Visible Light Inspection of Mo/Si Multilayer Mask Blanks

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Abstract

Mask blank inspection is one of the critical issues of EUV lithography. Visible light inspection has the advantages of high throughput and low tool cost, though actinic inspection will have high inspection capability.

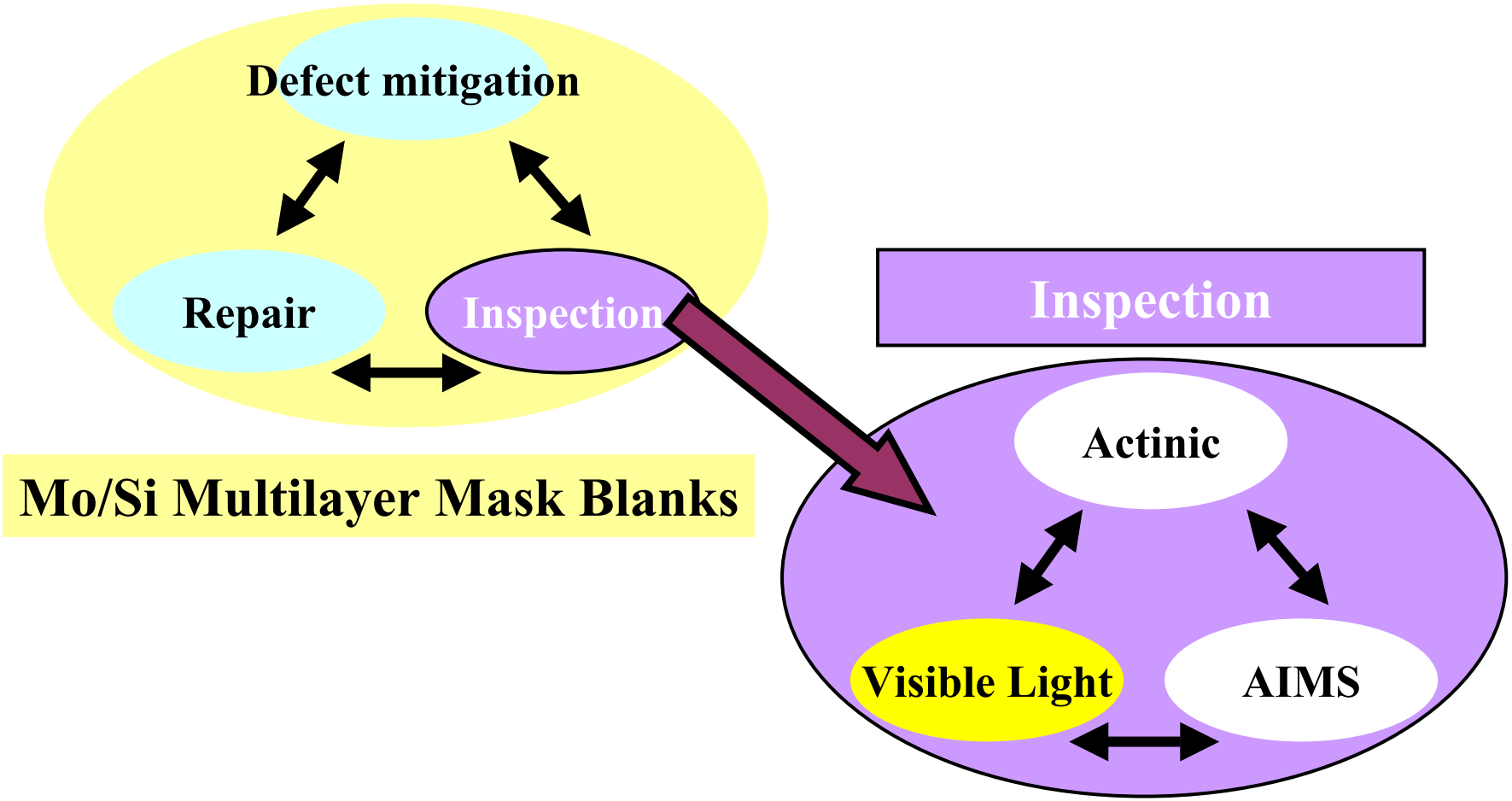
Hamamatsu Photonics Super Fine Particle Detection System that adopted a dark field scattering optics has high detection sensitivity and throughput. It could detect PSL(Polystyrene Latex) spheres below 50nm diameters on Si substrates. Then, we tried to detect fine PSL spheres on Mo/Si multilayer mask blanks.

