AK OPTICS
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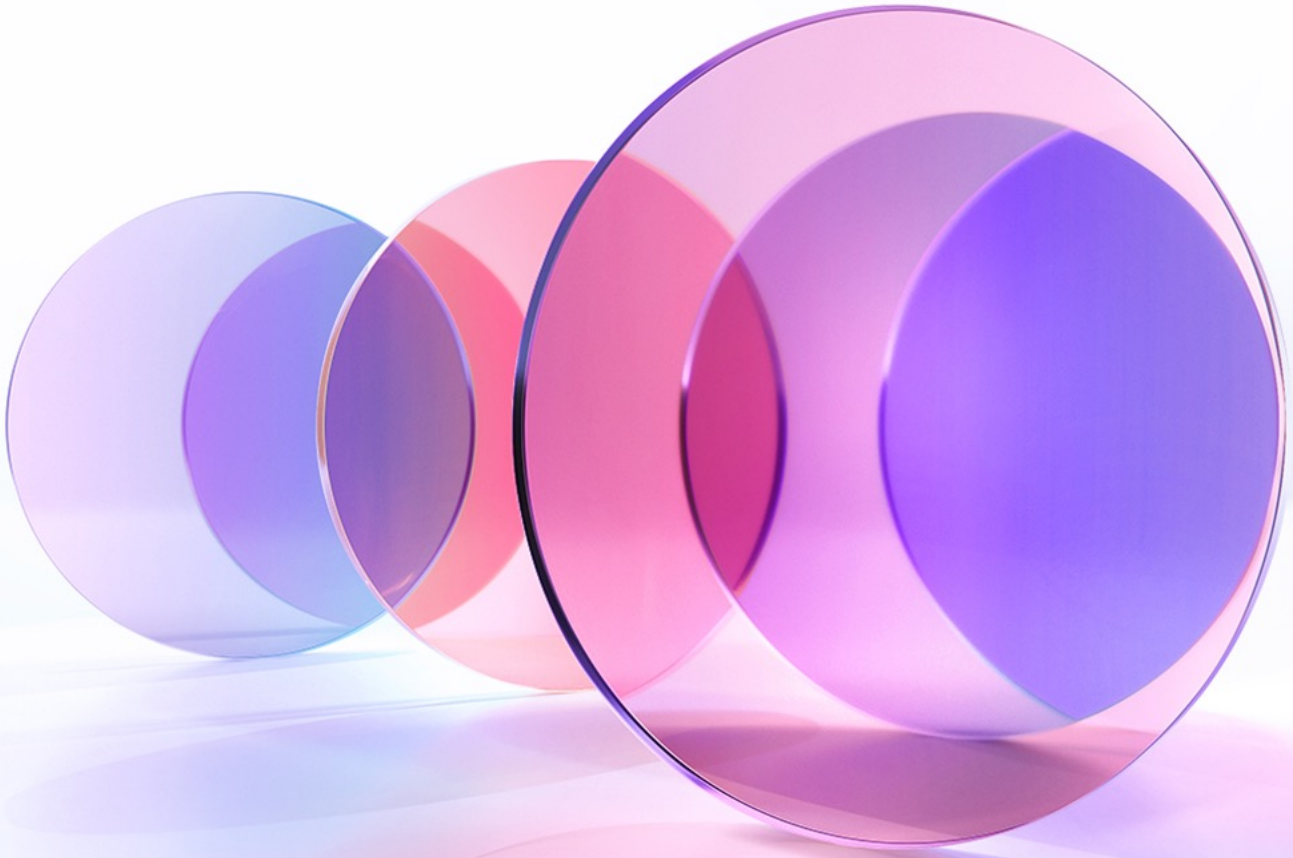


A HYBRID INSPECTION SYSTEM FOR SIC SUBSTRATE AND EPI WAFERS

APRIL 2024

CONTENTS

Dual laser vs. DIC microscopy for SiC Substrate

- Either DIC microscope or dual laser tools is used for SiC defect inspection.
- It became known that **each technology has its own pros and cons**

Defect type	Dual laser	DIC Microscopy	AK Comment
particle	good	poor	Bright field DIC and large pixel resolution (1.75um), not good for particle and shallow scratch
scratch	good	poor	
Micropipe	?	poor	Both poor
IDL	good	NA	
Inclusion	OK	OK	Usually not consistent
Pit	?	OK	Dual laser usually not good for pit and bump
Bump	?	OK	
PL SF	good	Poor	Xe-hg lamp maybe too weak for SF excitation
PL Black	NA	good	PL NIR is good for PL Black and white

Can both technologies be implemented in one system?

E3500G3^{XP} System Configurations

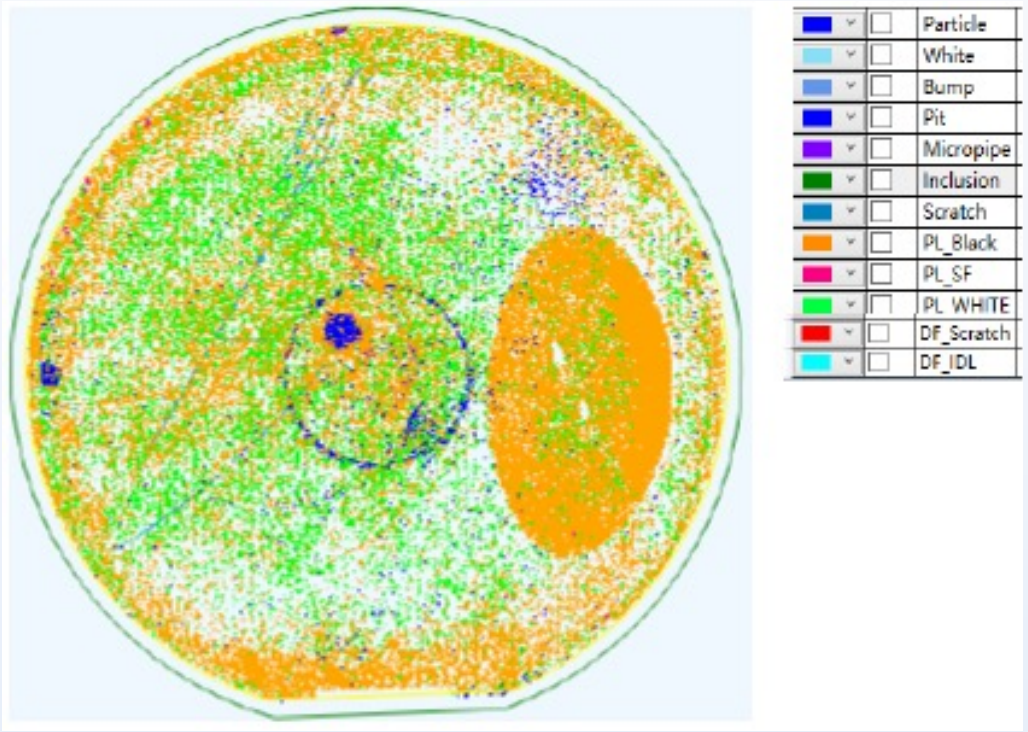
- Pixel 0.5um with DIC line scan
- Polarized light for better micropipe capture
- Laser dark filed capable down to 60nm
- Dual PL laser option: better S/N ratio for PL defects

Defect type	Dual laser	DIC Microscopy	E3500G3^{XP}
particle	good	poor	good
scratch	good	poor	good
Micropipe	?	poor	good
IDL	good	NA	good
Inclusion	OK	OK	OK
Pit	?	OK	good
Bump	?	OK	good
PL SF	good	Poor?	good
PL Black	?	good	good

Technology Comparison

Comparison	Dual laser	Conventional DIC	E3500G3^{XP}
Bright Field	?	Area scan with DIC	Line scan with DIC
BF pixel resolution	?	1.75um	0.5um
Dark Field	405 oblique laser 355nm ScN	365nm area scan	450nm oblique laser
DF Sensitivity	60nm	?	60nm
PL Channel	VIS/NUV	PL NIR PL VIS for separate scan	PL NIR and VIS
PL Source	355nm laser	Hg-xe lamp	Dual Laser

One map covers all

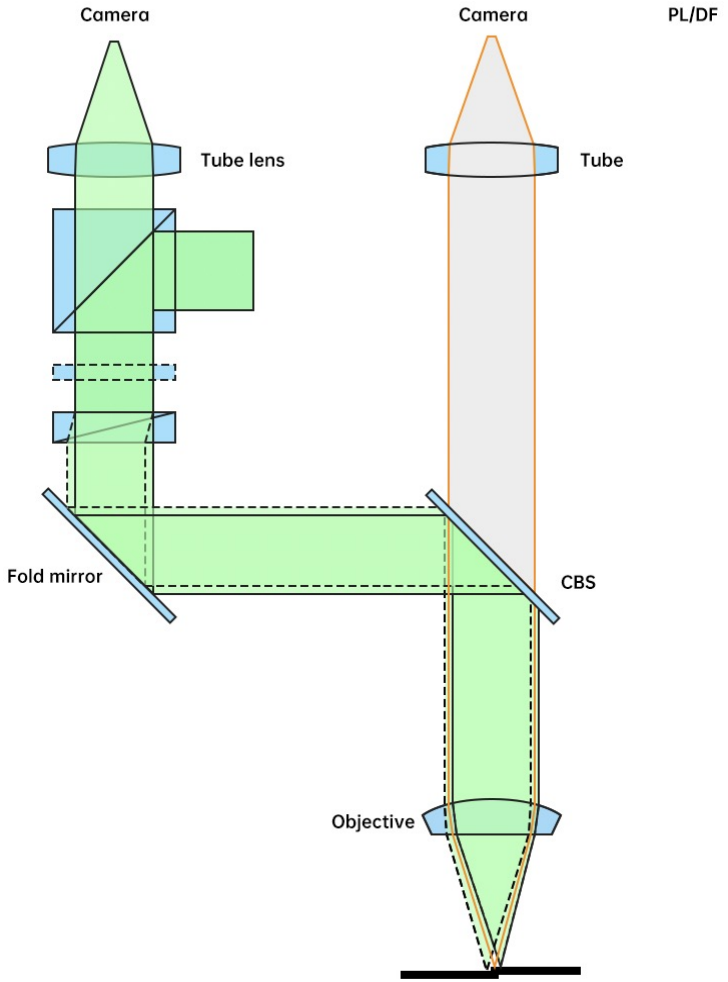


- One system can benchmark with both conventional tools
- Use can choose inspection recipe:
  - all
  - dual laser mode only
  - DIC microscopy mode only

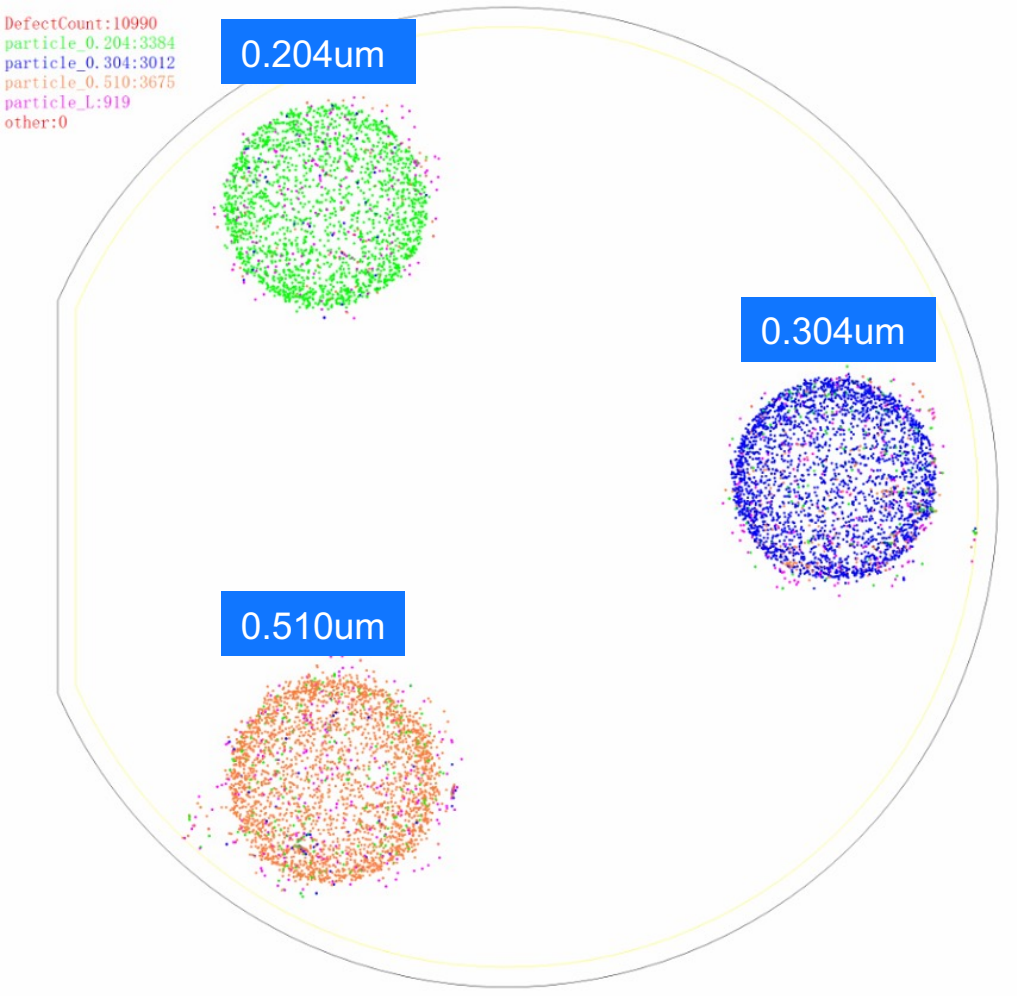
In-house designed optics of E3500G3^{XP}

Configurations	Key Spec
BF with DIC	✓200nm sensitivity
DF	✓ 60nm sensitivity
PL	✓Laser source for PL excitation ✓PL NIR channel inspection ✓PL VIS channel
Defect classification Algorithm	In-house developed artificial intelligence engine for defect capture and classifications
Scan method	Line scan
Throughput	✓ 9 WPH 6inch for SiC substrate (high sensitivity mode) ✓ 12 WPH 6 inch for SiC epi wafer ✓ 15 WPH 6 inch if only comparing with other DIC tools

