

# The capability of recent DUV inspection and printability for pattern defects on EUV mask in 45nm node and below

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**RAPID KLA-Tencor**

# Contents

- ◆ Introduction
- ◆ Experiment
- ◆ Result
- ◆ Analysis
- ◆ Conclusion

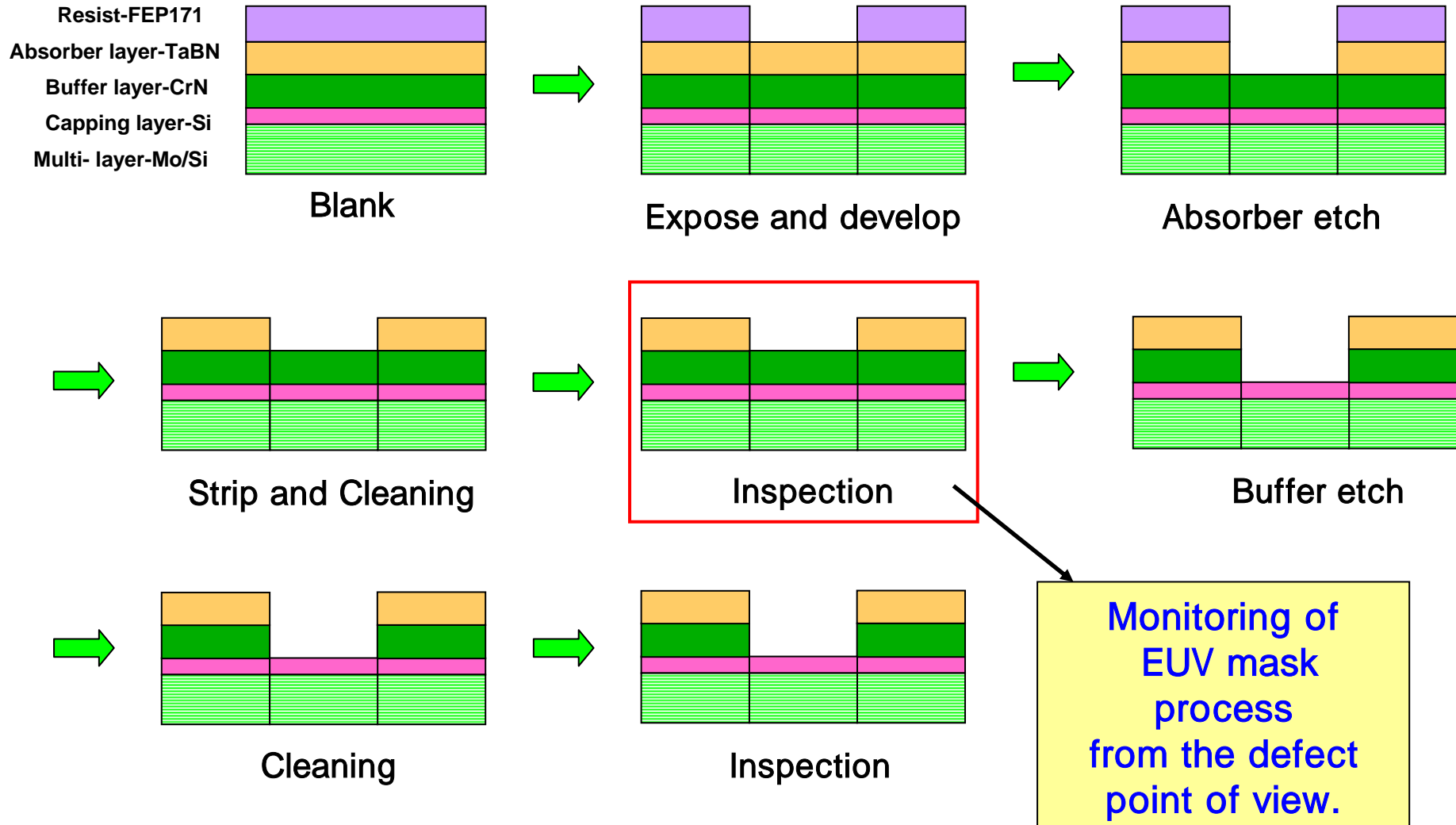
# Introduction

- ◆ EUVL has been prepared for **the real production in SEC.**
- ◆ Currently, SEC is **on the road of 45 nm node.**
- ◆ **EUV mask development** need to be completed before printing test with the ASML alpha-tool.
- ◆ **The pattern inspection** has been studied as a part of the development.