60nm PSL spheres on Mo/Si multilayer could be inspected successfully. However, it was difficult to detect PSL spheres whose diameters were less than 50nm, because of the noise caused by the surface roughness of Mo/Si multilayer.

We found that it was important to reduce surface roughness of multilayer in order to improve inspection capability of visible light inspection systems.

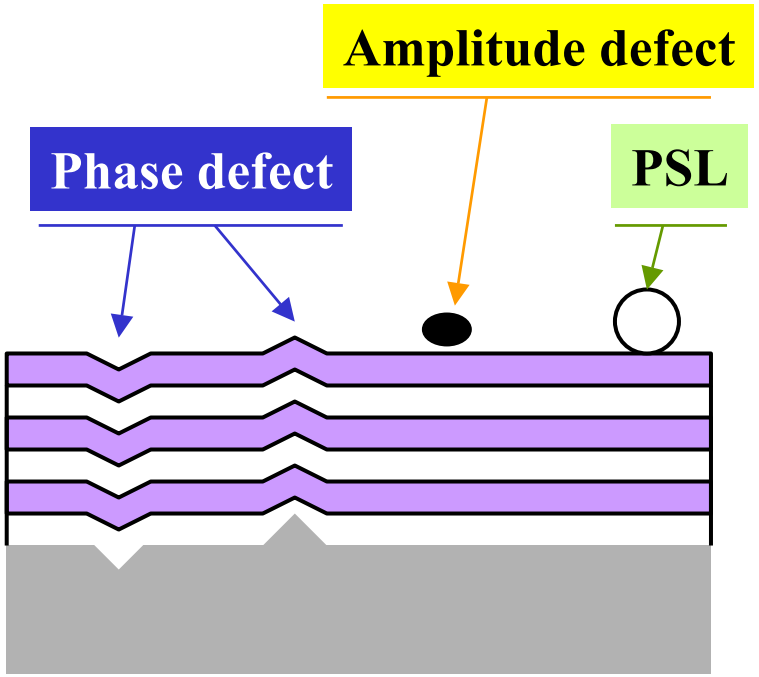
1. Background (1)

- Mask blank defects are one of critical issues of EUVL.