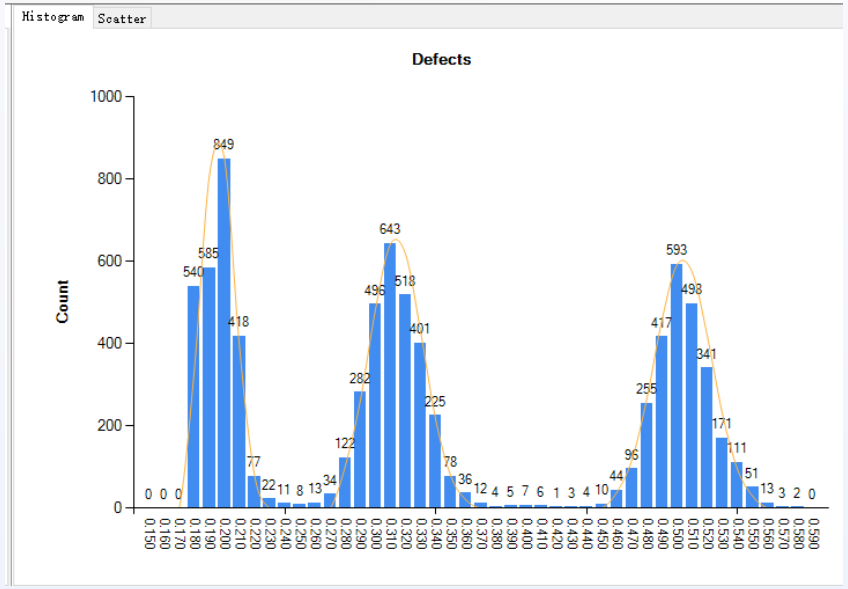
Main optics

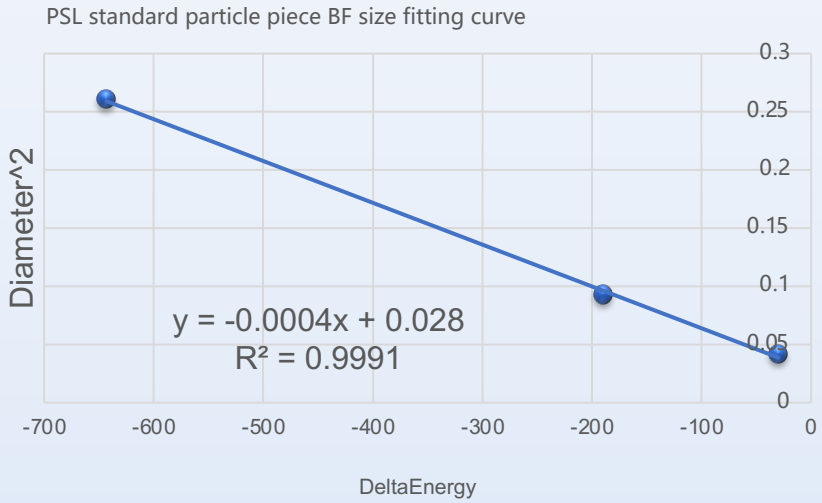


PSL wafer calibration for Bright Field



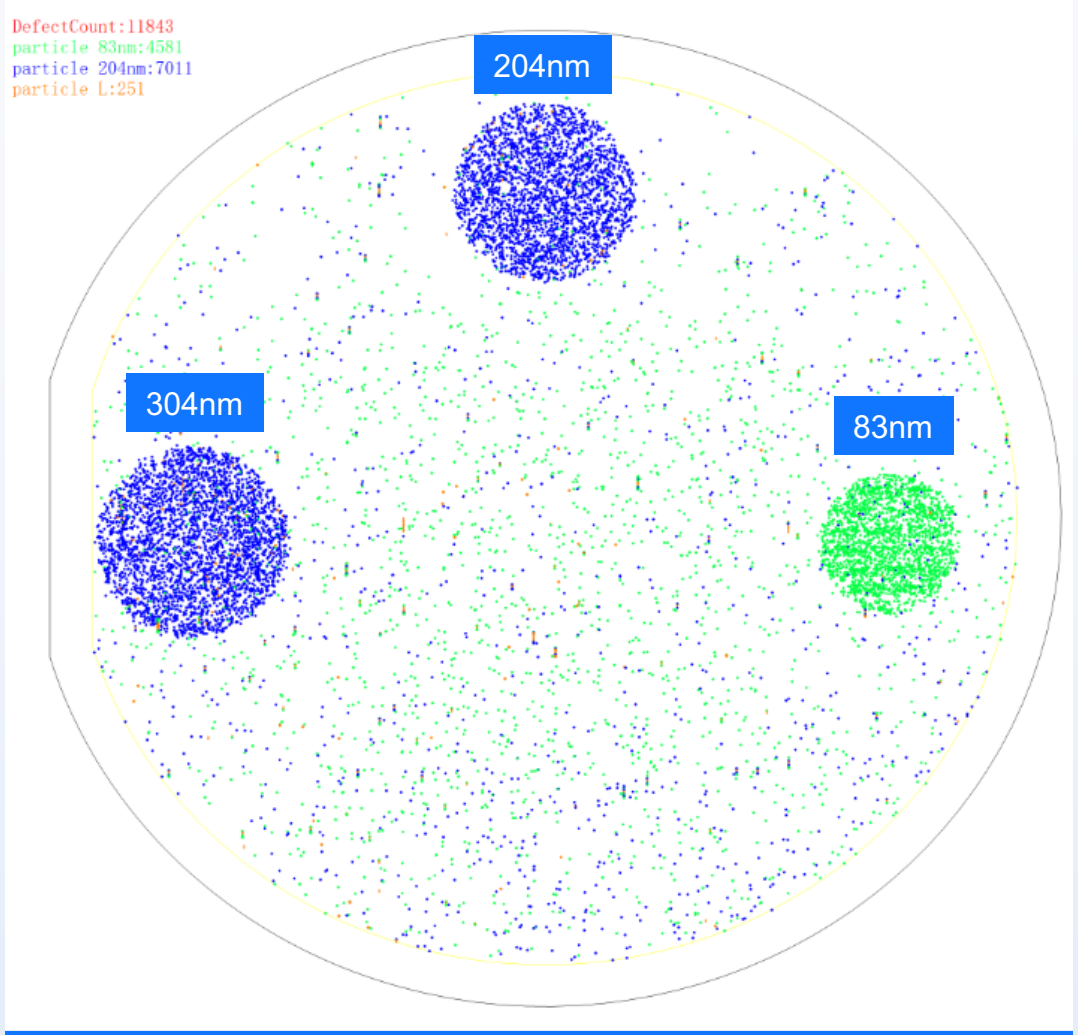
PSL standard particle map





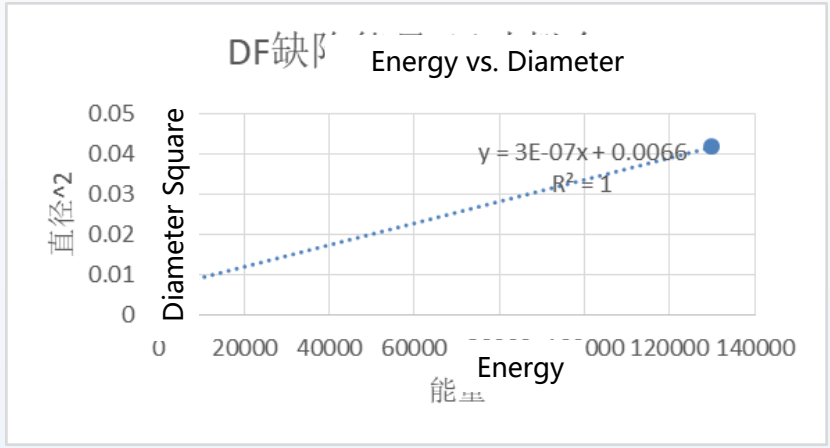
Particle size calibration curve

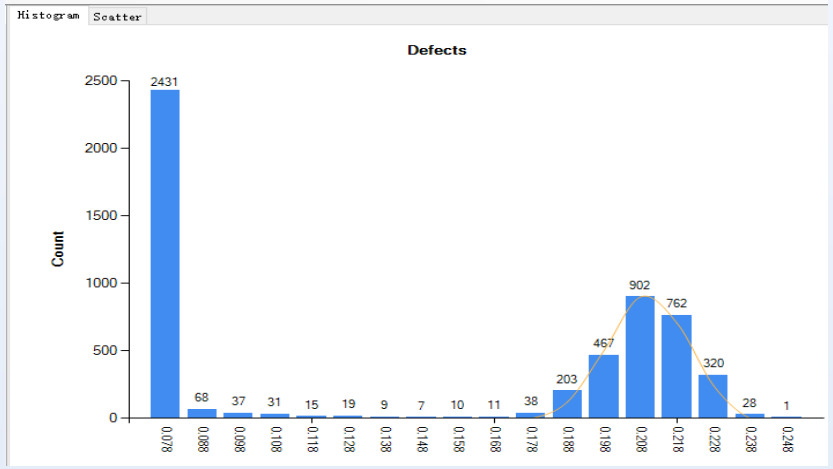
PSL wafer calibration for DF



Dark field PSL wafer defect map

Particle size calibration curve

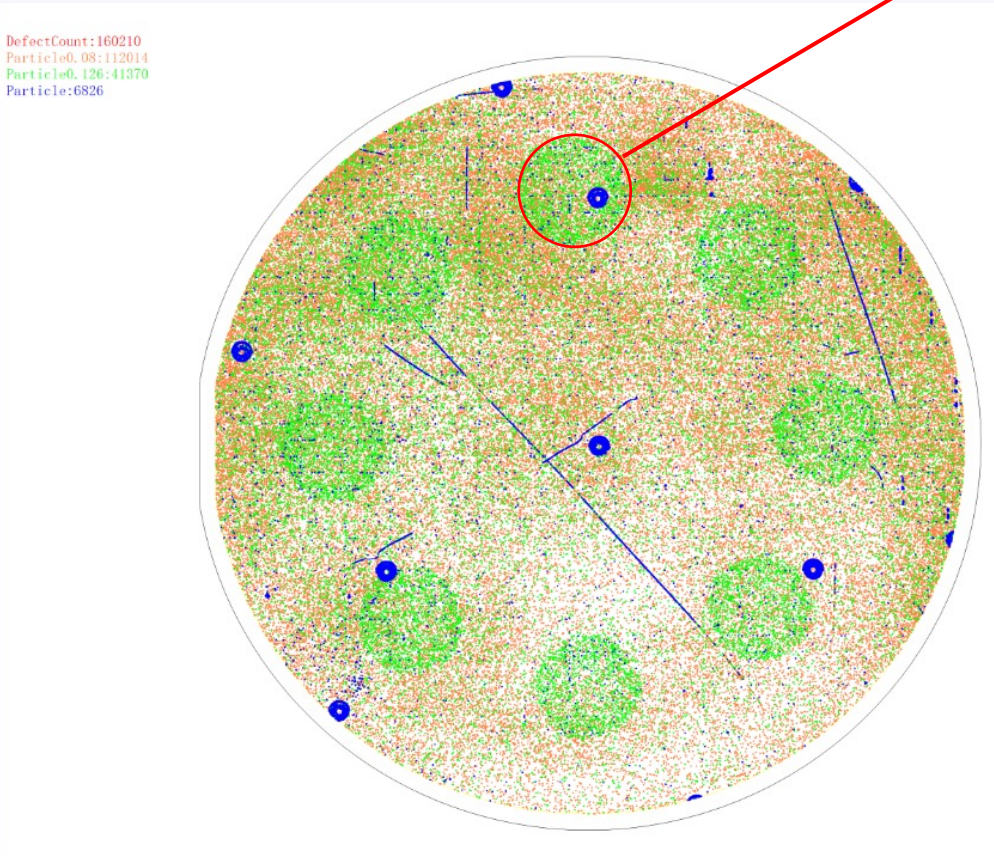


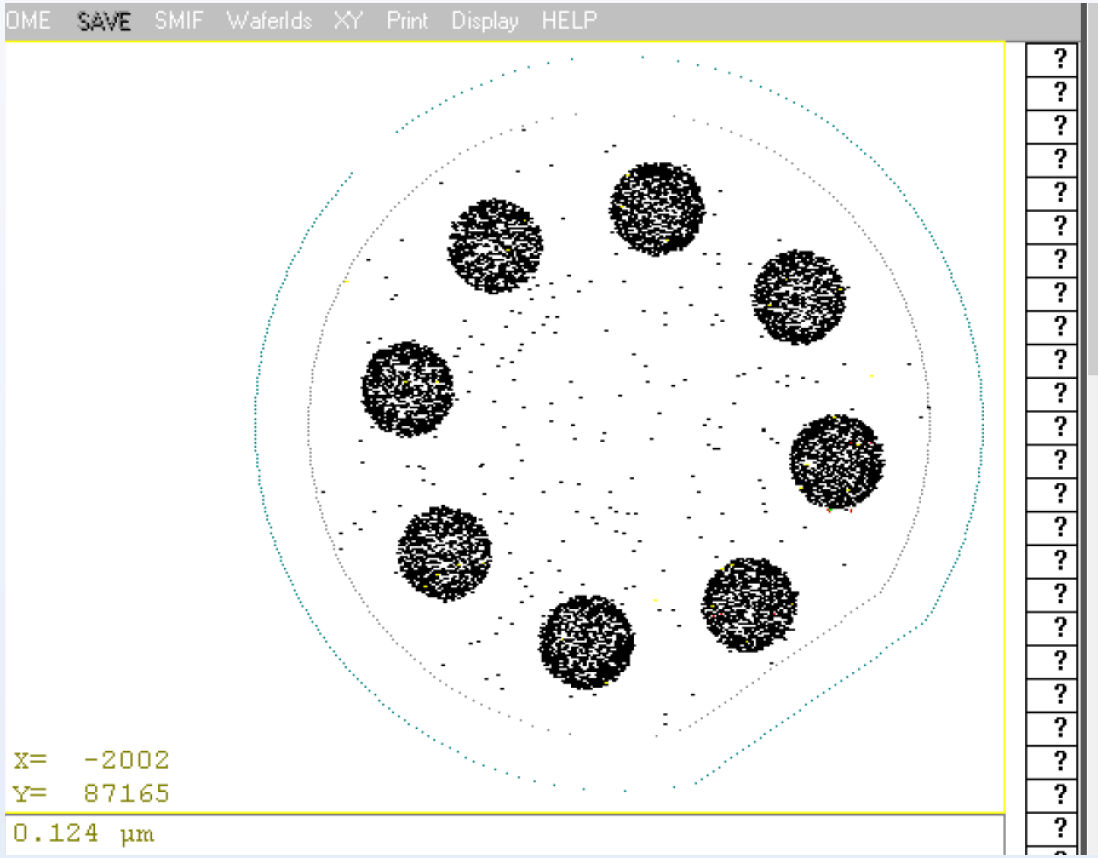


83nm and 204nm diameter

PSL on SiC substrate calibration

124nm PSL particle on SIC





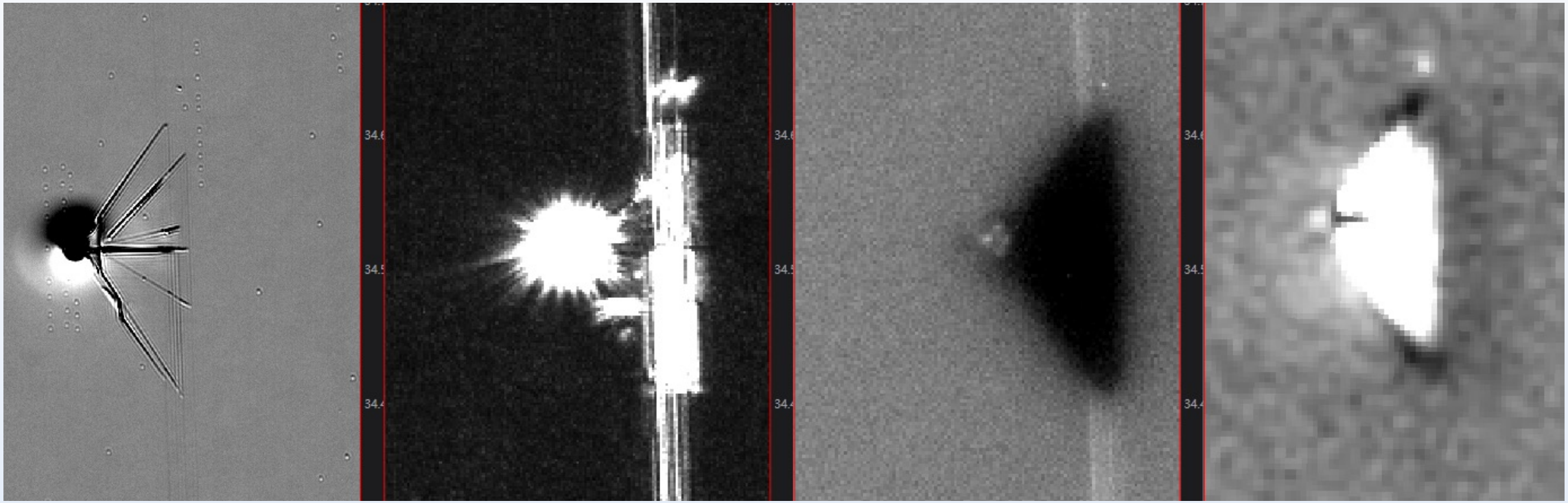
Four channel inspection for better defect classifications

