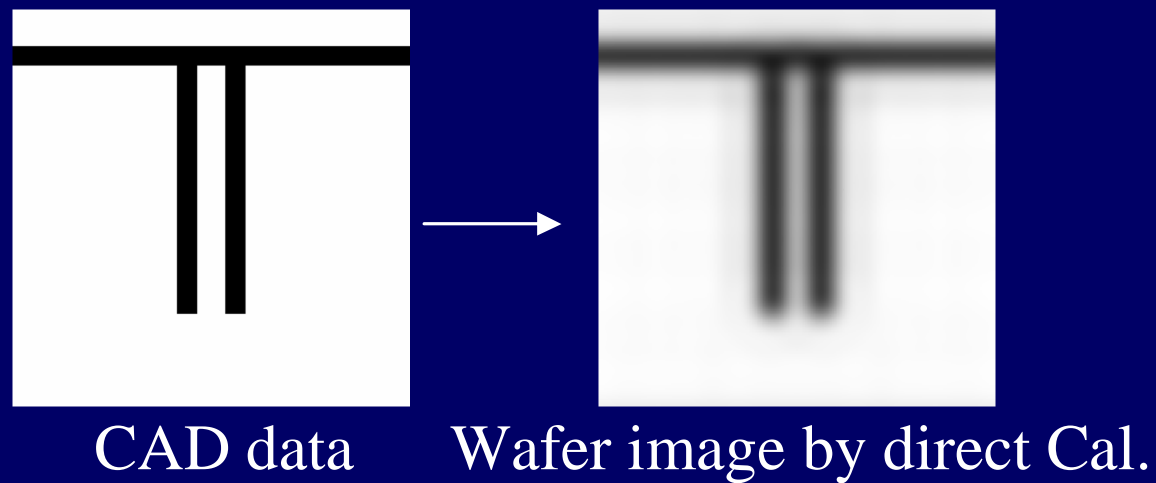
Measured data calculation



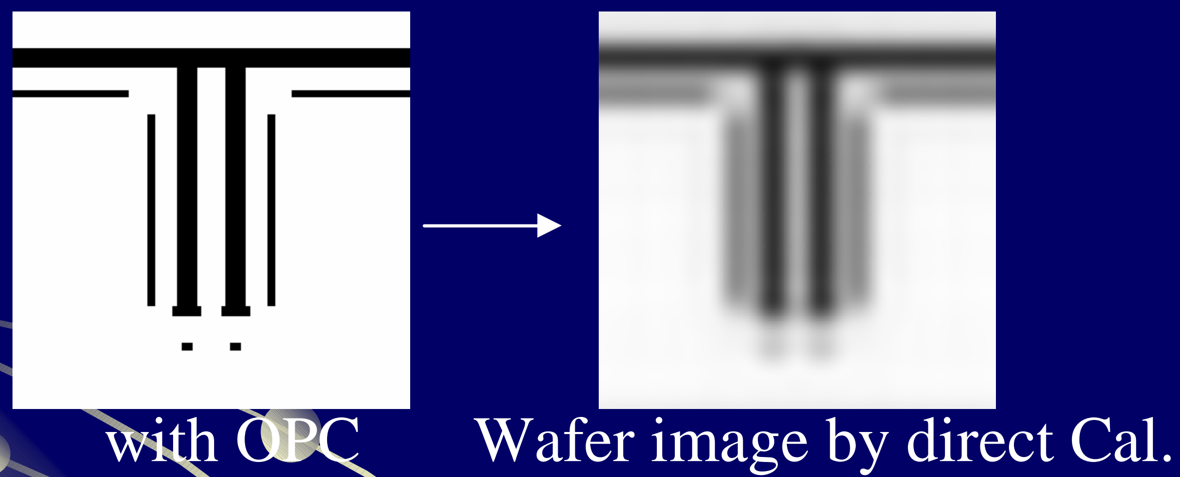
Design data



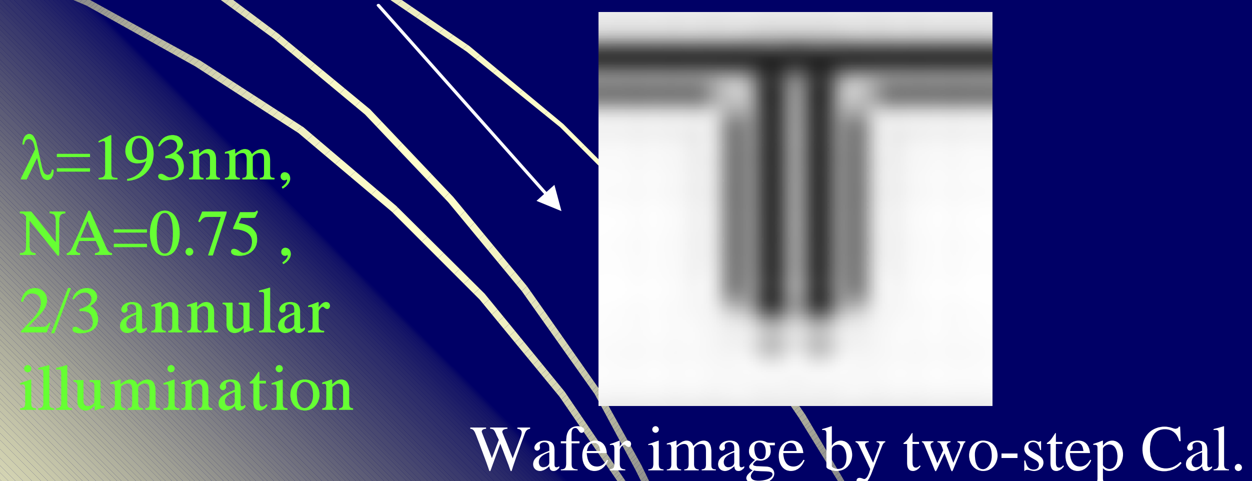
CD variation of wafer image for binary OPC mask (assist bar) when intensity level is set at 0.41



CAD data — Wafer image by direct Cal.

