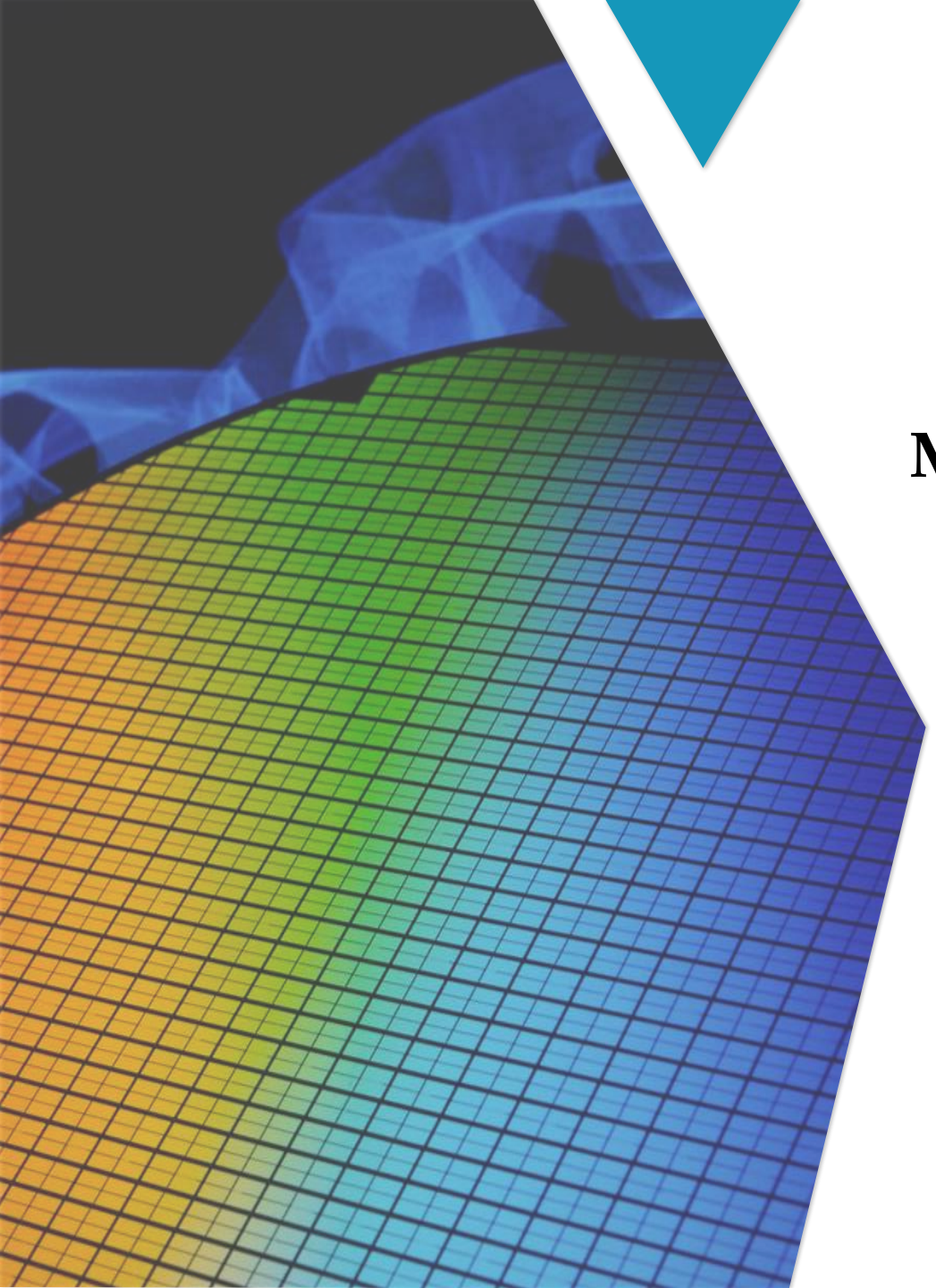


Implementing an OPC-based Analysis Method for Evaluating the Capabilities of Photoresist and Identifying Hot Spots

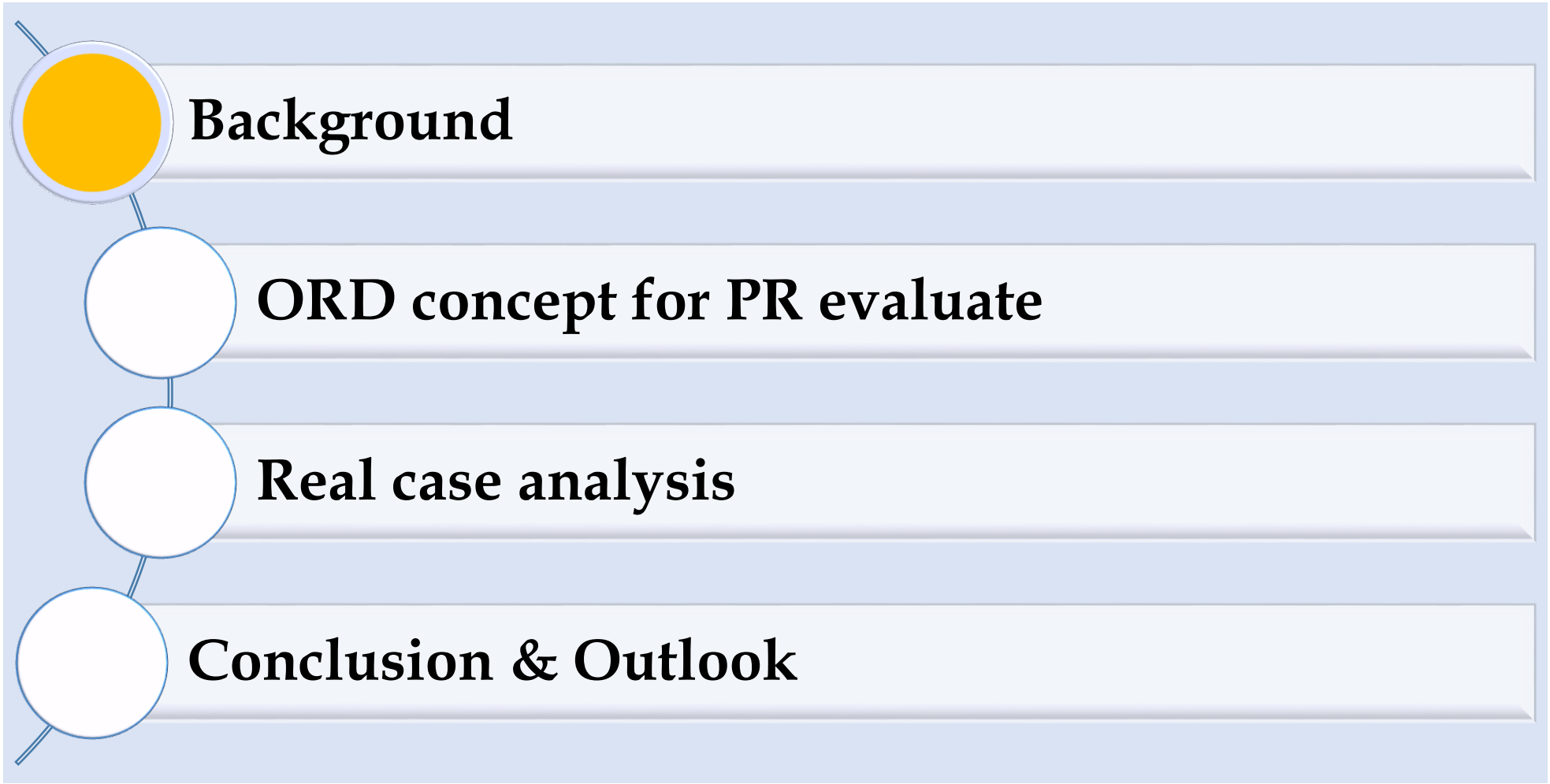
XiaoLong Wang[1,*], XueMei Zhao[1], BiCheng Chen[2], Chen Shen[2], QunLiang Ni[1], NanNan Zhang[1], ZhiMang Shao[1], WenHui Chen[2], LianFeng Guo[2], QingFeng Xue[1]