BF

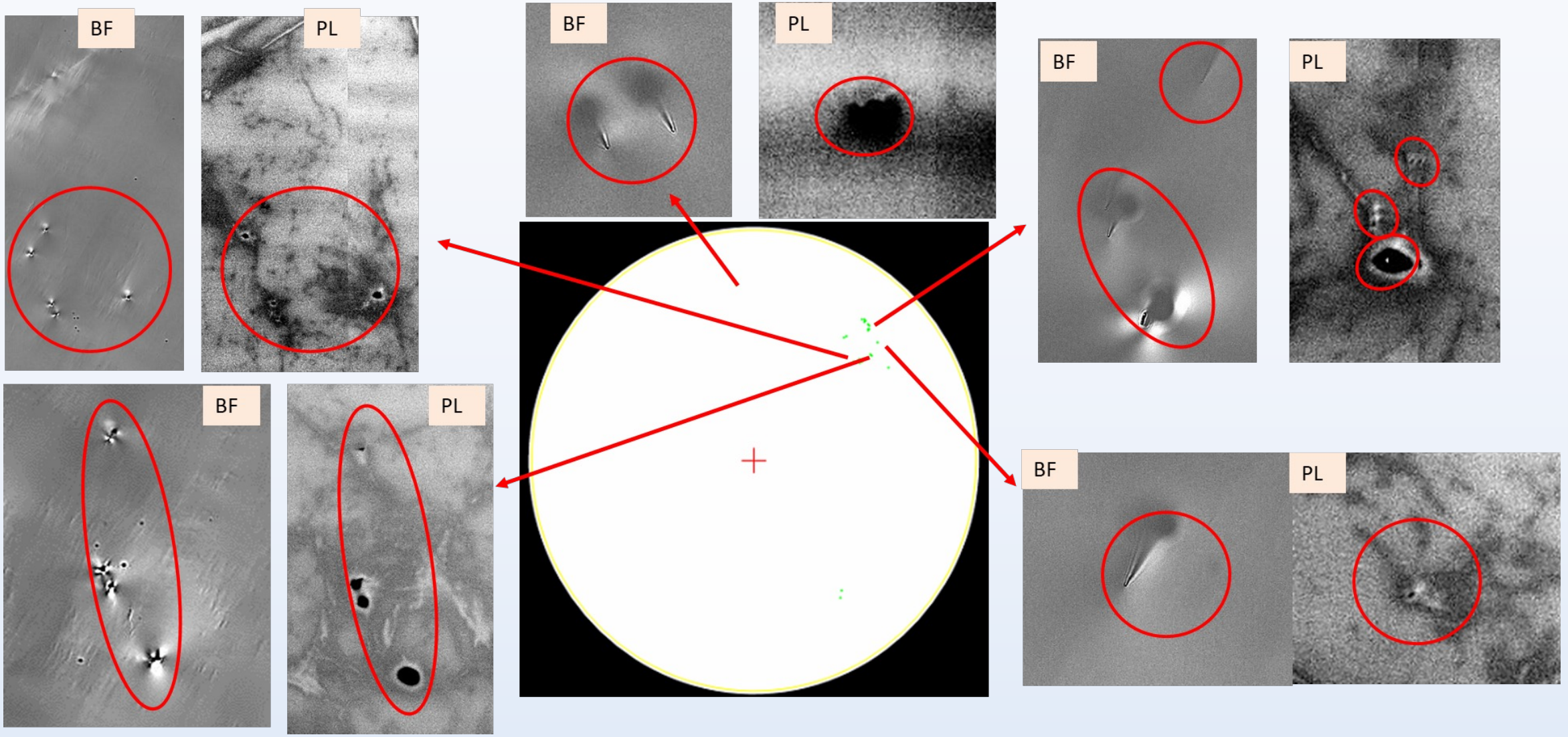
DF

PL

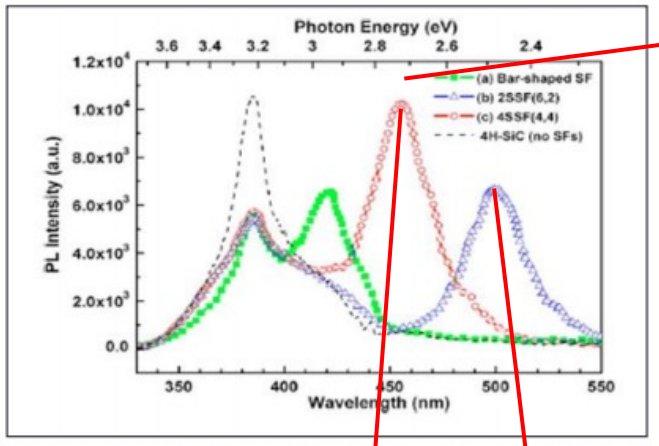
PLX



Polarized light for better micropipe detection

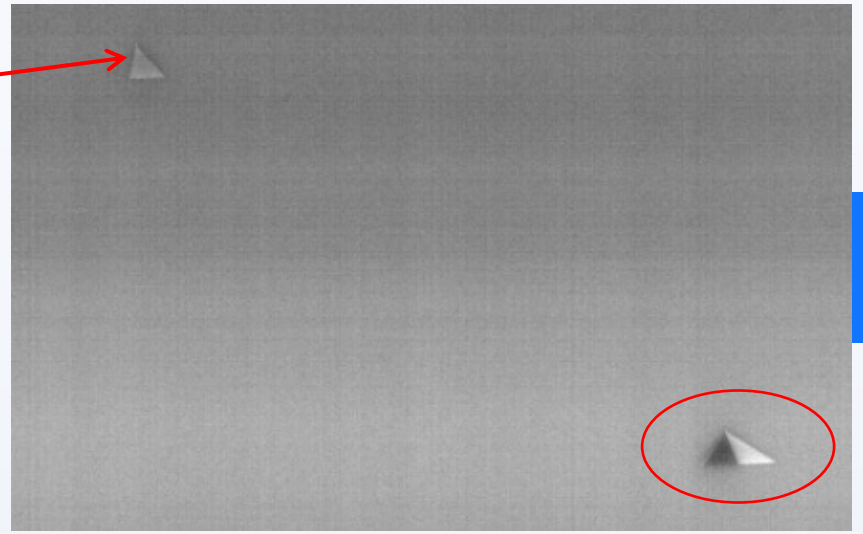


Differentiate SSFs

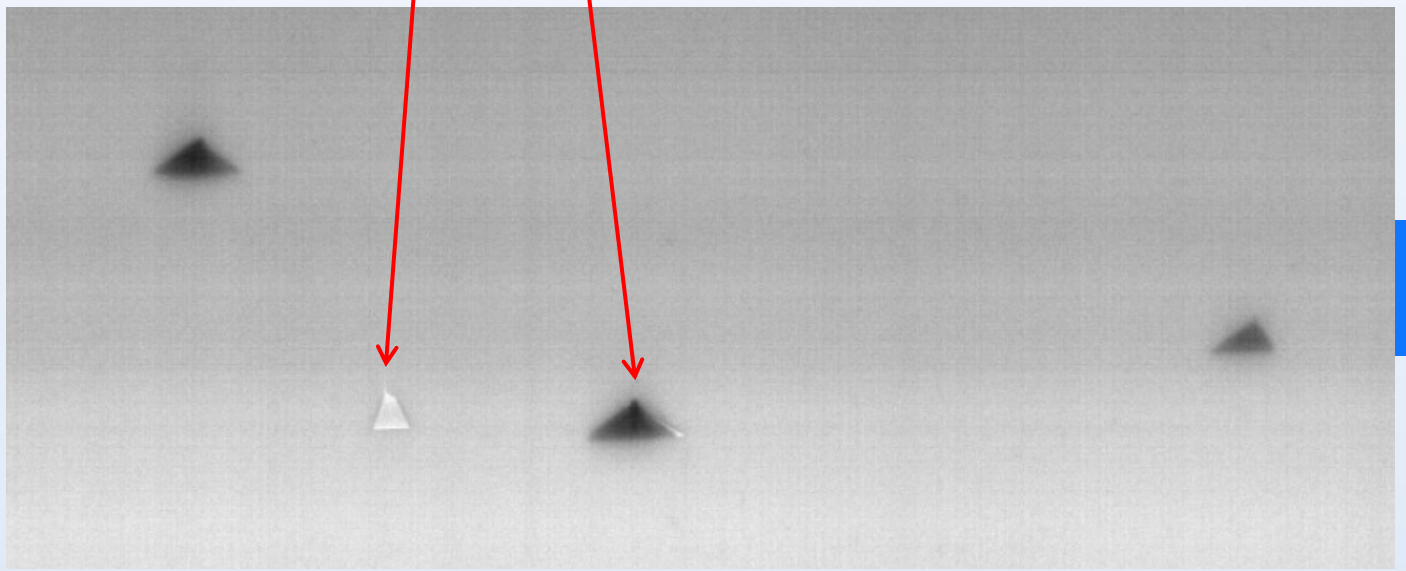


SiC and SFs photoluminescence spectrum

Appl. Phys. Lett. **92**, 221906, 2008

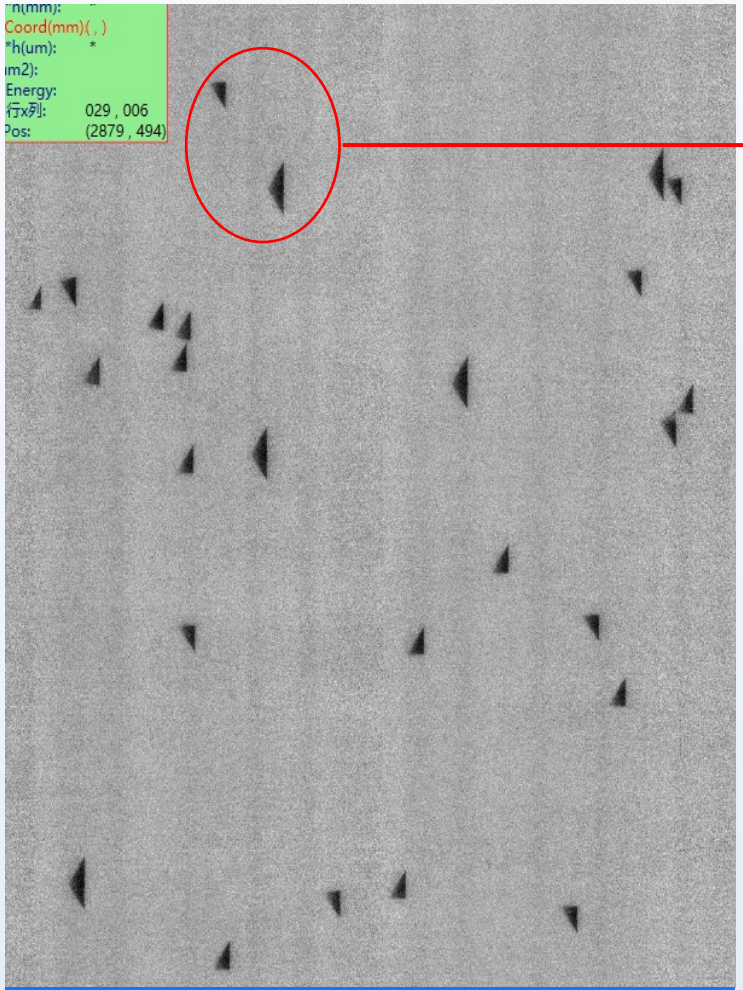


Both 450nm and 500 nm PL SF mixed

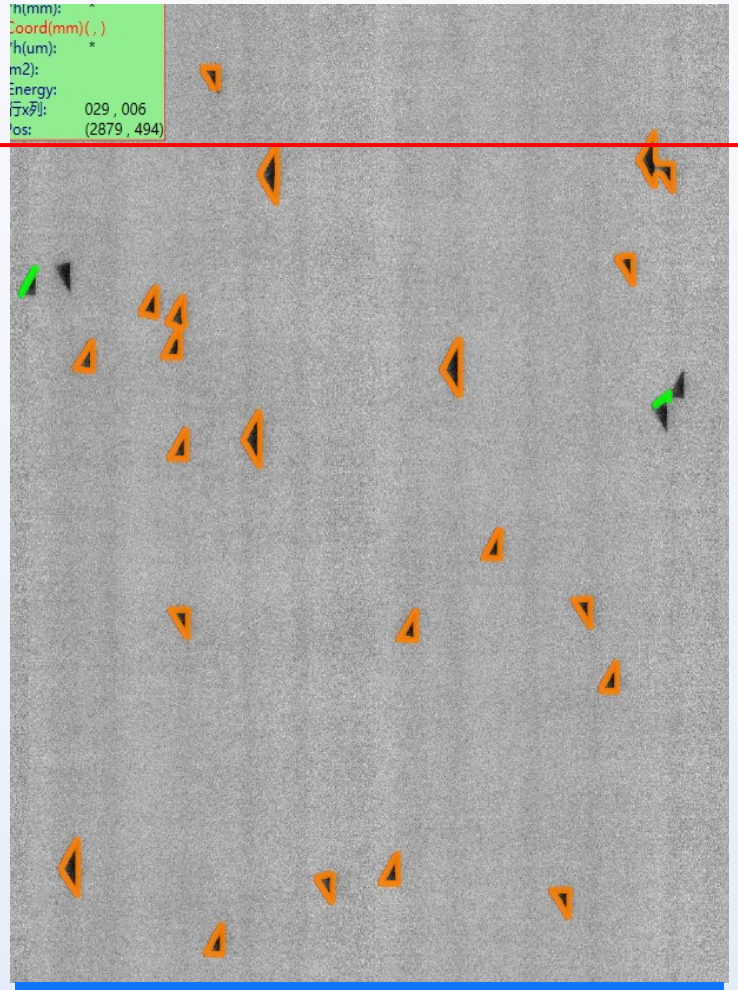


Different PL SF may have different impact on chip performance