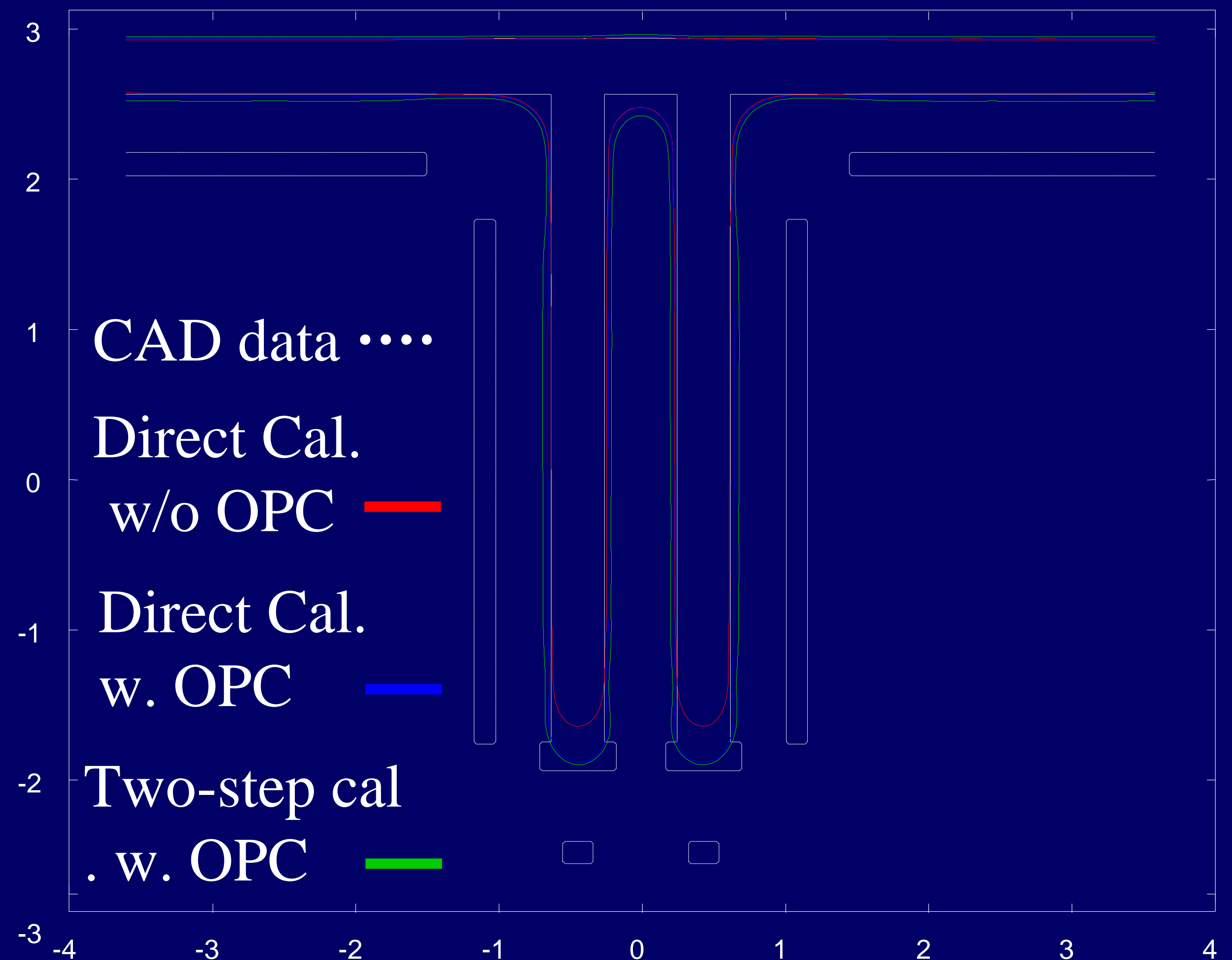


with OPC — Wafer image by direct Cal.