Roadmap of EUV development

	'06	'07	'08	'09~
		ASML $\alpha$ -tool (@IMEC)		
	4Xnm EUV mask	4xnm/3x EUV mask	3Xnm EUV mask V.P.	
EB Patterning	—————			
DUV inspection	● KLA5X7		● KLA6XX	
ITRS Roadmap			51 nm node	45 nm node

# Motivation

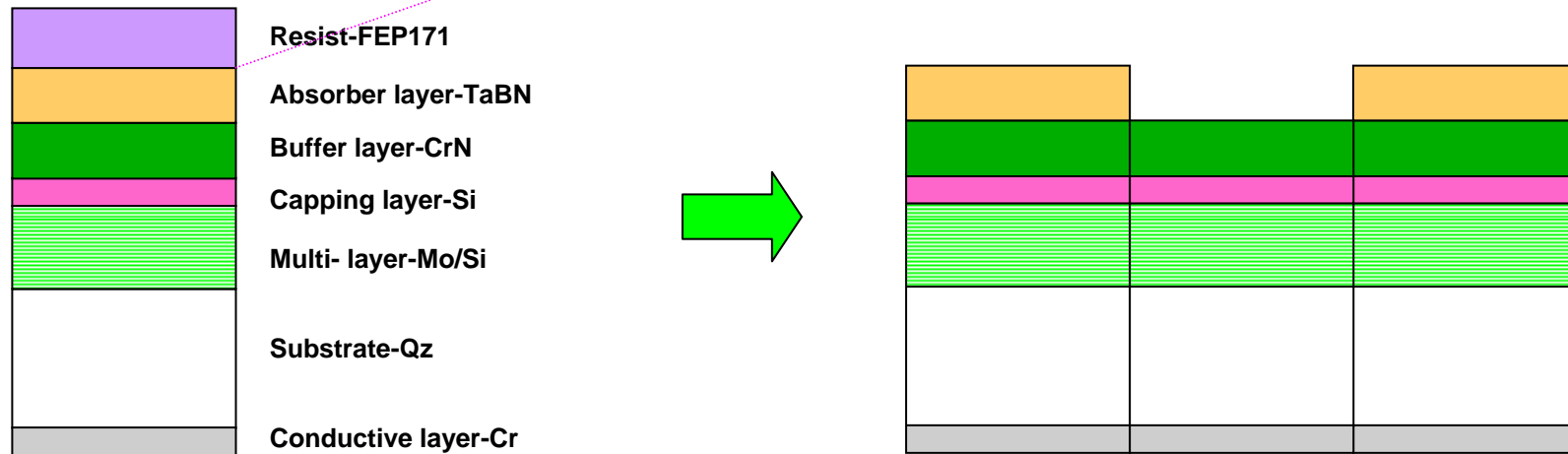


# Motivation

- ◆ What is the current problem in the pattern inspection?
  - There are no exclusive inspection tools for EUV reticle.
  
- ◆ We have checked the current level in the pattern inspection of the EUV mask.
  - Comparing the inspection performance on EUV mask to the current inspection performance on optical mask in the KLA 5xx tools.
  - Notifying the gap between those two inspection levels for the EUV and the Optical masks.
  - Denoting the gap between the inspection capability and the corresponding spec of the defect printability by simulation.
  
- ◆ Do we need the development of an exclusive EUV inspection method that can be a match for the optical mask inspection mode in 45 nm node and below?