[1]GalaxyCore Semiconductor Limited, Shanghai, China, 200000;

[2] ASML-Brion, Shanghai, China, 200000;

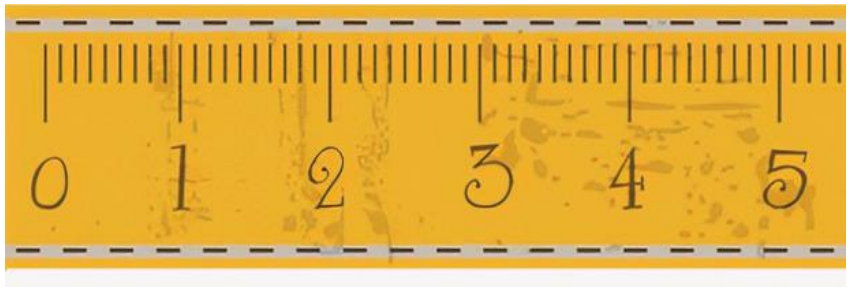
[*] peter_wang1@gcoreinc.com

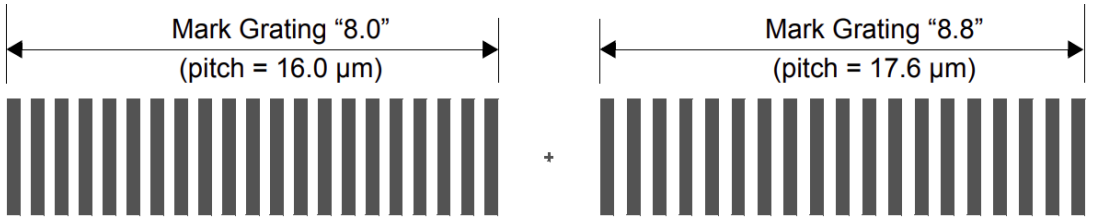
Outline



Background

- More and more Chinese resist vendors into mature Semiconductor generation





Loosen

Resist vendor provide data

Gap

The ruler fab HM required

Strict

- **Challenge:** If use more strict criteria as fab before testing resist going to fab, the resist implement safety and success rate will be much better and easier.

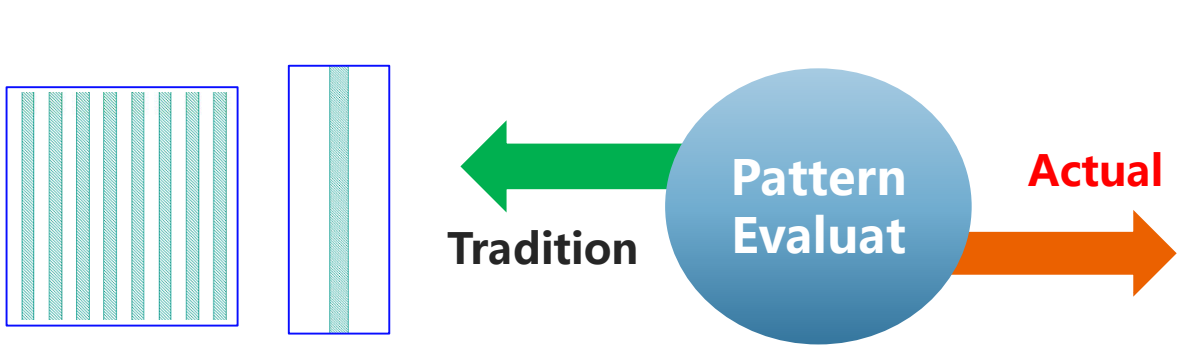
Traditional Resist vendor promotion information list

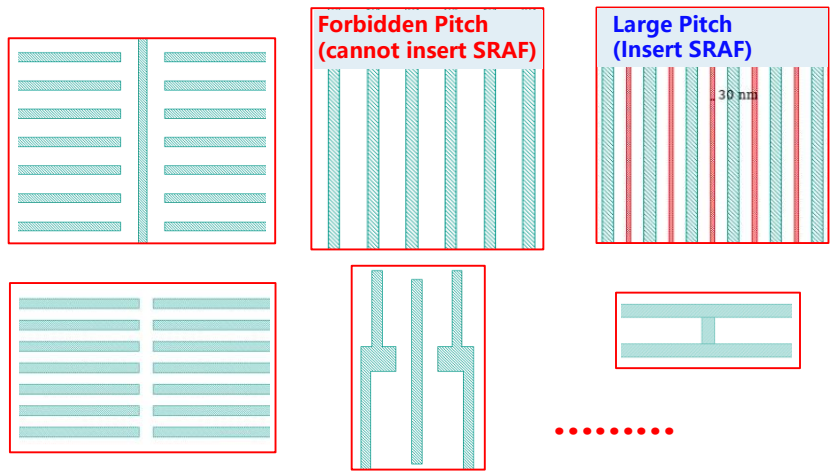
Content

- If resist qualify fail, One learning cycle will be more than half year, some vendor will be no more chance again.