1. Background (2)

SEMI P38 – 1102



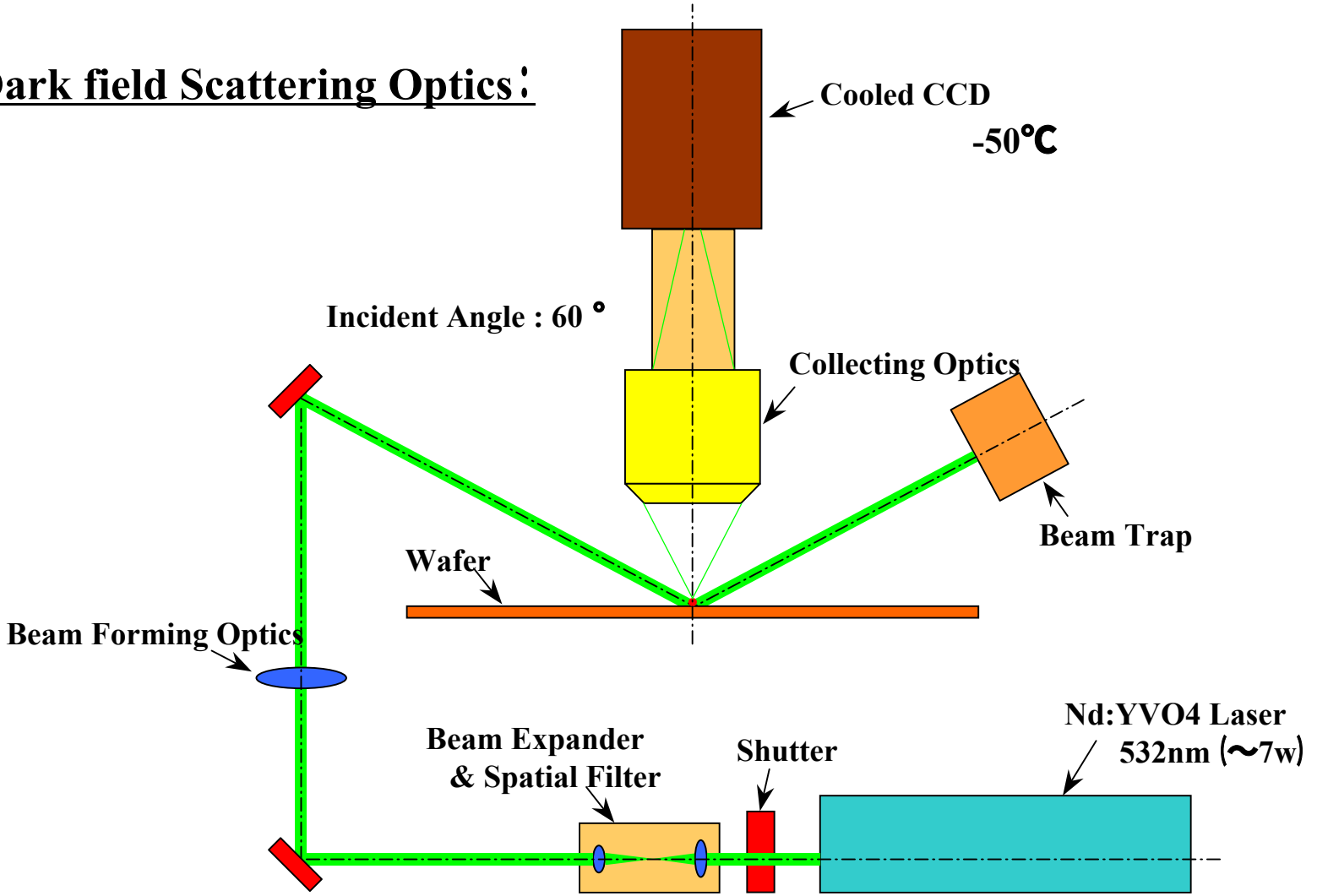
Schematic of multilayer defects

Defect Requirements for Multilayer Stack

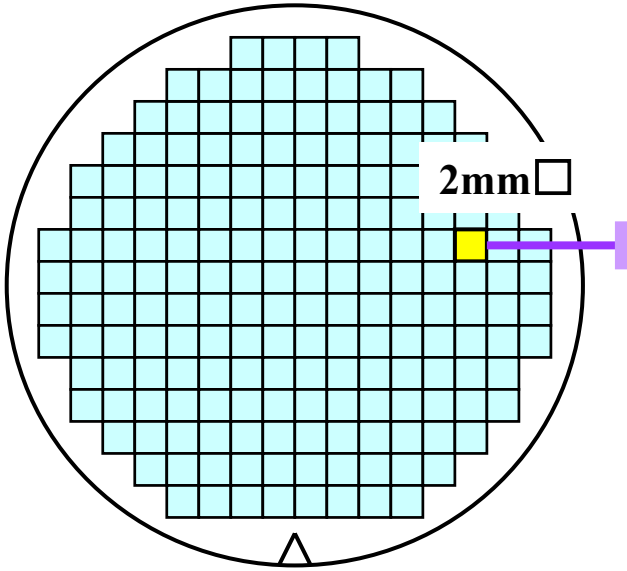
Class	PSL equivalent range (nm)	Maximum defect count
A	>25	0
B	>30	0
C	>40	0
D	>60	Agreed upon between user and supplier

2．1 Visible Light Inspection Tool (1)

Dark field Scattering Optics：

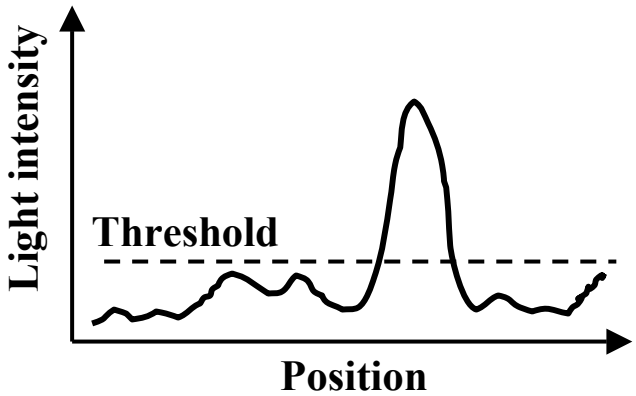


2．1 Visible Light Inspection Tool (2)



CCD Camera Image

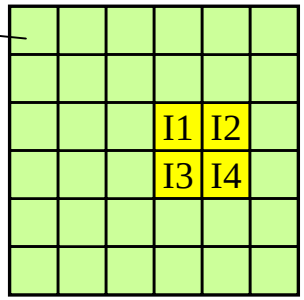
1000×1018 pixel



Intensity < threshold

Intensity ≥ threshold

CCD pixel



SPI: Sum of Pixel Intensities

SPI= 10×(ln Σ intensity)

・Position
・SPI
} were recorded.