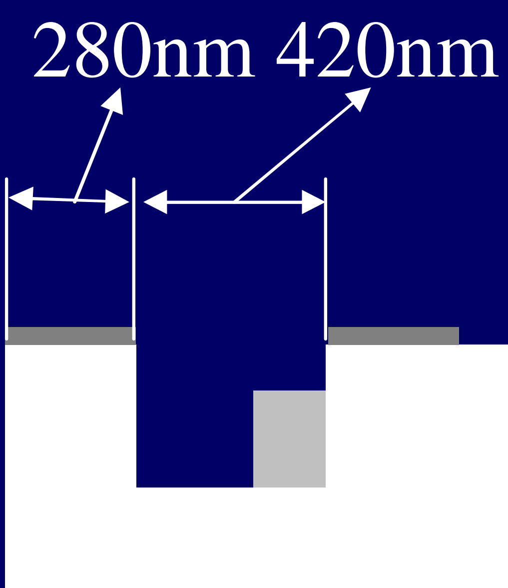
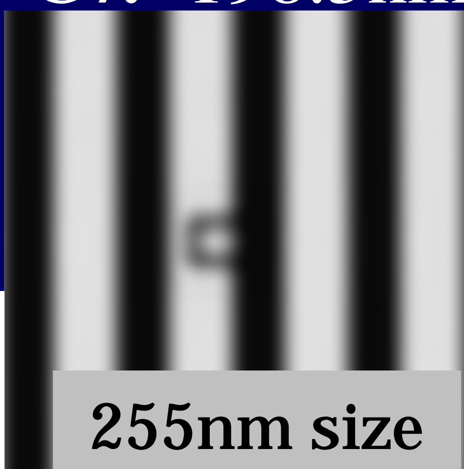
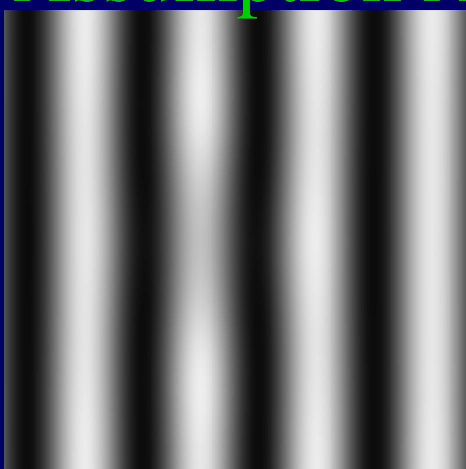
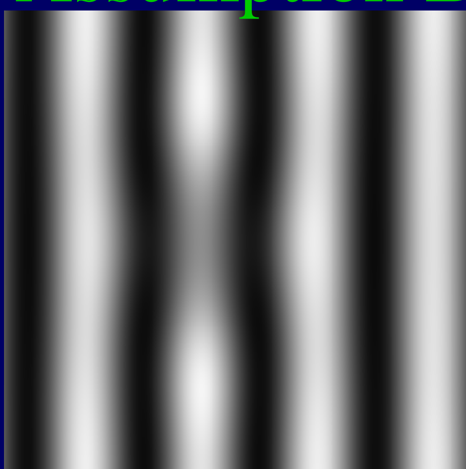
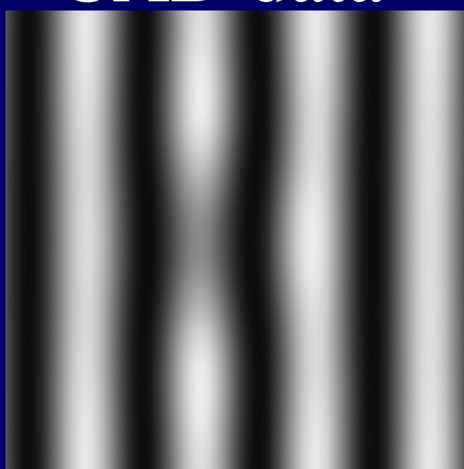
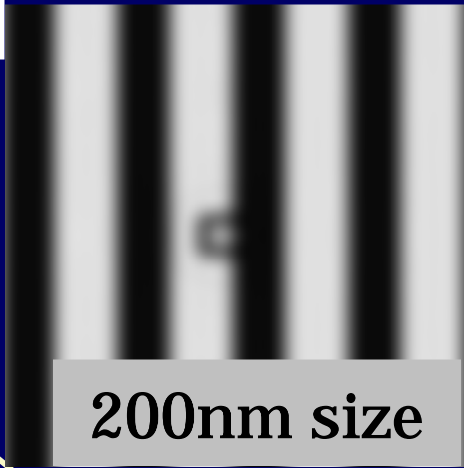
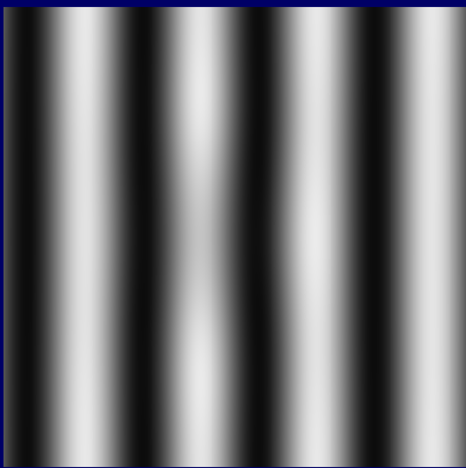