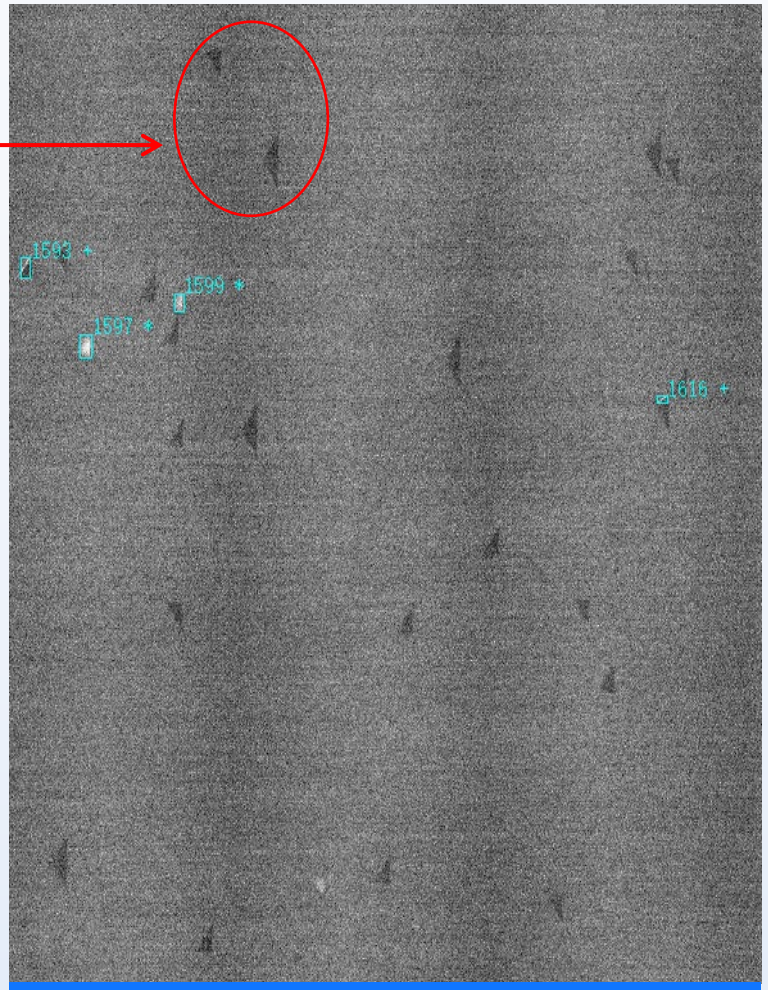
PL laser better for SSF detection than Hg-Xe Lamp



E3500 Image

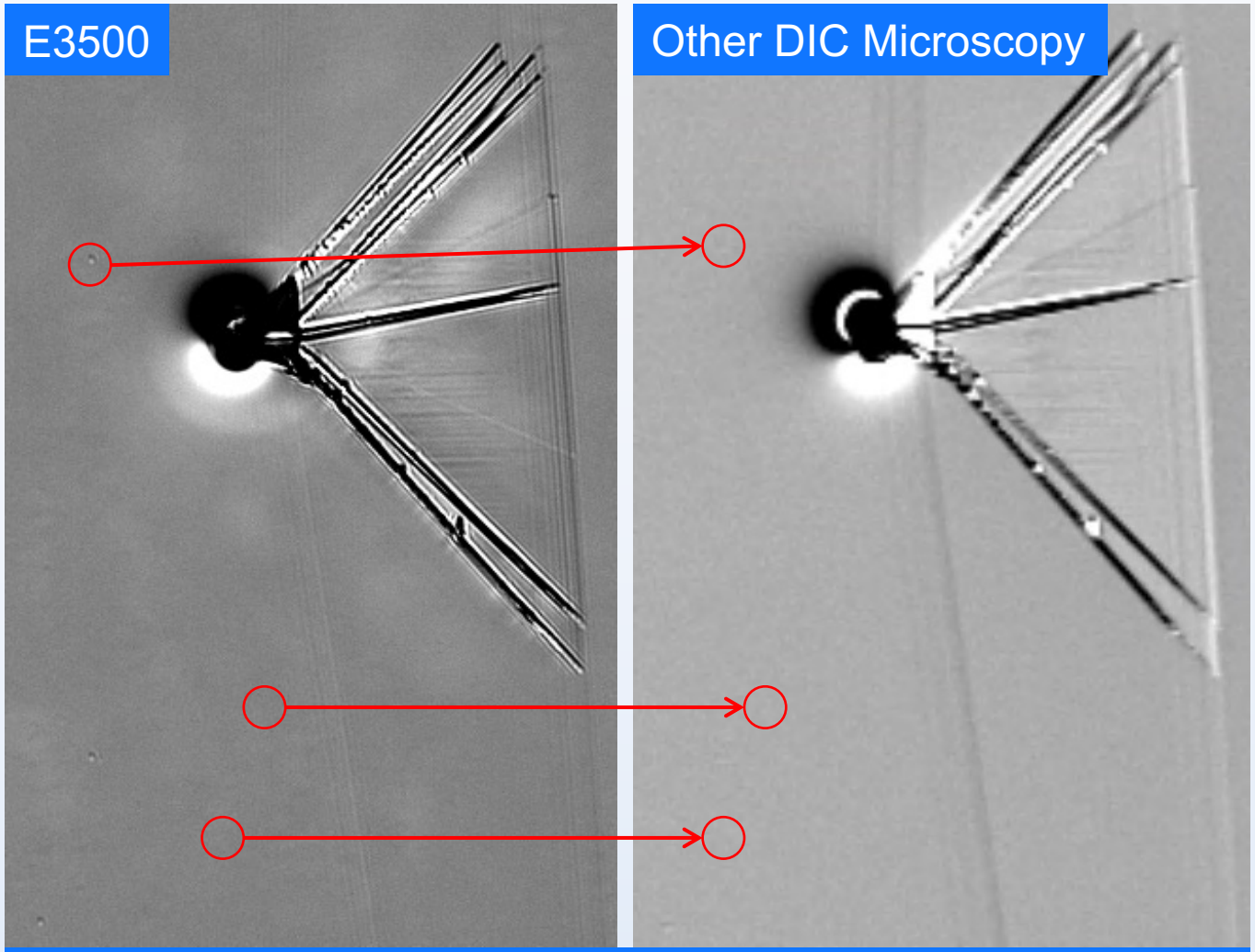


E3500 Inspection Results: more PL SF inspected

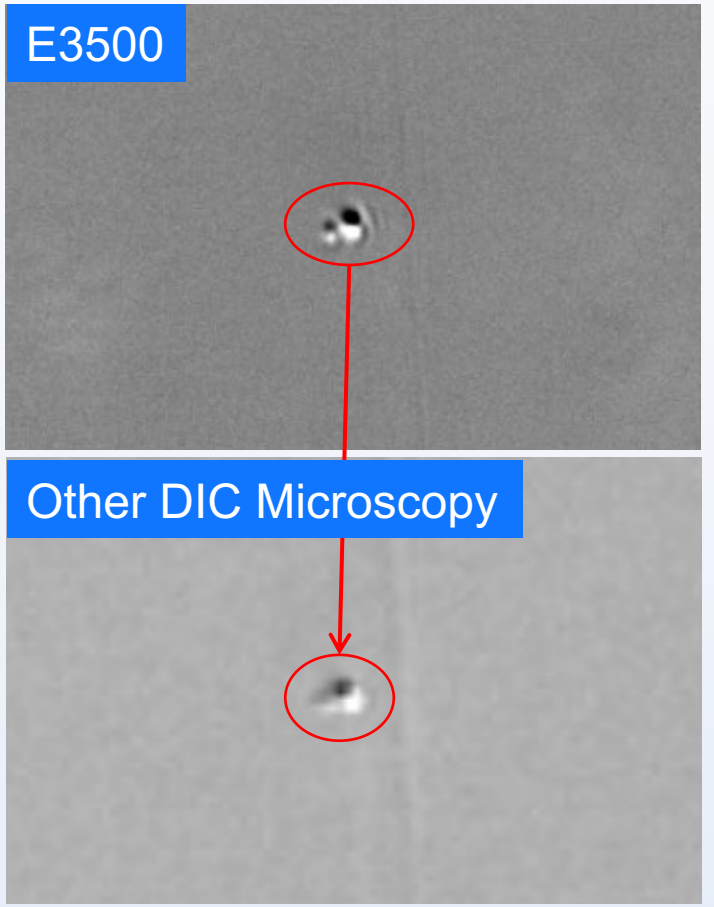


Hg-Xe Image and inspection results: missing PL SF

BF smaller pixel resolution for better small defect capture



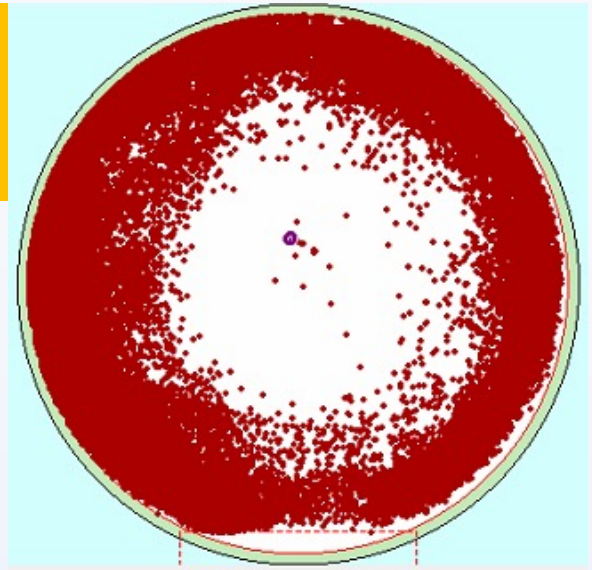
E3500 have a better DIC signal contrast



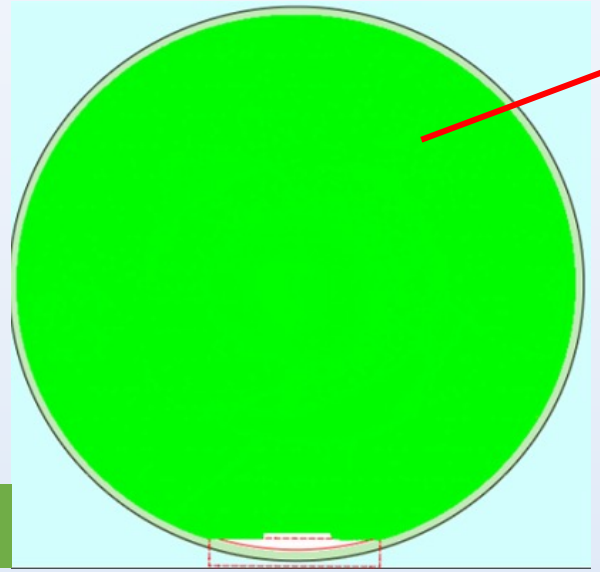
Other DIC Microscopy
can not differentiate two pits
due to large pixel size