# Experiment

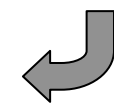
◆ EUV mask ARC for 257 nm inspection



		Reflectivity	
Tools	WL(nm)	CrN @Ins	TaBN @Ins
KLA5xx	257nm	45.95%	5.46%
KLASLF	365nm	49.03%	23.37%

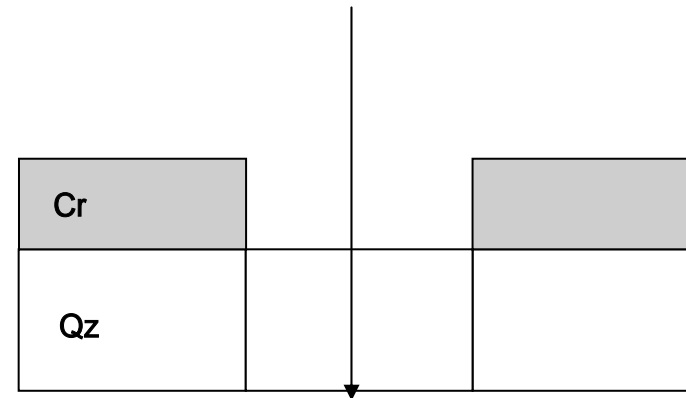
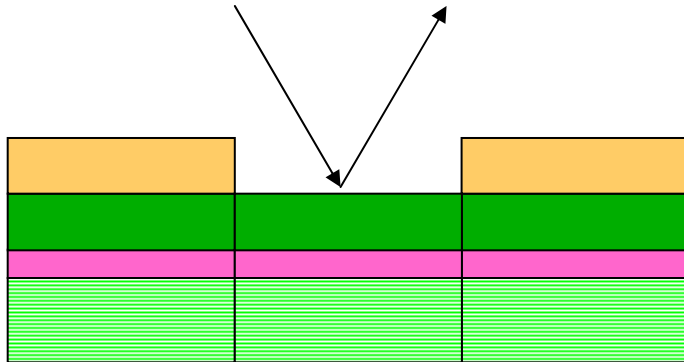
contrast (Absorber – Buffer)		
WL(nm)	<i>standard</i>	<i>data</i>
257nm	83.8%	78.8%
365nm	40.2%	35.4%

KLA5xx is proper for the mask inspection since it uses 257 nm wavelength.