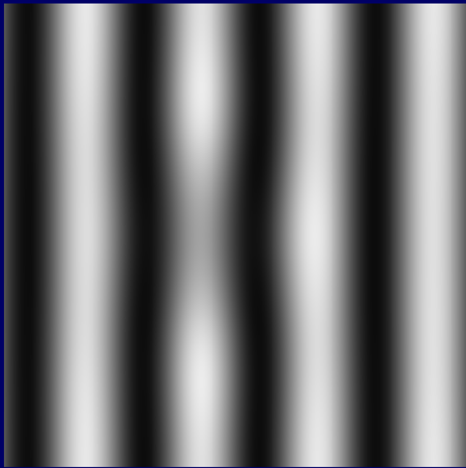
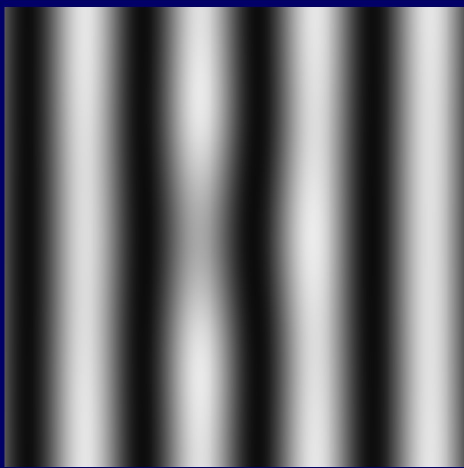
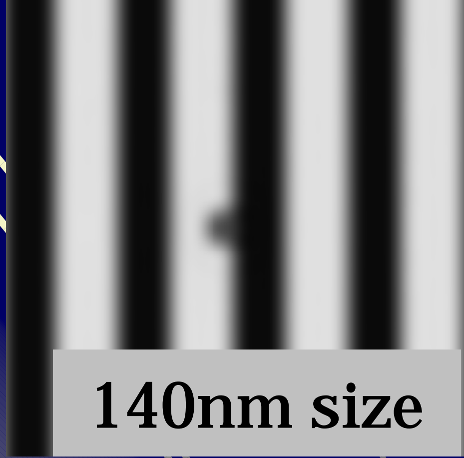
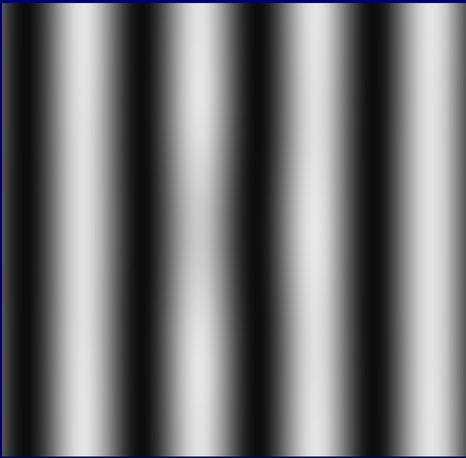
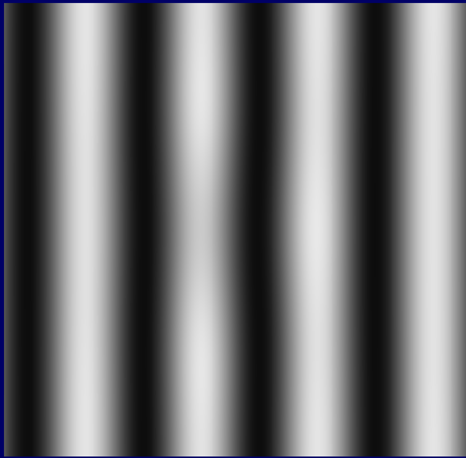
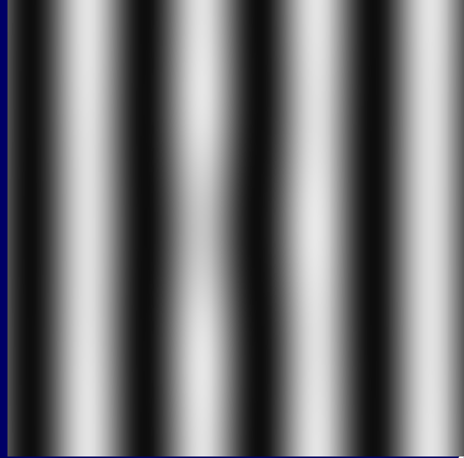
Wafer image by two-step Cal.