BF smaller pixel resolution for better pit capture

Other DIC microscopy：
195,198

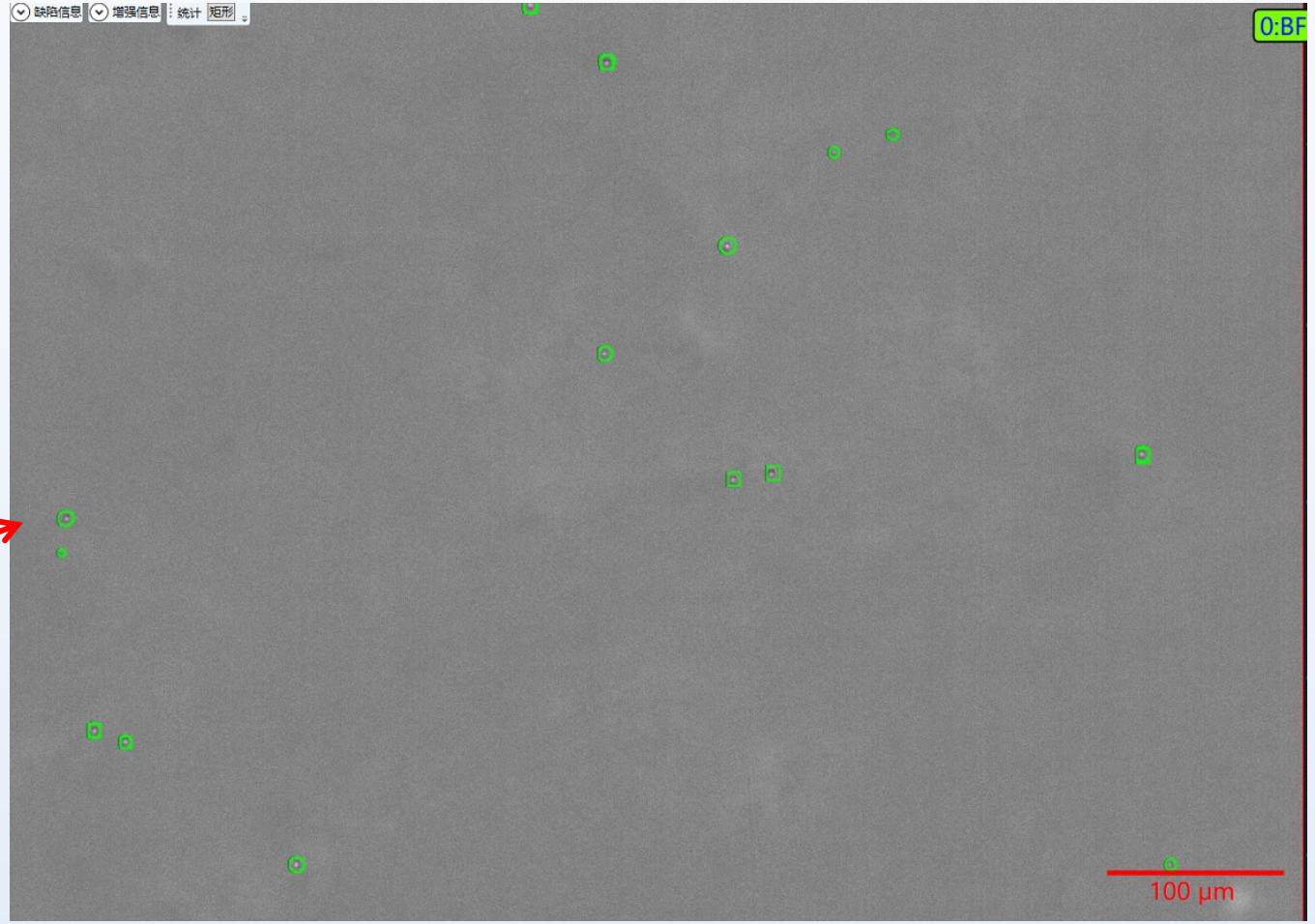


AK：
4,721,589



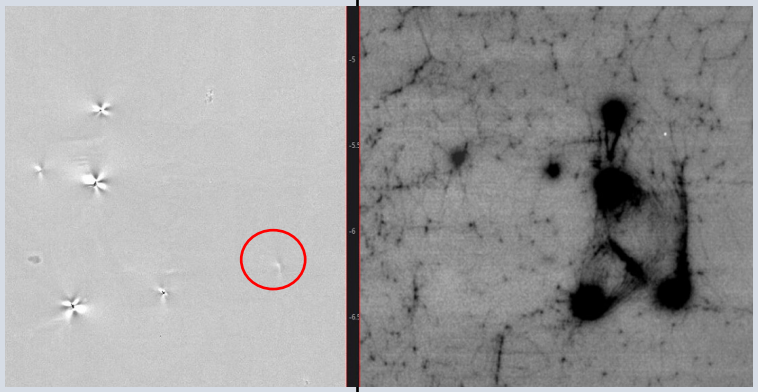
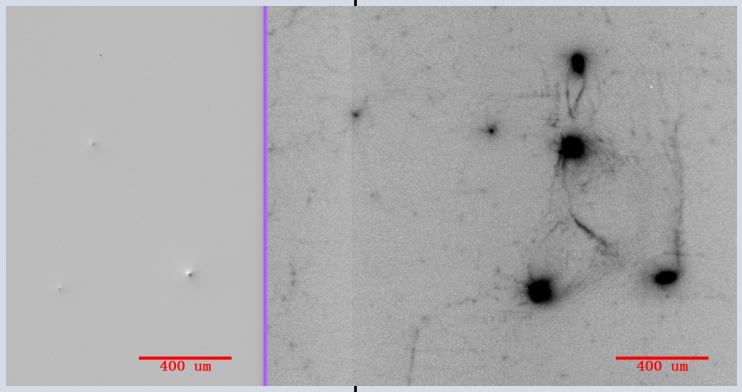
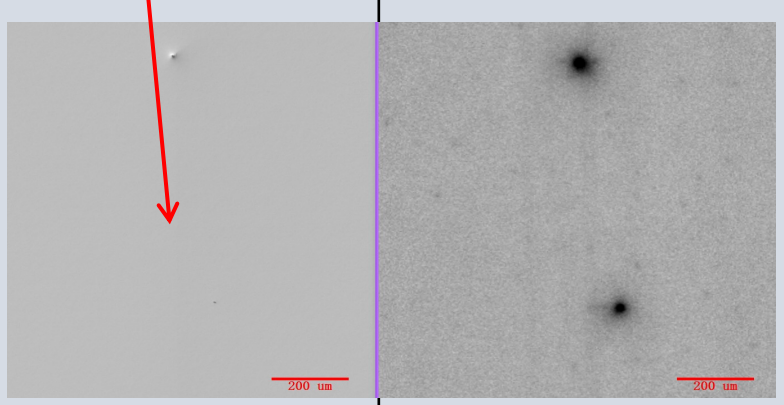
Small pit map

■ More pits reported than other DIC microscopy



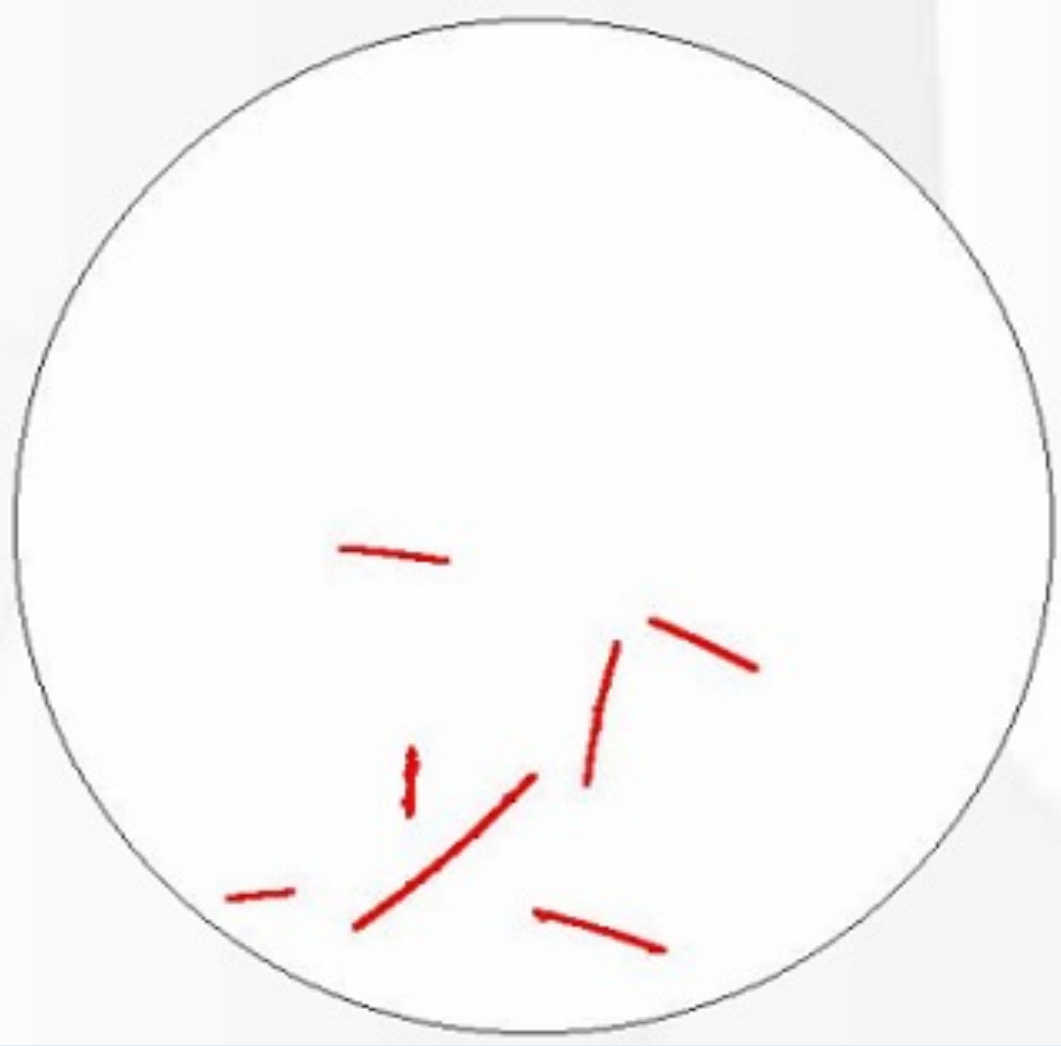
Many pit in center region as well

BF smaller pixel resolution for better micropipe detection

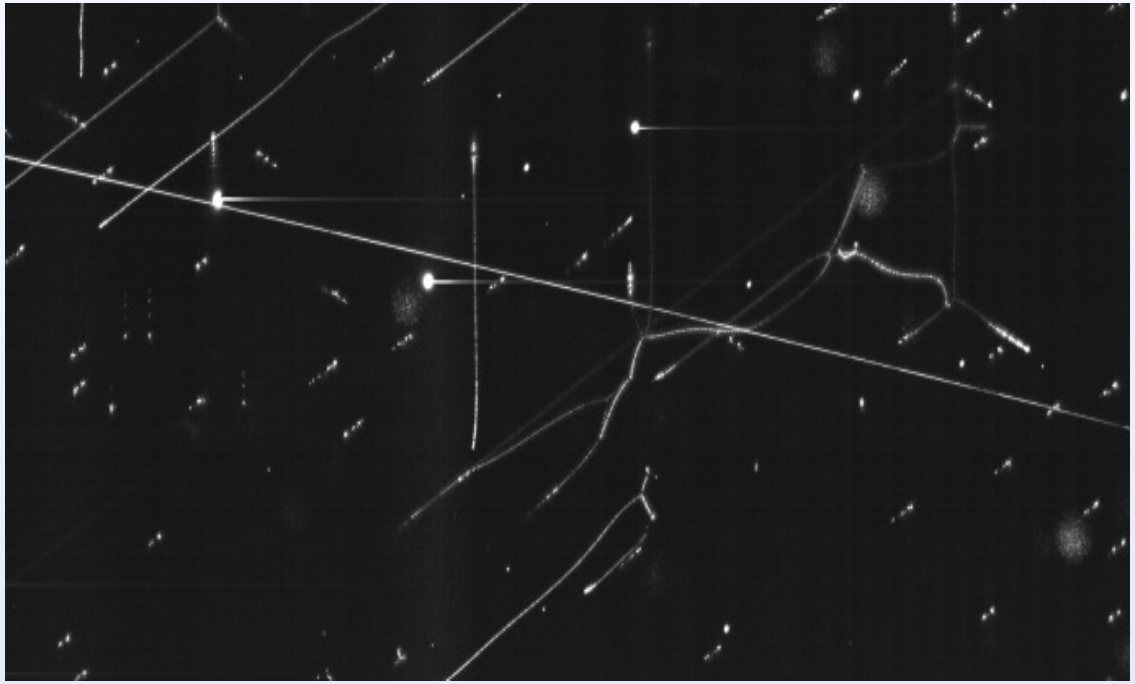
Tool	BF Defect 1	PL Defect 1	BF Defect 2	PL Defect 2
E3500				
Other DIC Microscopy				

Other DIC Microscopy missing micropipe due to large pixel size

Laser DF for shallow scratch

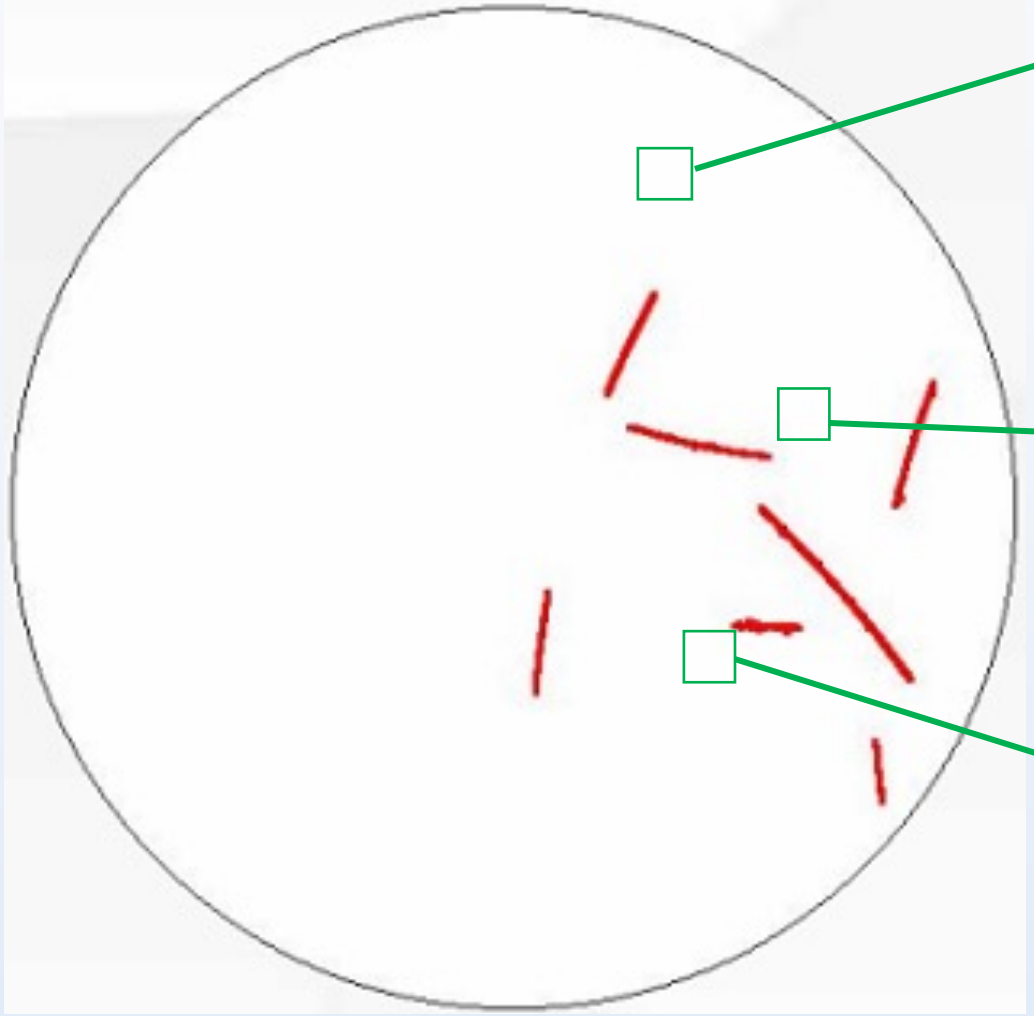


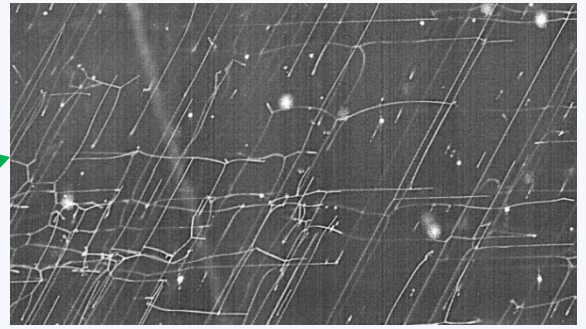
- Shallow scratch can NOT be detected by BF
- Can be detected with 60nm sensitivity