Major provide data information	Disadvantage
Install base	Overstate mos[illegible] time, Different t[illegible]quired for different fab to compare
Spin Curve/Swing Curve	/
Process window data Dense/ISO FEM/Cross-Section MEFF, Linearity etc(very few)	1. Don't know real product Hot Spot process window 2. No Post OPC result, data only limited to single structure 3. Illumination source is not suitable for actual litho process

OPC can cover!

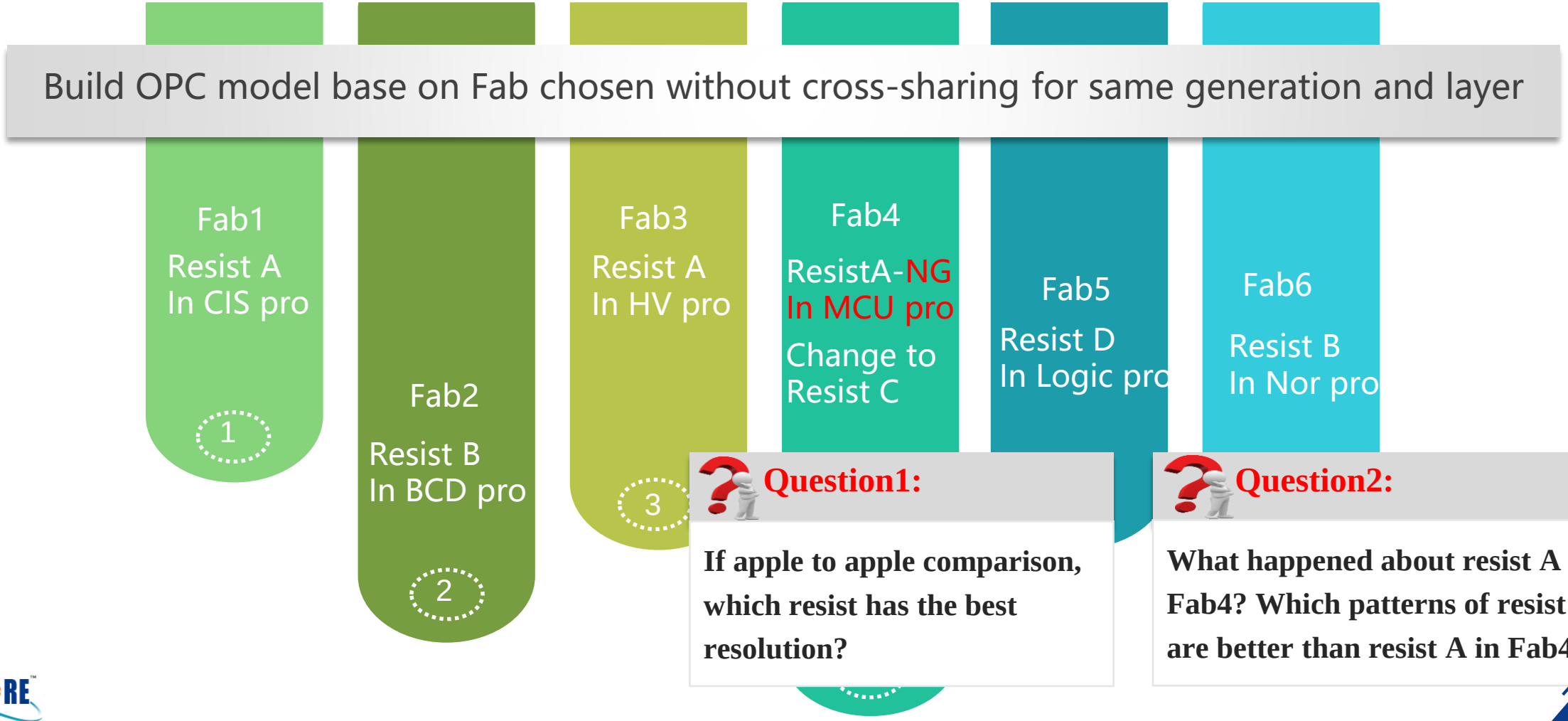




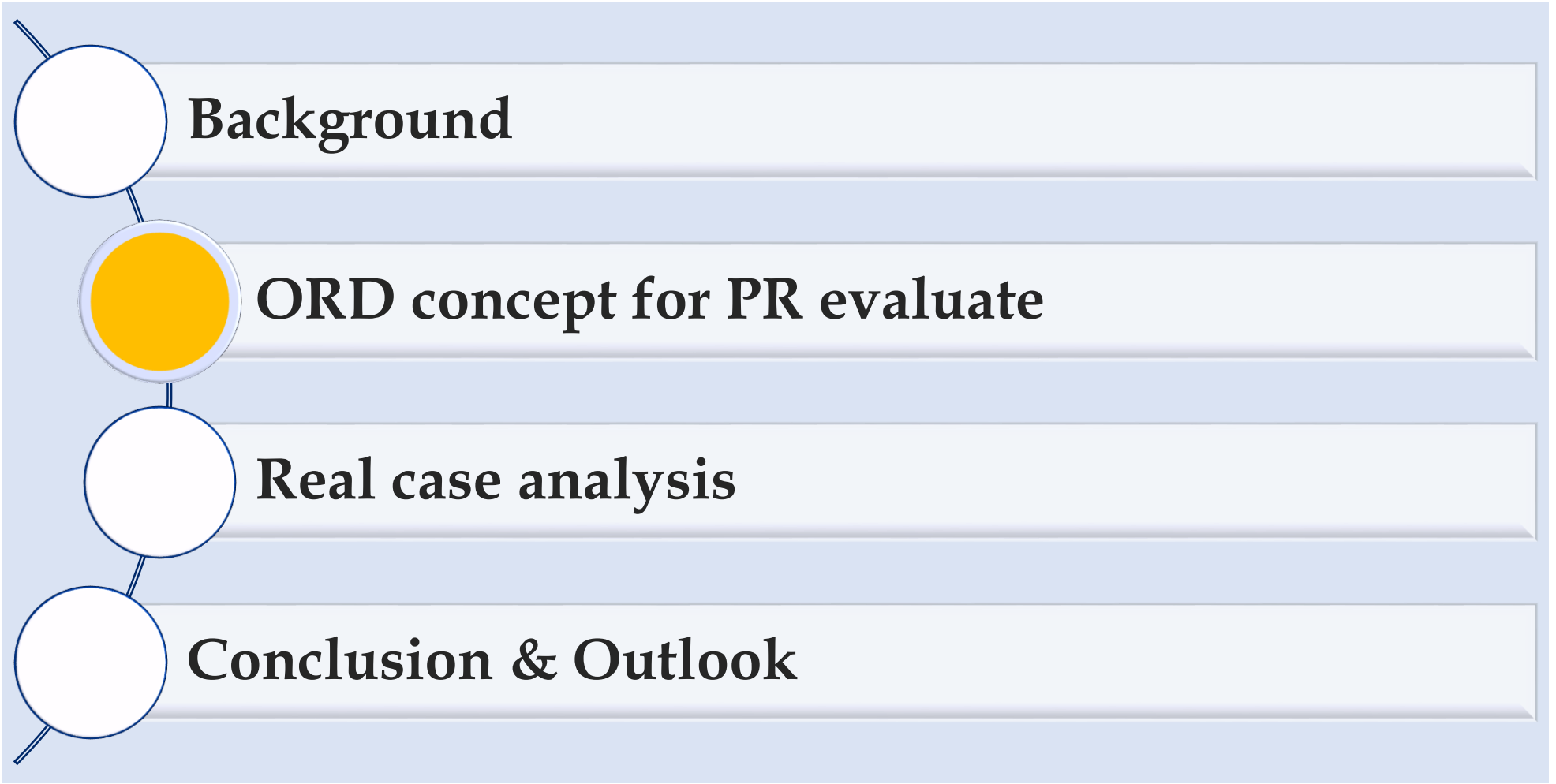
Traditional OPC practice

Content

- Traditional OPC set up is based on the fab conditions provided by the lithography department and the information is confidential.



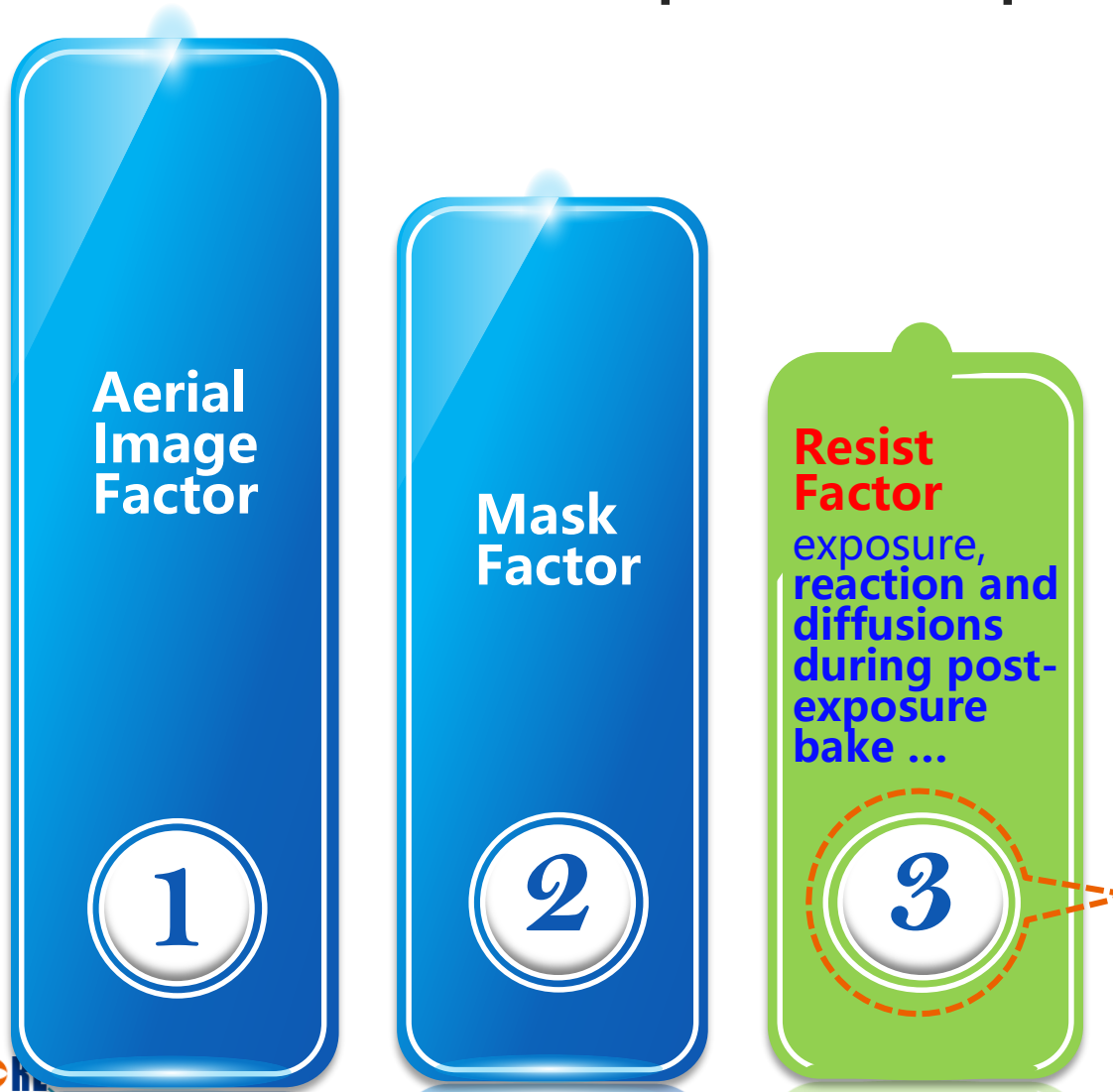
Outline



The New Concept of ORD (Optical-Resist Delta)

■ Modular structure correspond to real process.