Mask pattern size: Primary feature=360nm, Assist bar=34nm



λ=193nm, NA=0.75 , 2/3 annular illumination

Wafer-like image comparison of direct calculation with two-step calculation for alternative phase shift mask

	Inspection image @λ=198.5nm	Two-step cal. Assumption A	Two-step cal. Assumption B	Direct cal. from CAD data
	 255nm size			
	 200nm size			
	 140nm size			

280nm 420nm

120° Edge bump defect

λ=193nm, NA=0.75 , σ=0.43

1. Background
2. Mask inspection system using 198.5nm wavelength
3. Possibility of transmitted light and reflected light concurrent inspection logistics (TREFOIL)
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Summary

1) Wavelength consistency between exposure system and mask inspection system is strongly required so as to obtain high defect detection sensitivity.
2) A novel high-resolution mask inspection platform using 198.5nm wavelength has been developed for 65nm node and beyond. The initial state D-to-D/D-to-DB inspection performances of 20-60nm defect sensitivity are certified.
3) For 45nm node inspection, the possibility of transmitted light and reflected light concurrent inspection is shown. A novel TREND optics is demonstrated.
4) The D-to-WI inspection method using measured mask pattern images is presented. Although accuracy of assumption and applicable limits should be investigated, this method is considered to be effective for industrial use.

A part of this work was supported by NEDO

Thank you for your attention