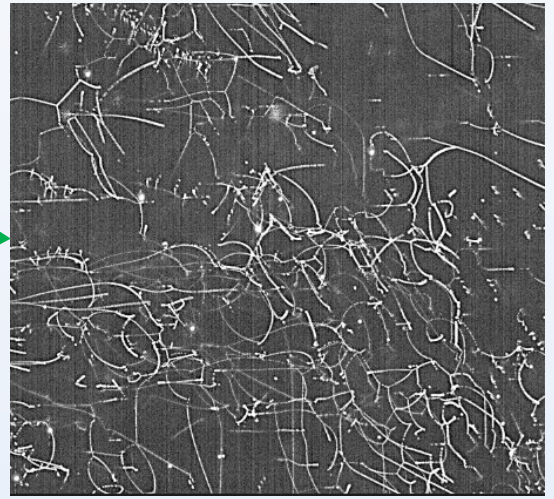


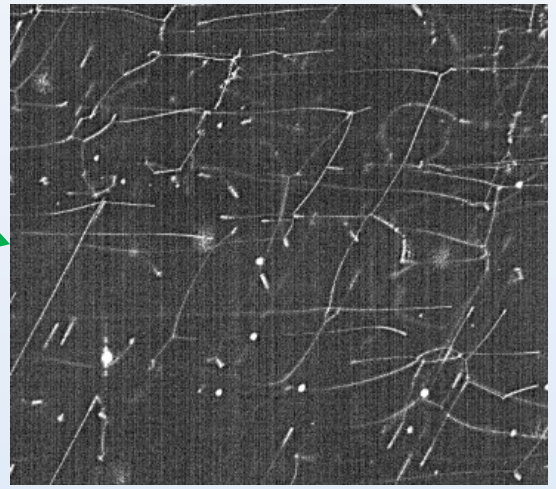
Laser DF for IDL

Irregular Dashed Lines





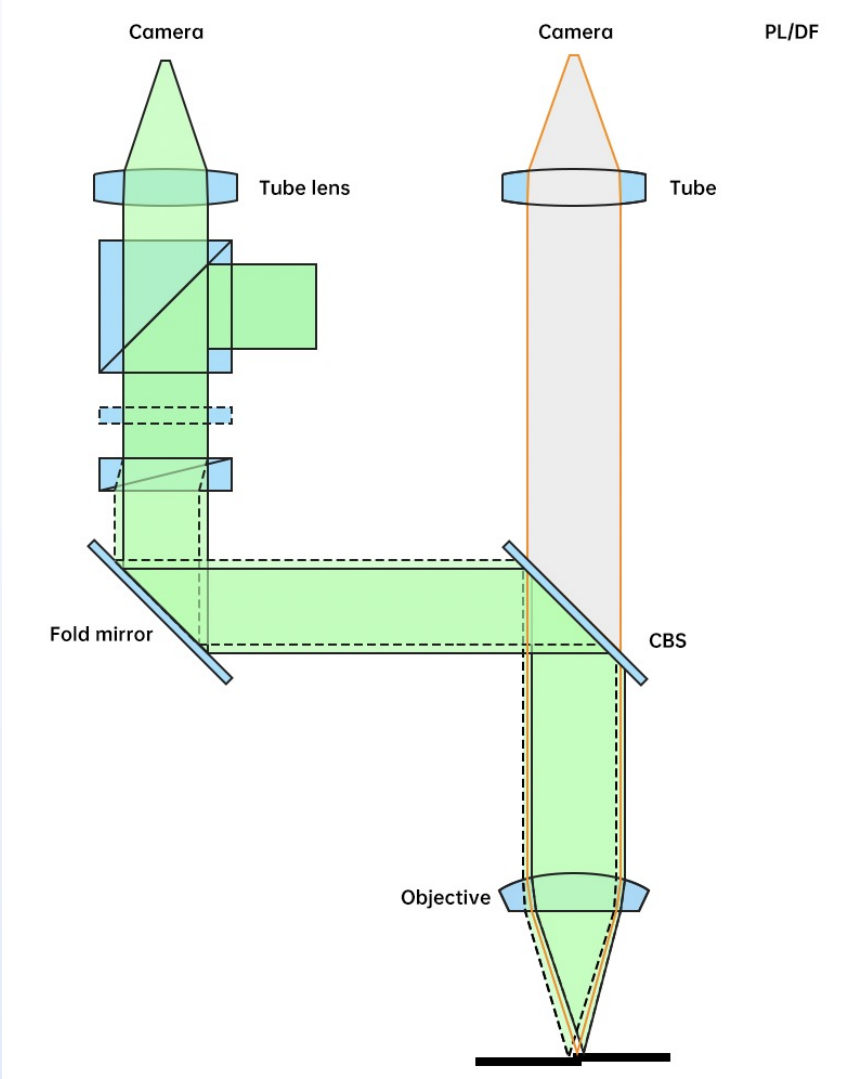




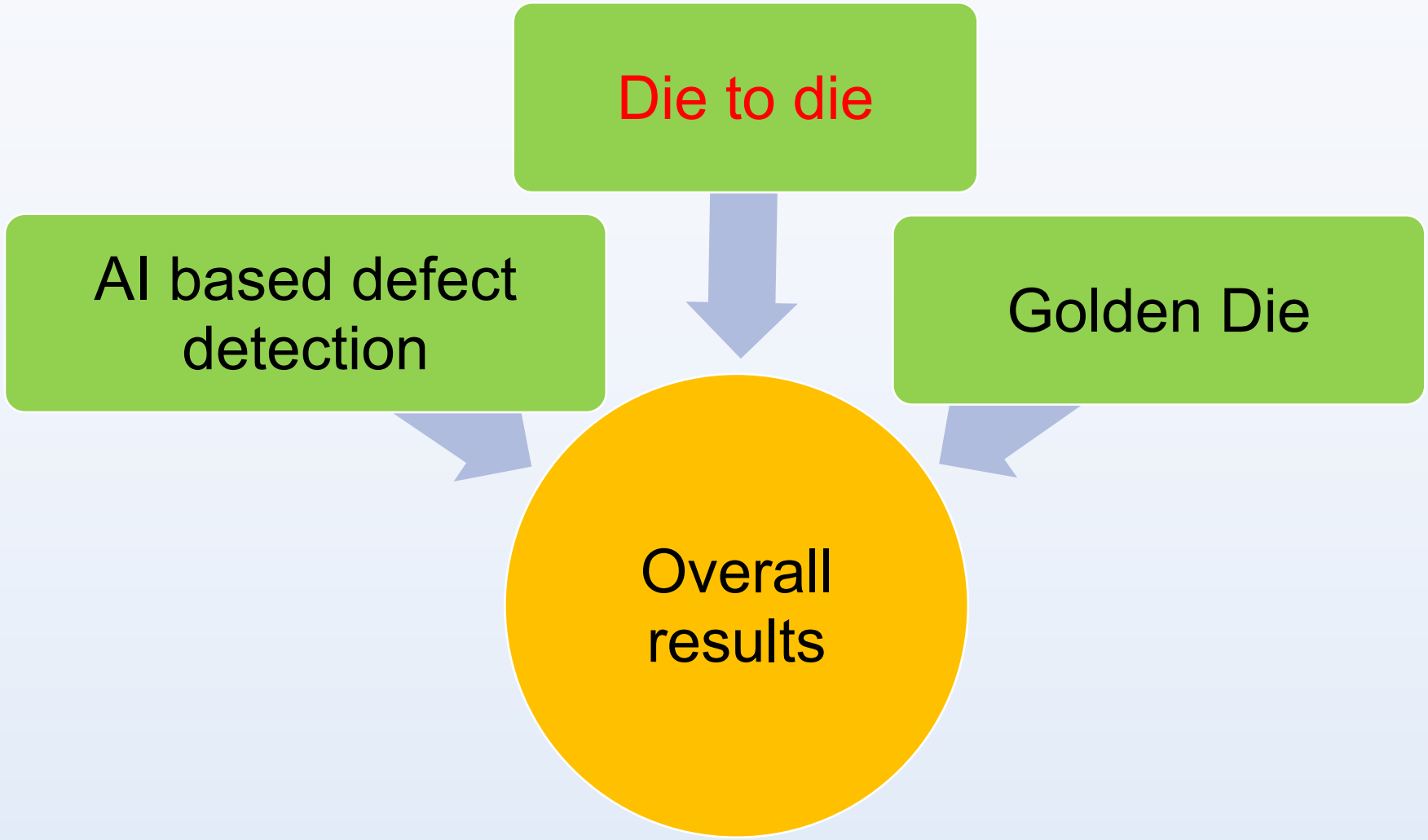
CONTENTS

H2000: patterned wafer inspection with sensitivity of 100nm

Configurations	Key Spec
BF	✓500nm sensitivity
DF with smart filter technology	✓100nm sensitivity
Defect classification Algorithm	In-house developed artificial intelligence engine for defect capture and classifications
Scan method	✓ Line scan ✓ Scan mode: **BF scan， DF scan， DF/BF simultaneous scan**
Throughput	✓ 20 WPH 6inch for SiC Patterned wafers with sensitivity of 100nm

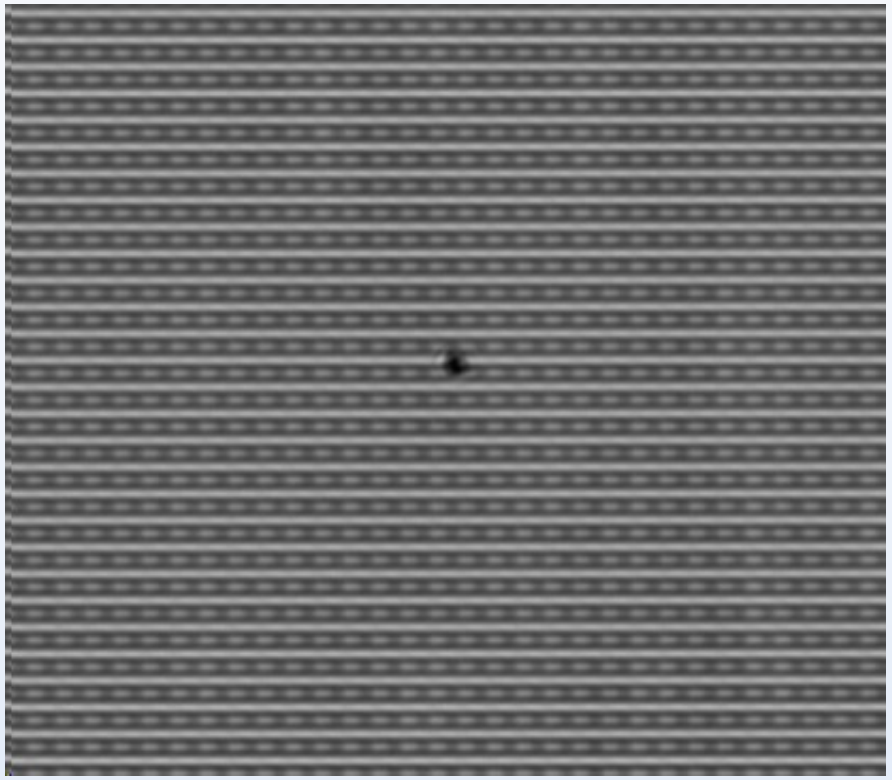


Inspection algorithms for patterned wafers

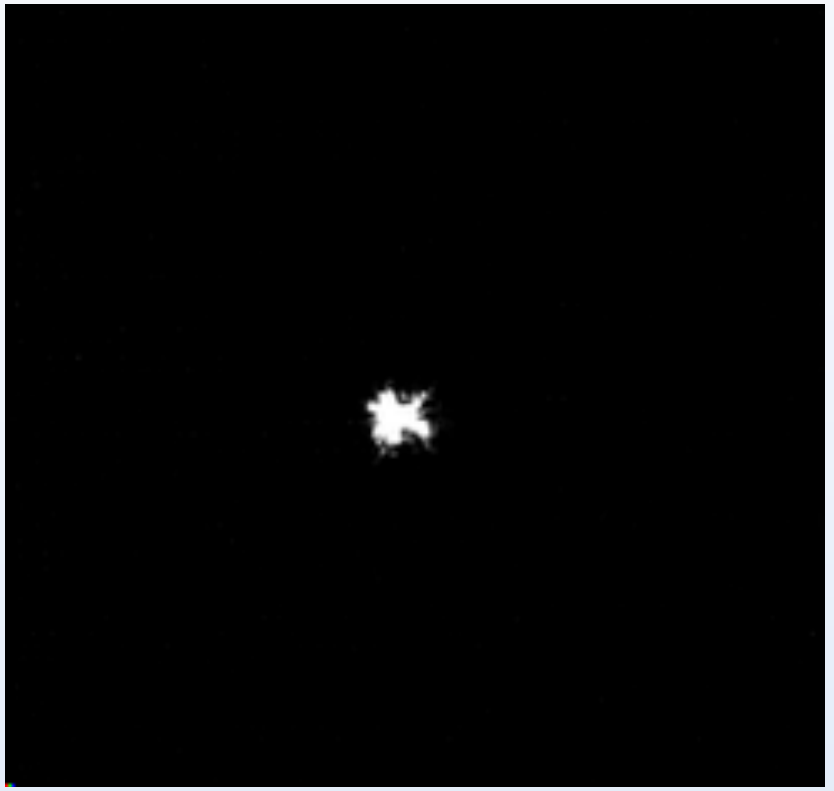


BF vs. DF with smarter filter technology

✓ Laser dark field with smart filter technology - only defect signal for better capture rate

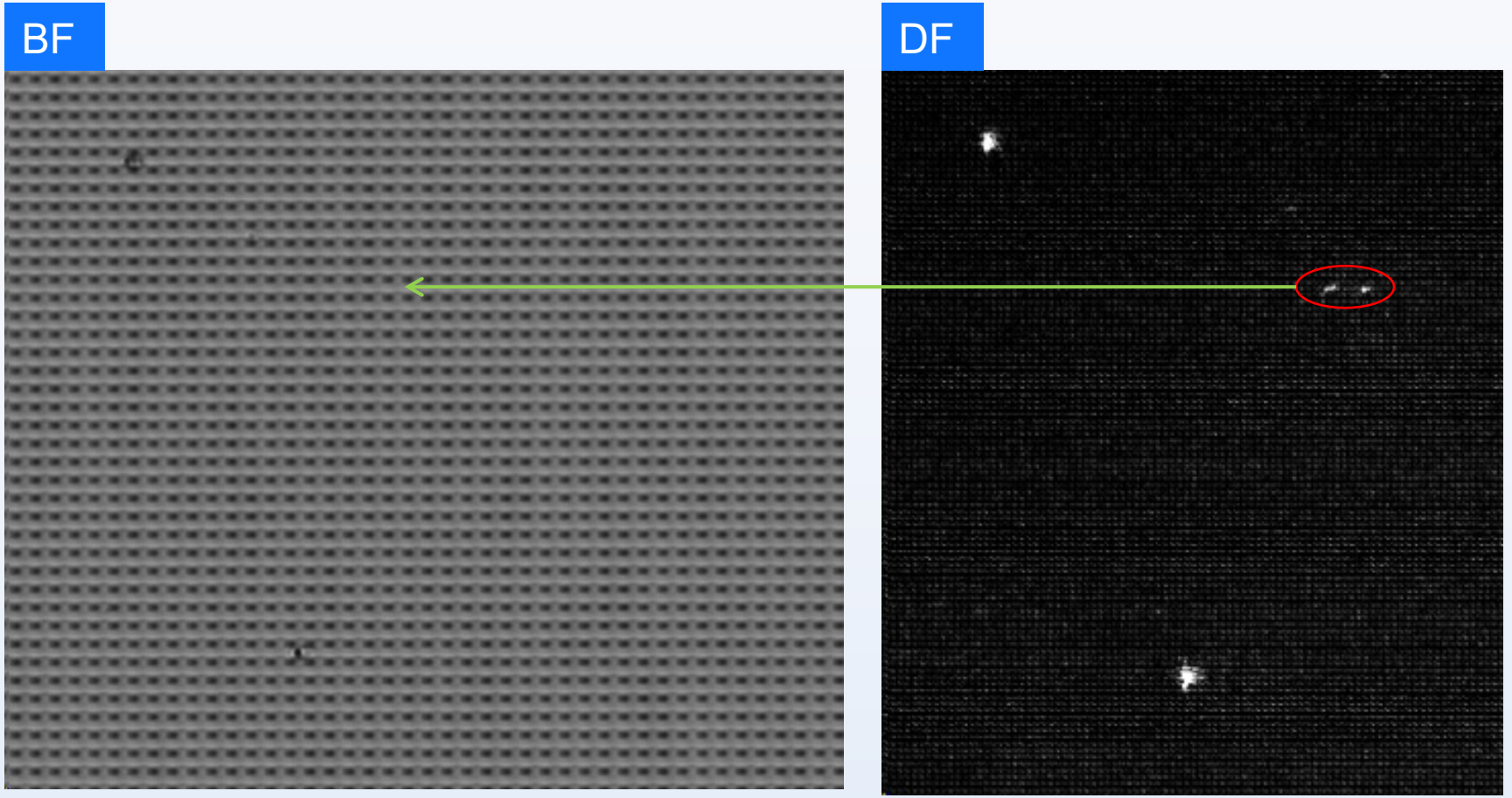


BF



DF

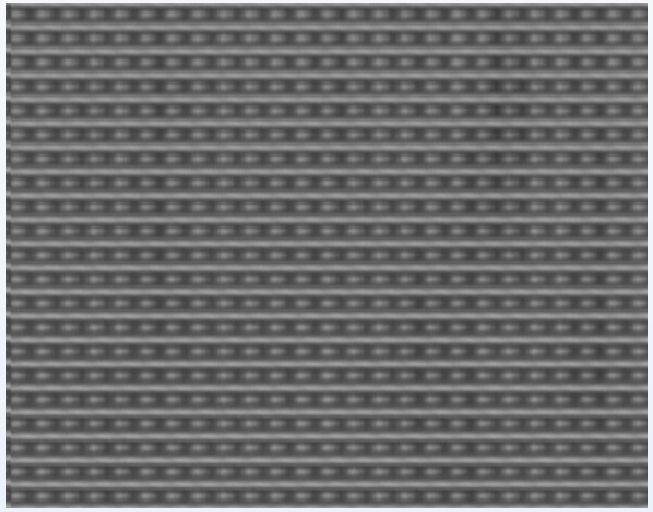
Small particle detection capability using DF