Resist Model



Optical model : OPC simulation result base on source+machine+mask+filmstack NK value

Resist model: OPC output with resist terms base on collected wafer data

- Acid diffusion
- Neighbor pattern influence
- Local pattern density effect
- Acid-base concentration
- (Contrast dependent resist bias)
- ...

The New Concept of ORD (Optical-Resist Delta)

■ New concept of ORD for photoresist evaluation

➢ **ORD formula:**

ΔORD = (Indicator) Optical - (Indicator) Resist

Note: Indicator include **NILS,DOF,MEFF etc.**

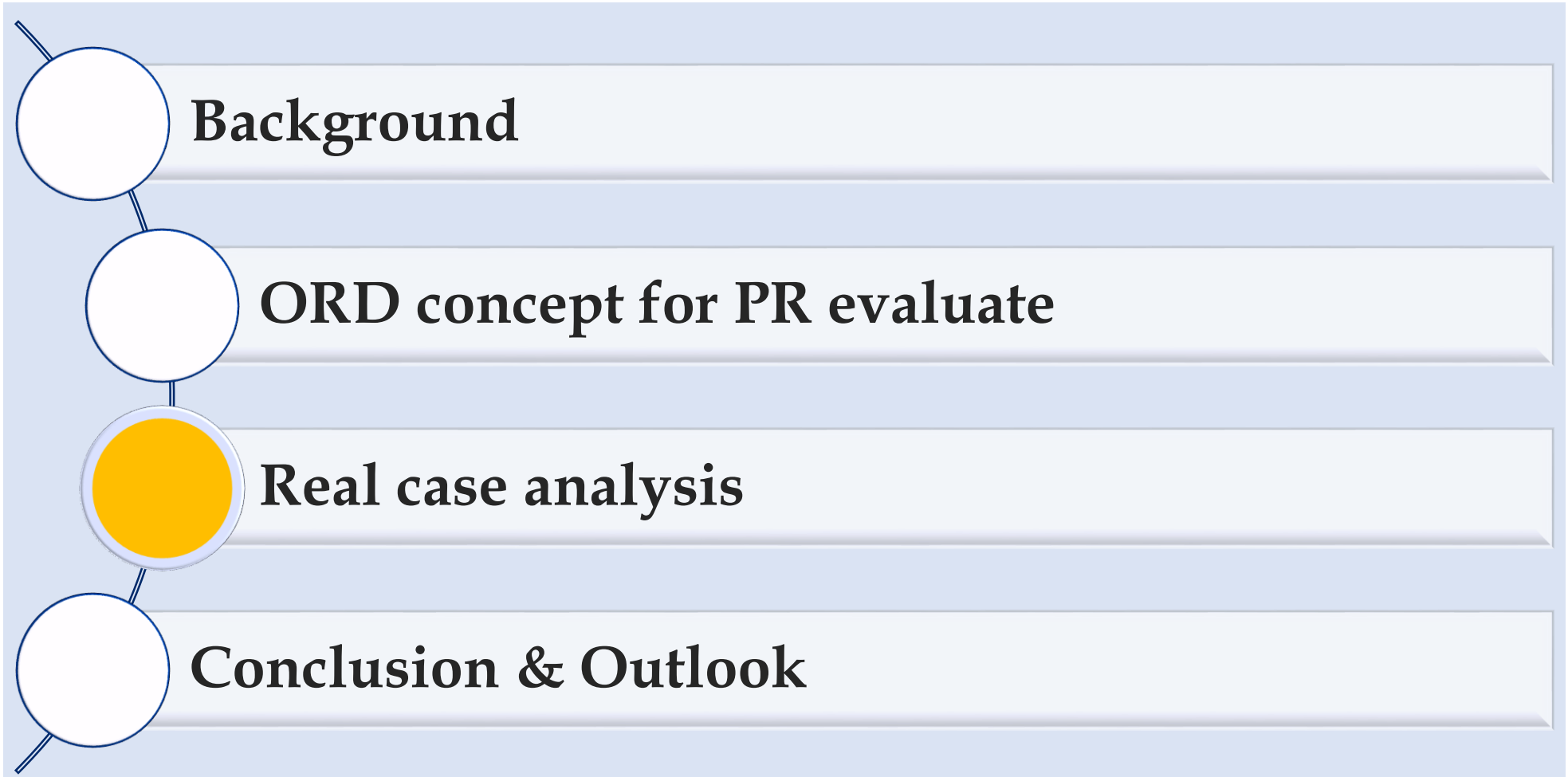
NILS will be the major indicator to explain in paper.