# Experiment

## ◆ EUV mask vs Optical mask

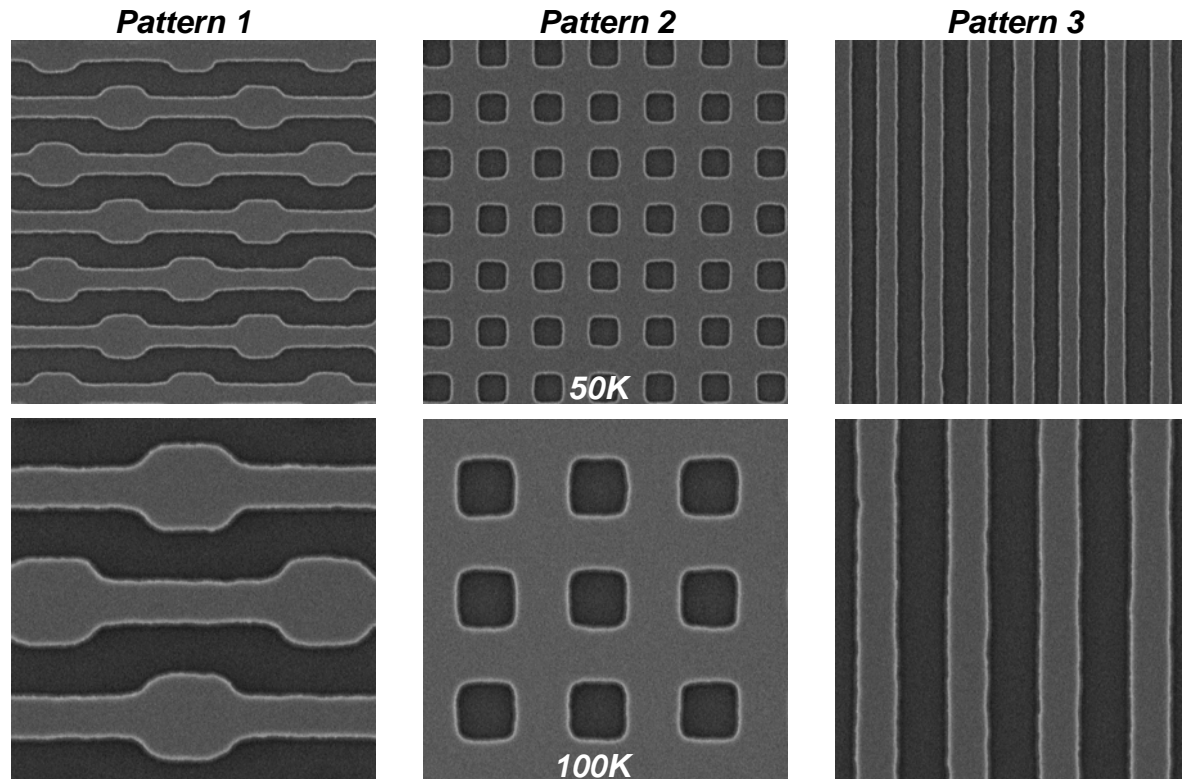


	Exposure	Inspection
<b>EUV mask</b>	<b>Reflect</b>	<b>Reflect</b>
<b>Optical mask</b>	<b>Trans.</b>	<b>Trans. &amp; Reflect</b>

Tool	WL(nm)	Pixel size	Inspection mode
KLA5x6	257nm	90 nm	T, R
KLA5x7	257nm	90 nm , 72 nm	T, R