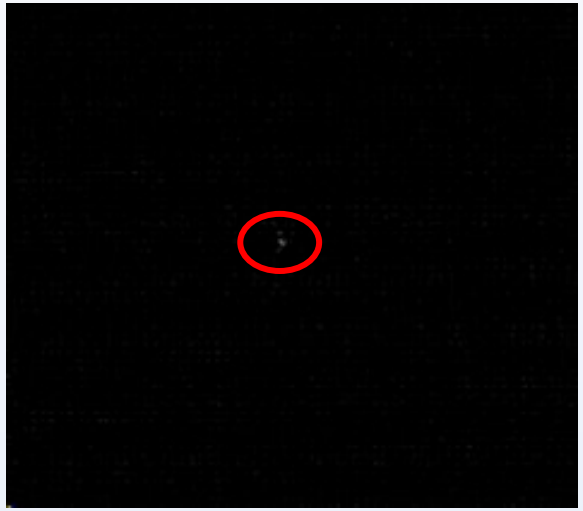
DF can capture more small particle which maybe critical for device reliability

Small particle detection capability using DF

BF



DF



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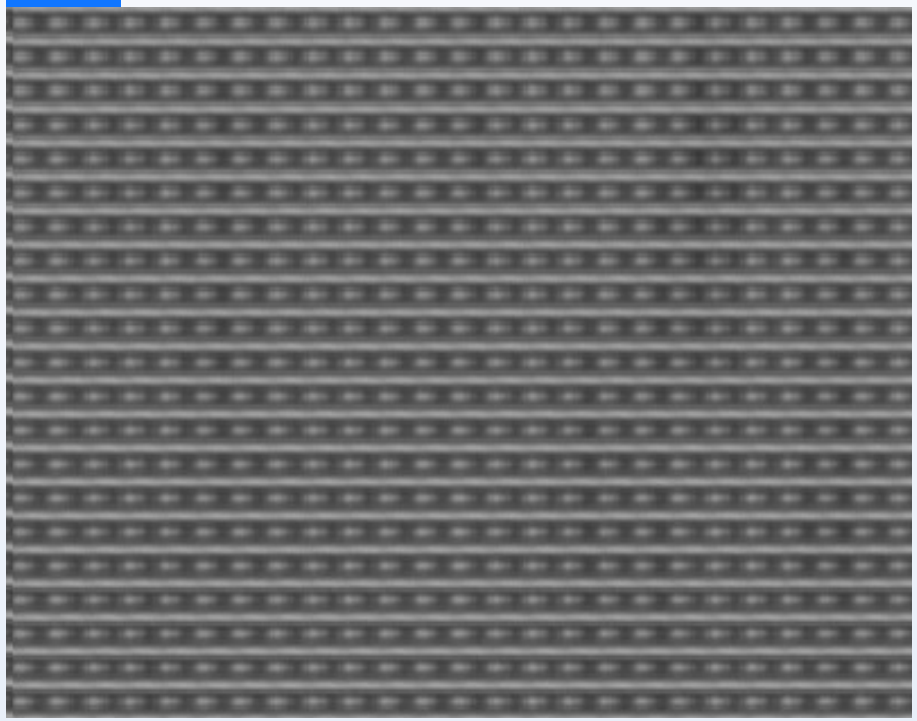
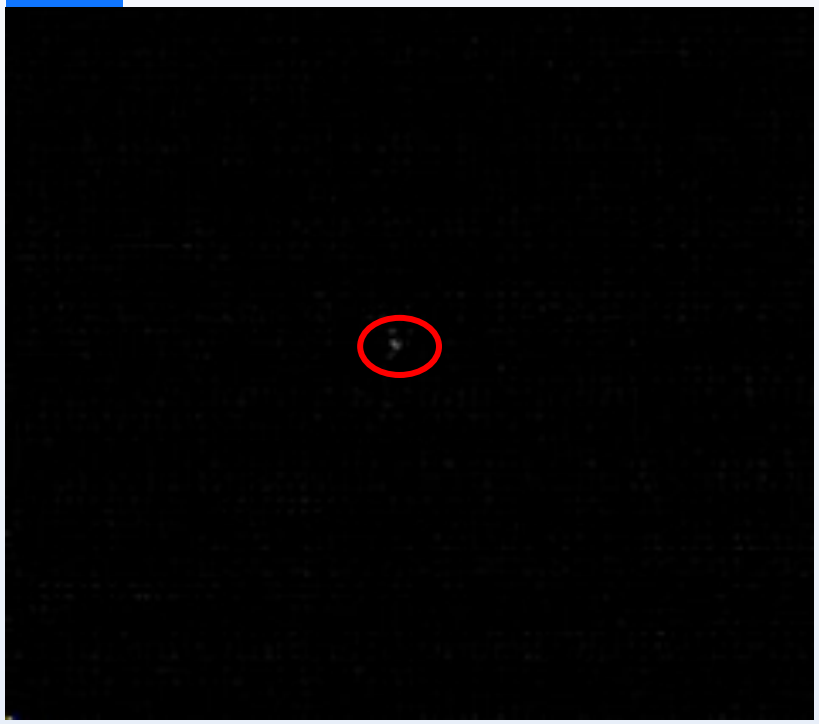
Small particle detection capability using DF

BF



DF



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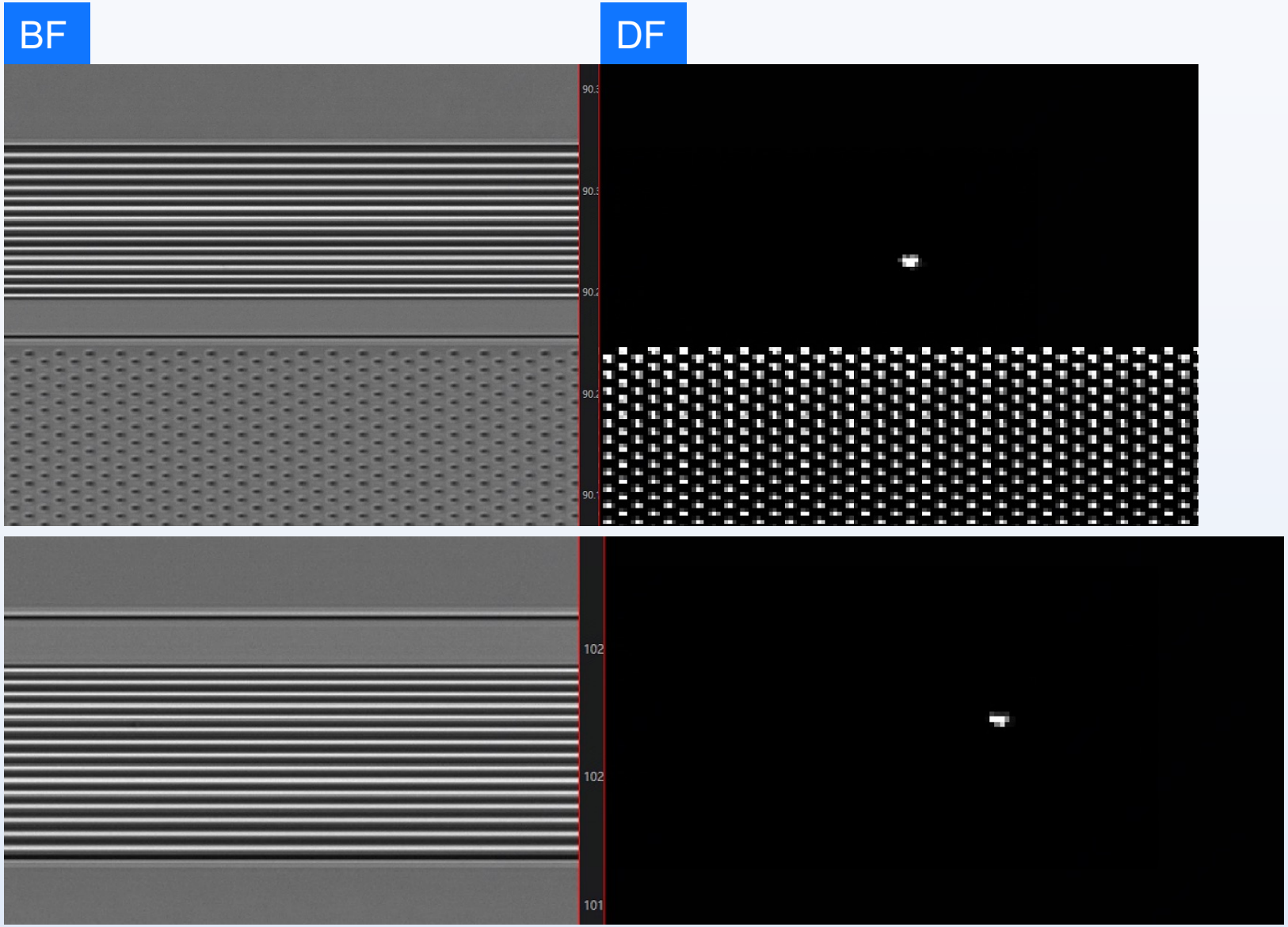
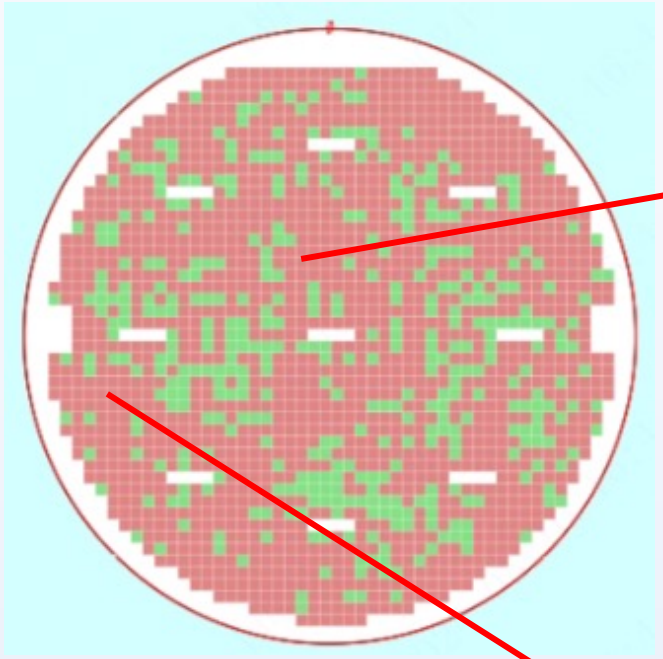
Small particle detection capability using DF