(Indicator) Optical : OPC simulation result base on source+machine+mask+filmstack NK value

(Indicator) Resist : OPC output with resist terms base on collected wafer data

Criteria **ORD_NILS small →Good, ORD_NILS large →Poor**

Outline



The Real case using ORD Concept to judgment Resist

■ E.g. condition: 55nm Poly layer

➢ Data collection for Experiment

TABLE I. Data collection condition of poly layer

Quantity		Delta Focus				
		-80	*-40*	*0*	*40*	*80*
Delta Dose (%)	*-5*	220	220	220	220	220
	-2.5	220	220	220	220	220
	0	220	220	220	220	220
	2.5	220	220	220	220	220
	5	220	220	220	220	220
Total quantity		5500				

Big data

➢ Set up Poly layer OPC FEM model

$$EL = \frac{\Delta CD}{E}\frac{dE}{dCD} \times 100\%$$

$$EL\ error = EL_{model} - EL_{wafer}$$

High precision

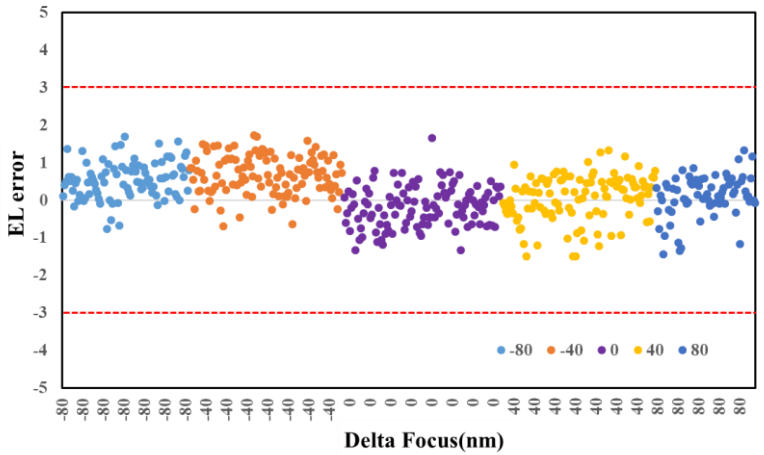


Fig. 1. Wafer and model EL error of A photoresist

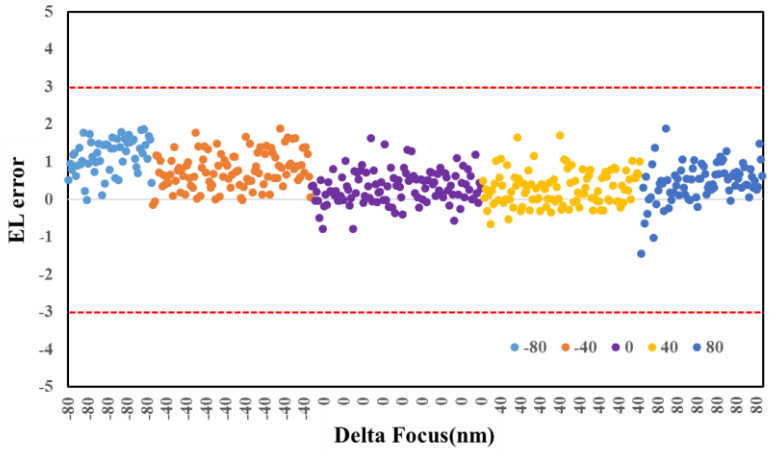


Fig. 2. Wafer and model EL error of B photoresist

The Real case using ORD Concept to judgment Resist

- **E.g. condition: 55nm Poly layer**
  - Results and Discussion for **Through Pitch** of A and B photoresist

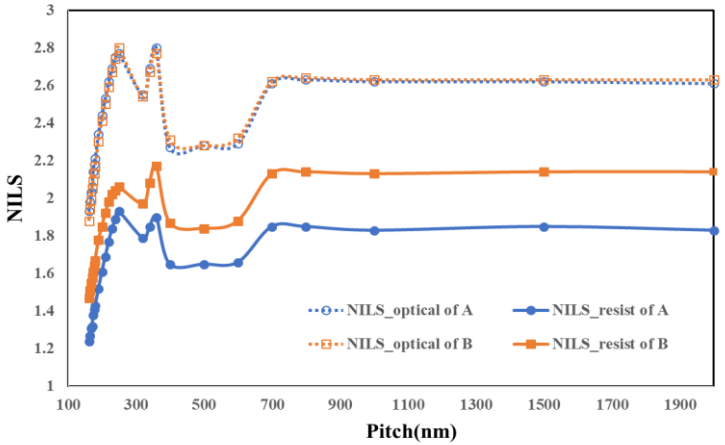


Fig. 3. NILS analysis of different photoresists A and B

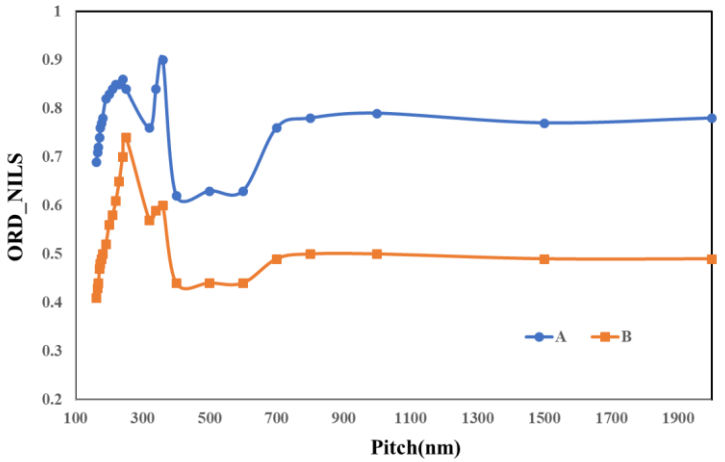


Fig. 4. ORD analysis of different photoresists A and B

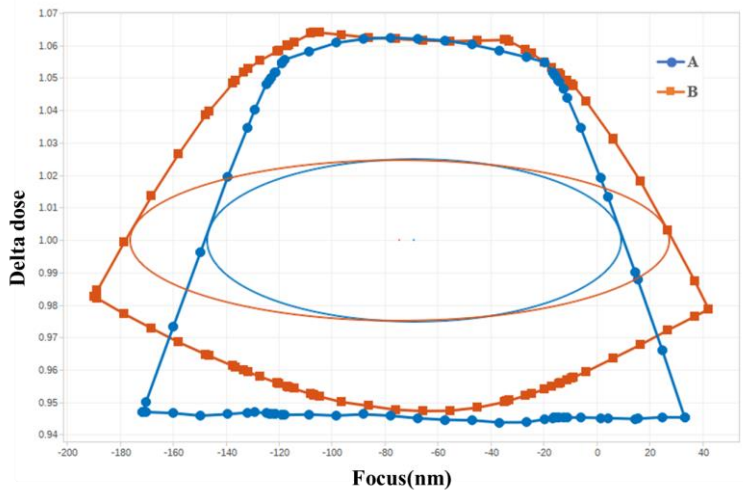


Fig. 5. DOF analysis of different photoresists A and B

✓ **Conclusion: ORD_NILS B small → Good**

ORD_NILS A large → Poor

The Real case using ORD Concept to judgment Resist

- **E.g. condition: 55nm Poly layer**
  - Results and Discussion for **Hot Spots predict** of A and B photoresist