Reflected inspection on EUV mask vs Transmitted inspection on BIN mask

# Experiment-Test Patterns

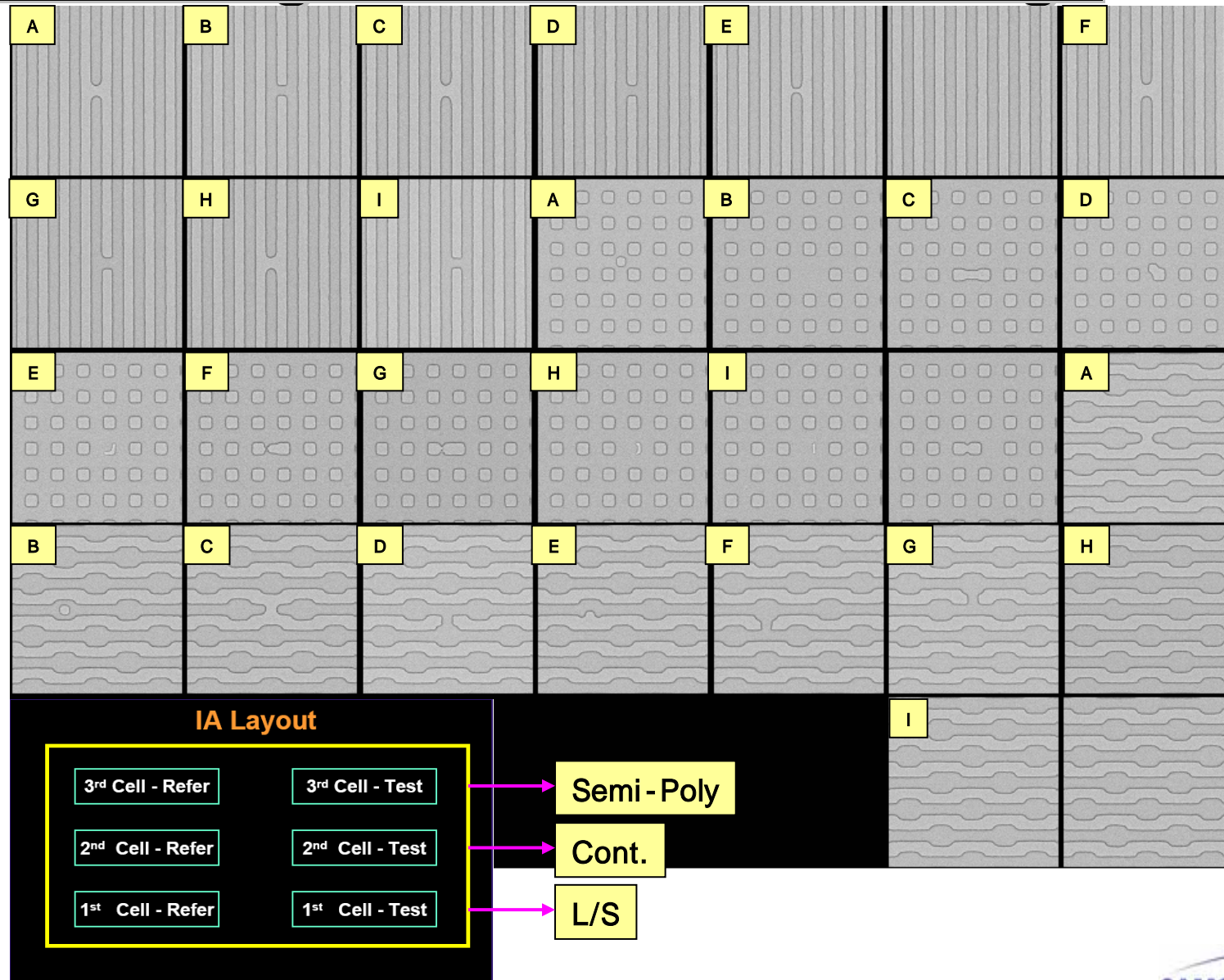


nm	dark	clear
<b>Design CD</b>	<b>180</b>	
<b>Measured CD</b>	<b>183.47</b>	<b>184.54</b>
1	183.88	183.97
2	183.86	184.21
3	180.30	185.88
4	183.41	187.05
5	179.65	184.28
6	183.26	181.86

The **test patterns** in **45 nm node** are not bad.