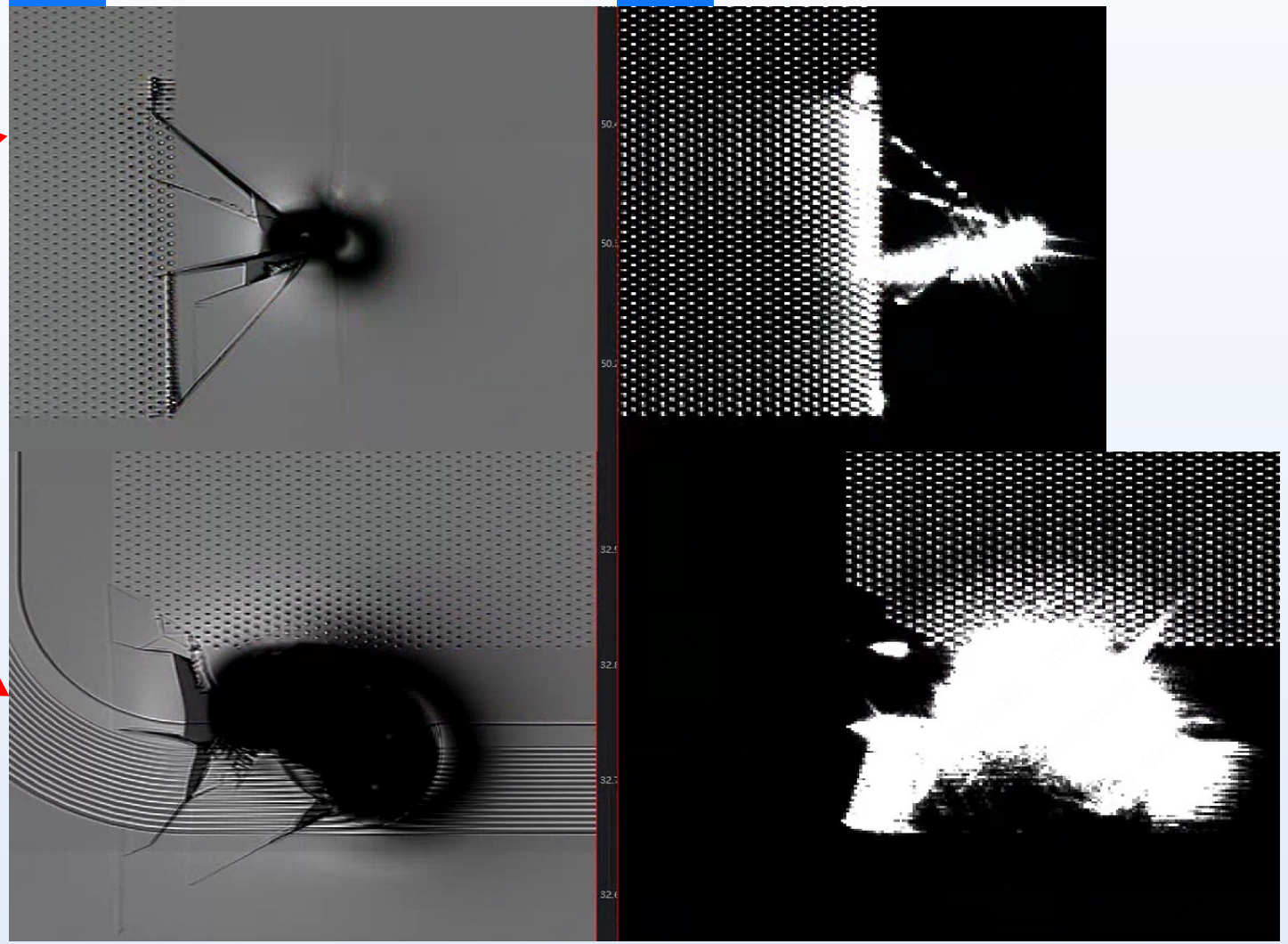


Large defect examples: downfall

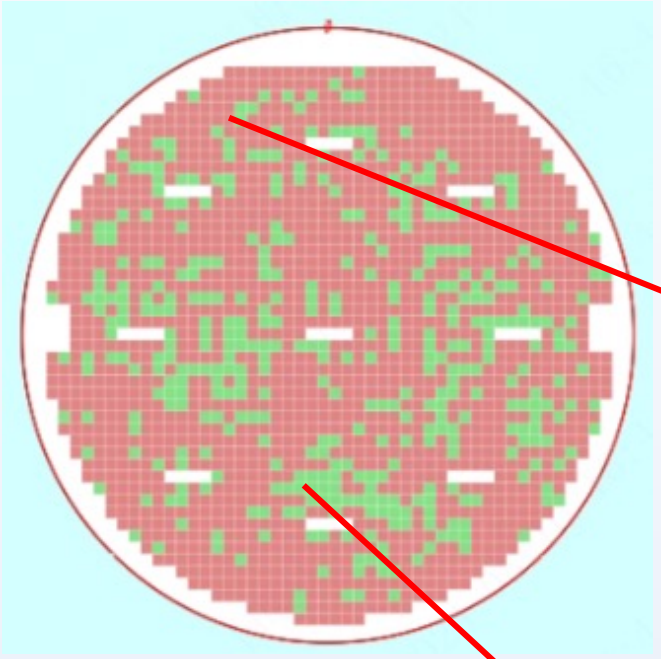


BF

DF

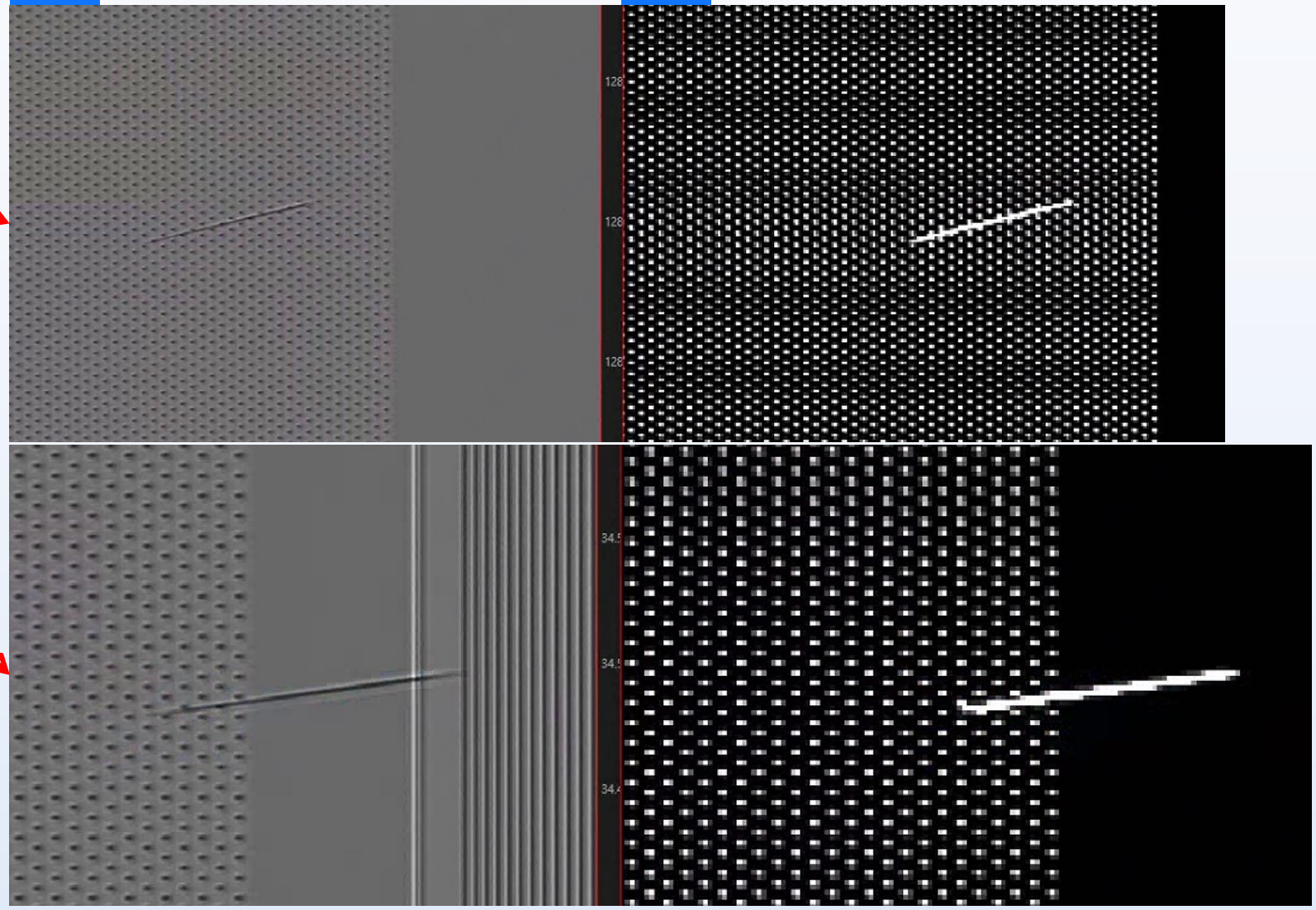


Large defect examples: lines

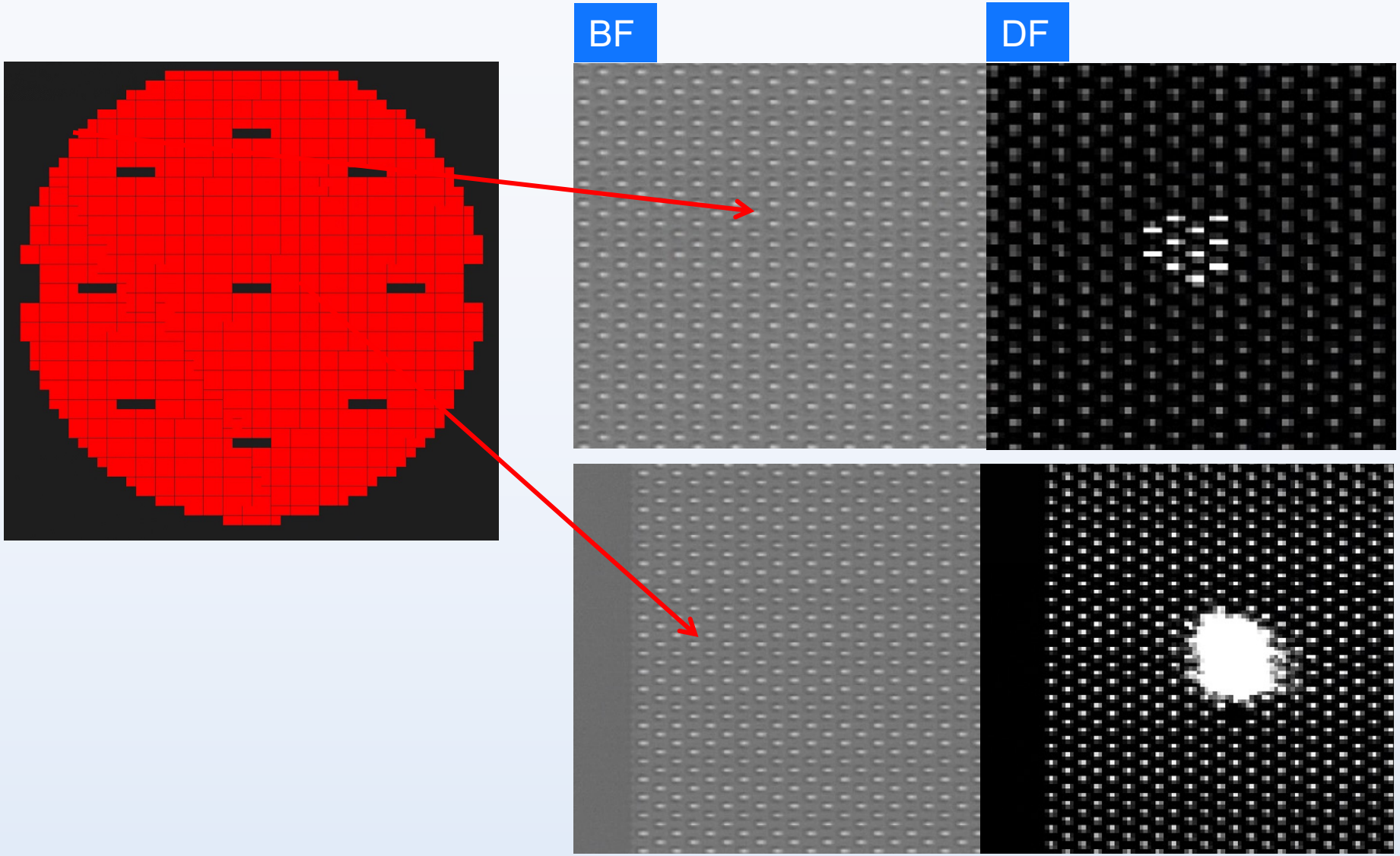


BF

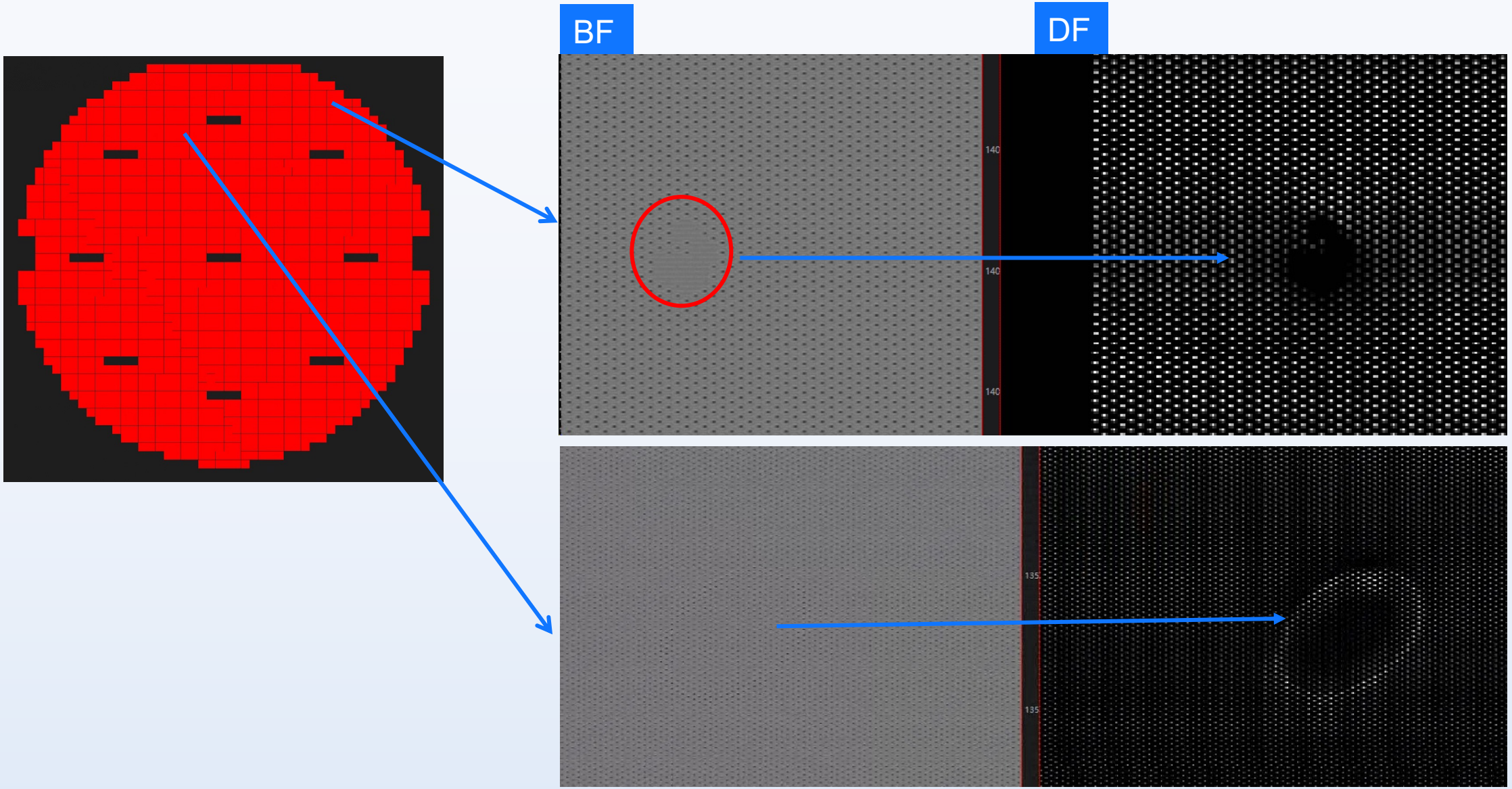
DF



More defects captured by DF



More defects captured by DF

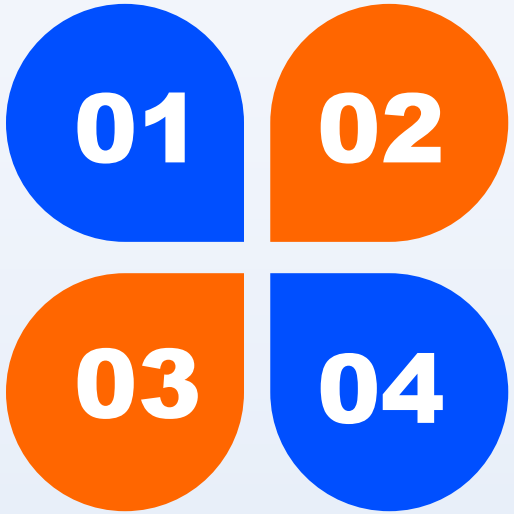


CONTENTS

For Compound Semiconductor: from ingot to substrate

- Over 250 units are in mass production
- Estimated >50% of market share in 2023 in China

SPI300 for Bow, warp , TTV, THK etc.



E500: macro defect such as polytype, micropipe, inclusion, scratch, chipping etc.

E3500: compete with SICA and CS8520

SPI1000（vs. Tropel，under development）

For Compound Semiconductor： from epi to chip

- Over 150 units are in mass production

01 Substrate and Epi

E1000，E3200，E3500

02 Patterned wafer H2000

H2000：100nm

03 Patterned wafer F550

Variable mag inspection

04 OV1000: overlay 30nm

3nm option is available

05 F2000

particle counter 80nm

Summary

1. E3500G3^{XP} is a hybrid system for SiC defect inspection
2. H2000 is suitable for front end critical process for better particle control and detection with sensitivity of 100nm

AK OPTICS
昂坤视觉

Thanks !