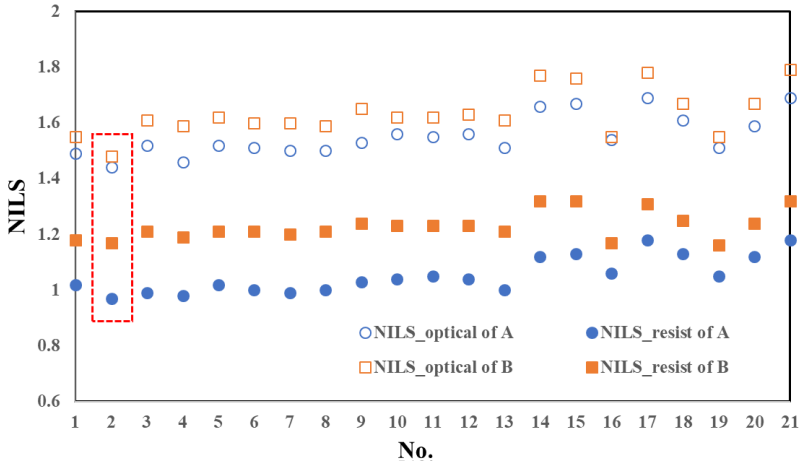


Fig. 6. NILS analysis of different photoresists A and B

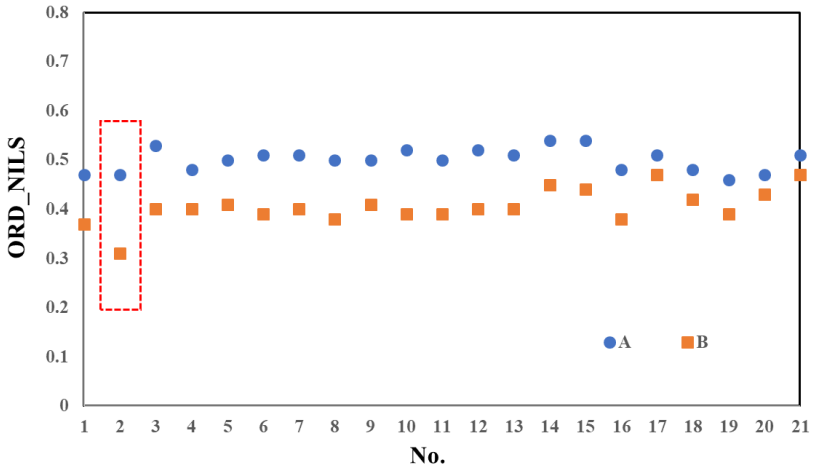


Fig. 7. ORD analysis of different photoresists A and B

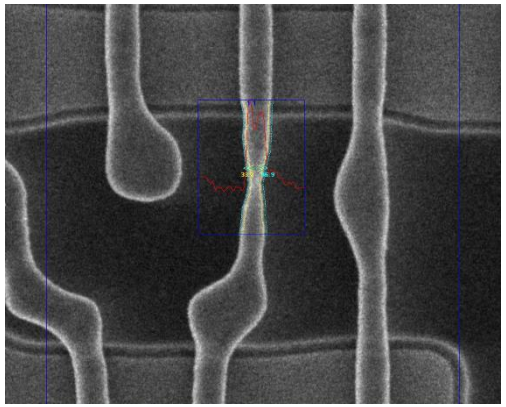


Fig. 8. Hot spot for NO.2 of A photoresist

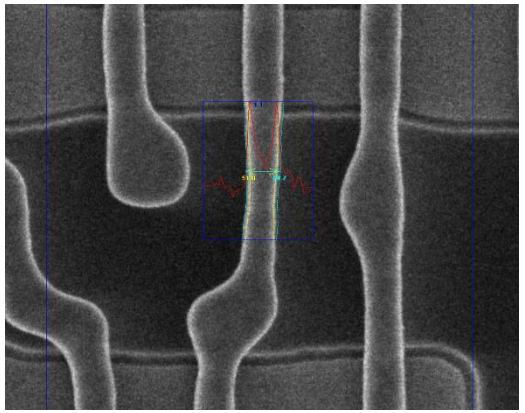
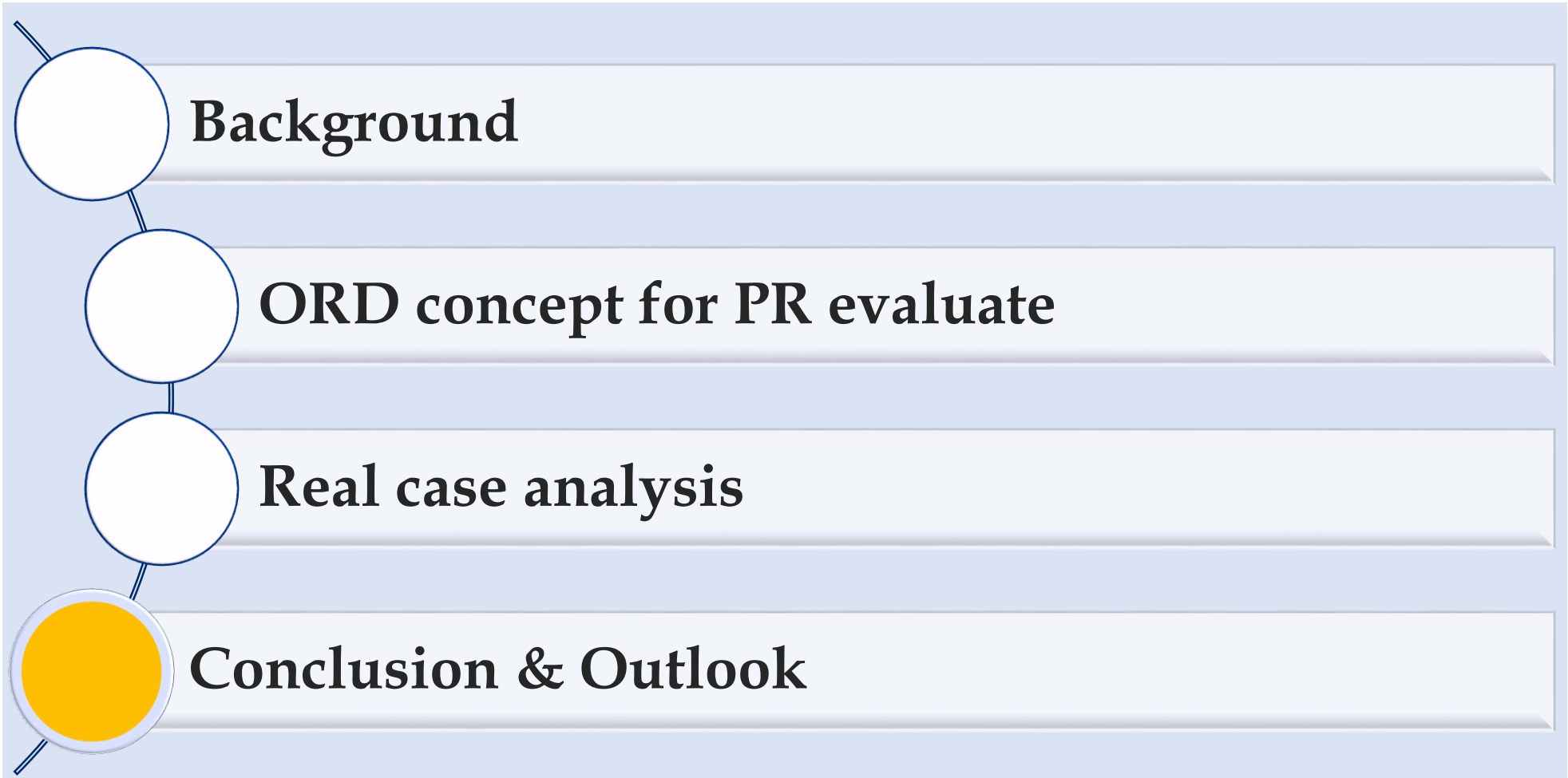


Fig. 9. Hot spot for NO.2 of B photoresist

✓ **Conclusion: Hot Spot B small → Good**

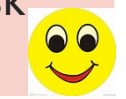
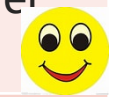
Hot Spot A large → Poor

Outline



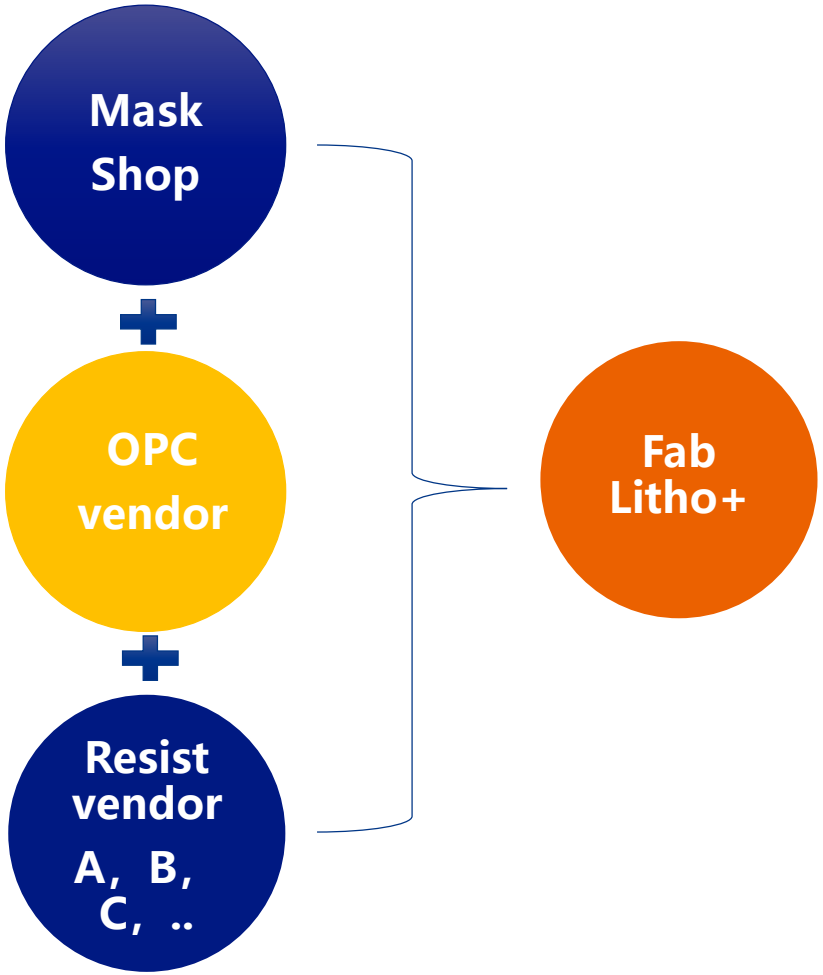
Conclusion

- **The new ORD approach provides a good complement to the traditional method.**

	Traditional	ORD solution
Source	Resist vendor/fab with different source	Optimize lib DOE source 
Judgement data sample size	General<50	>5000points 
Weak-point detection	Only PWQ scan after production Reticle tape-out	ORD higher point in OPC test mask before product mask tape-out 
Resist Capability Judge Ruler	Different fab, Different Resist vendor, different ruler	Same ruler for one generation+layer (same OPC gauge + same source) 
Resist Selection	Benchmark&put in	ORD data in system pre-check (in-future) 

Outlook

- **“ One Button "solution maybe be realized in the future**
  - For specific generation/layer, OPC data collection base on same source/gauge/anchor point/target.
  - **OPC software can integrate different resist ORD information.**



One Button:

Select proper Resist

Correction and verification with existing resist OPC model

Resist vendor to diagnose weakness

THANKS