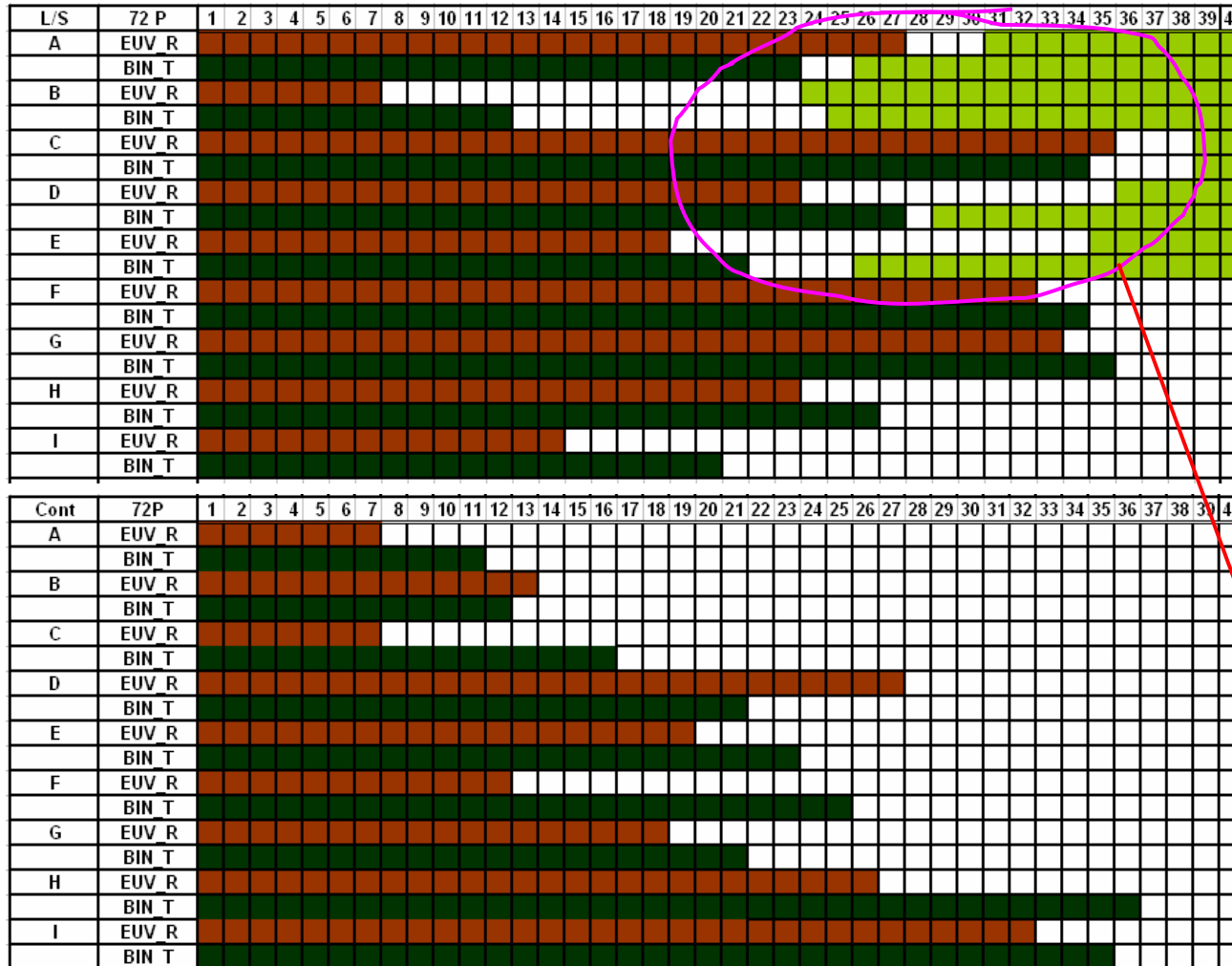


# Result-Programmed Defect Image





# Result-KLA537 72 nm pixel

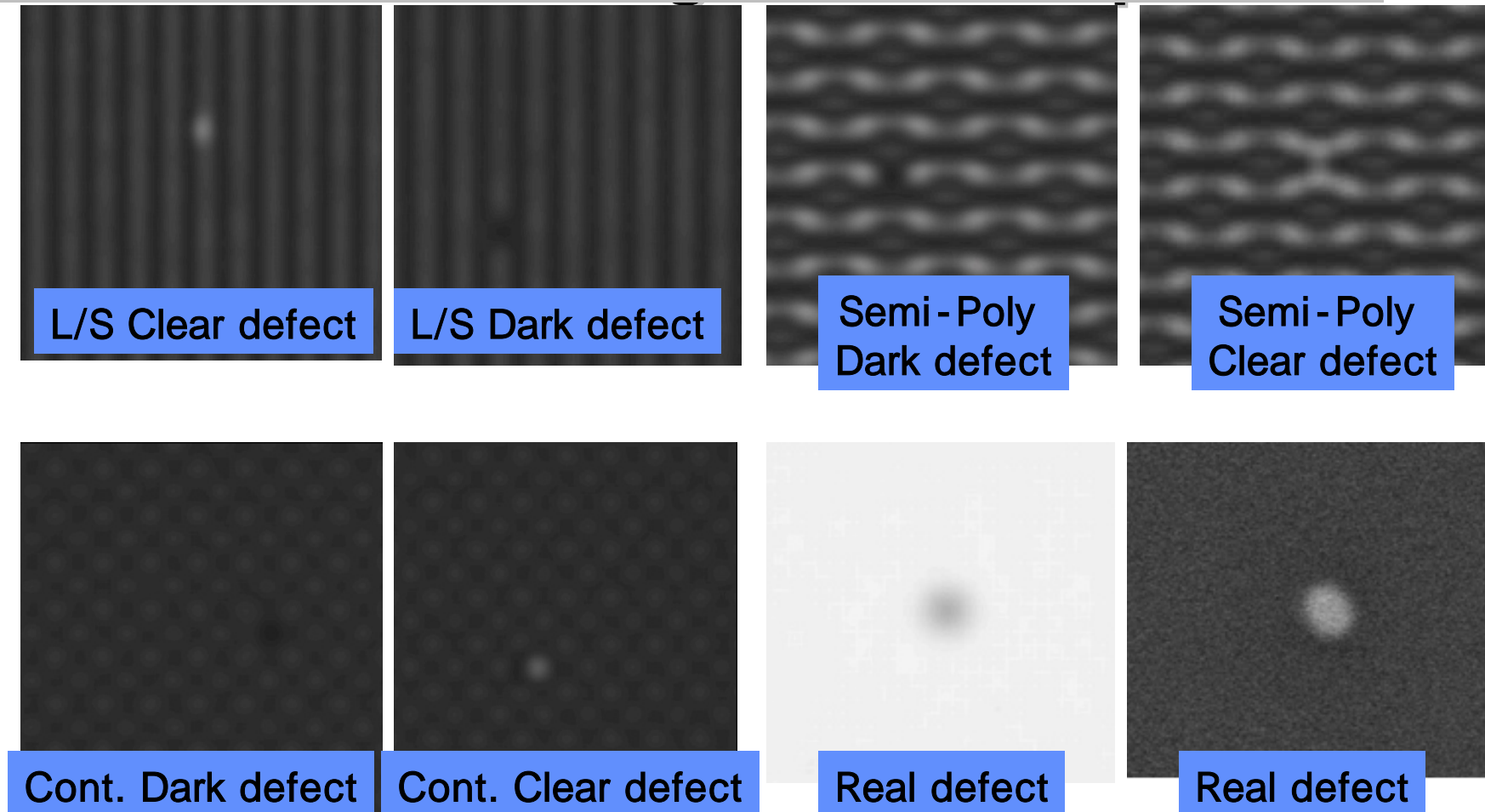


- Sensitivity on EUV Mask
- Sensitivity on BIN COG
- Defect printability by simulation

The 72 nm pixel inspection mode is better than the 90 nm pixel mode in terms of inspection capability. Also, the inspection result is comparable to the printability simulation result on EUV mask



# Result-Defect Image in the inspection



Inspection images are blurred due to the optical limitation and image resolution of them is a little bit poor compared to that of SEM images. **The real defects** in the process are detected. (70-90 nm size)

# Analysis

- ◆ The inspection performance on the EUV mask turns out to be comparable to the inspection performance on the optical mask.
- ◆ KLA537 72P inspection mode is better than 90P mode.
  - The inspection capability spec is close to the defect printability spec in 45 nm node.
  - 72P EUV inspection is useful in the development of EUV mask process in 45 nm node.
- ◆ The gap between defect detection results in those two inspections is dependent on type of defects.
  - The range of the difference is from 0 nm to 24 nm.
  - A few of defects are detected better in the EUV inspection.
- ◆ Real defects in the mask processes can be detected.

# Conclusion

- ◆ We presented the pattern inspection results of EUV mask and optical mask in 45 nm node.
- ◆ **KLA 537 DUV tool has the defect detection sensitivity enough for the EUV mask of 45 nm node in the 72P mode while KLA 536 does not.**
- ◆ **KLA537 and KLA536 have slightly better performance in the optical mask inspection than the EUV mask inspection.**
- ◆ **The EUV inspection tools need to be developed for 3X nm node.**  
(Ex, ~sub 200 nm, NA > 0.8, 60 nm Pixel size)
  - KLA6xx and others...

# Future Work

- ◆ SEC will do inspection tests on the EUV masks fabricated with the **Dram or Flash design** of 45 nm node and below.
  
- ◆ In **3X nm node**, we will do **the printability simulation** and predict the **level of the future inspection tool**.
  - wavelength, NA, illumination condition and pixel size.

# Acknowledgment

- ◆ DY would like to appreciate the help made by engineers of **KLA-Tencor** who made efforts to find out the optimal inspection status of the KLA 537.