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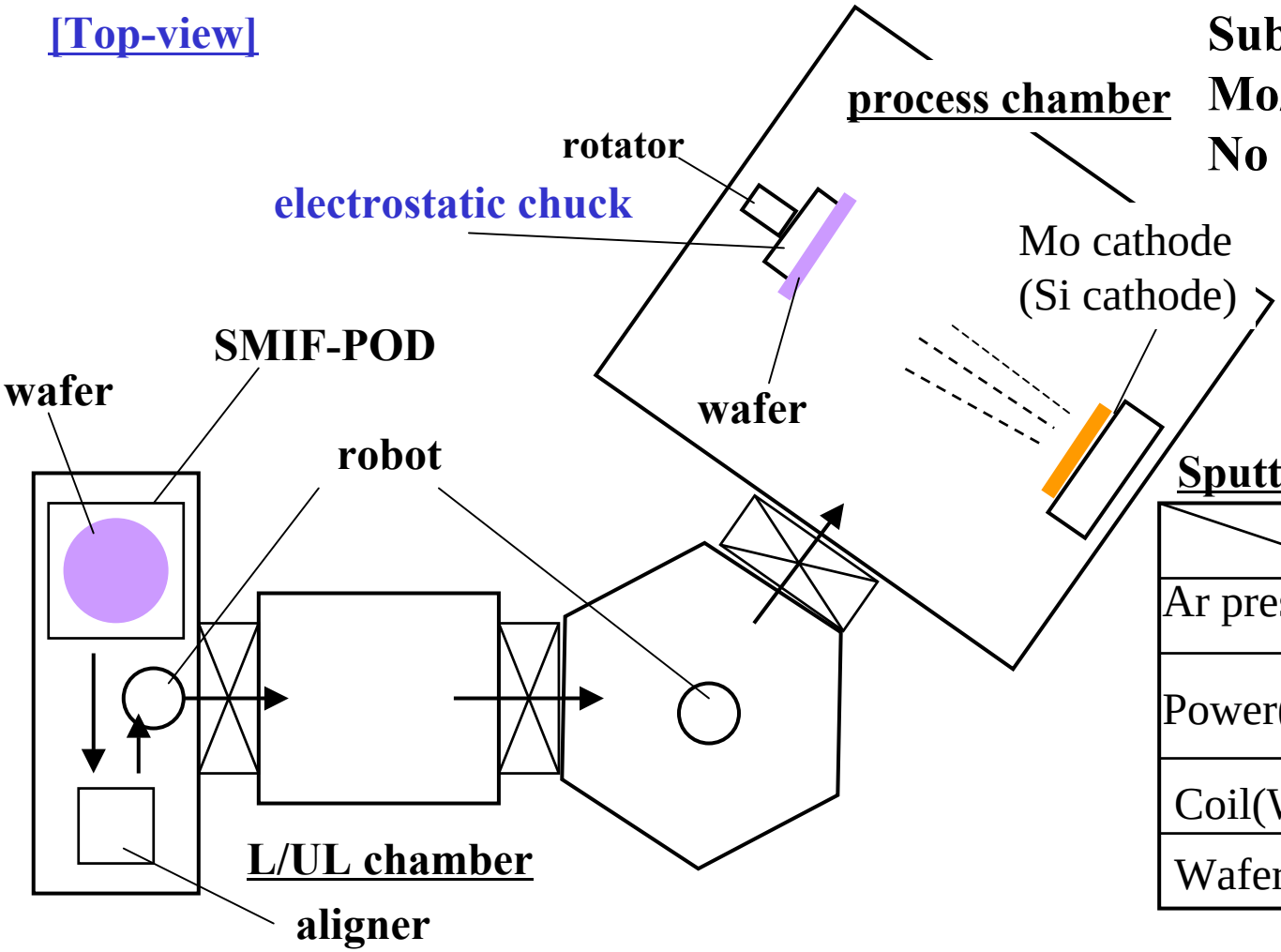
2．2－1 Mo/Si Multilayer Sputtering

Helicon Sputtering

[Top-view]

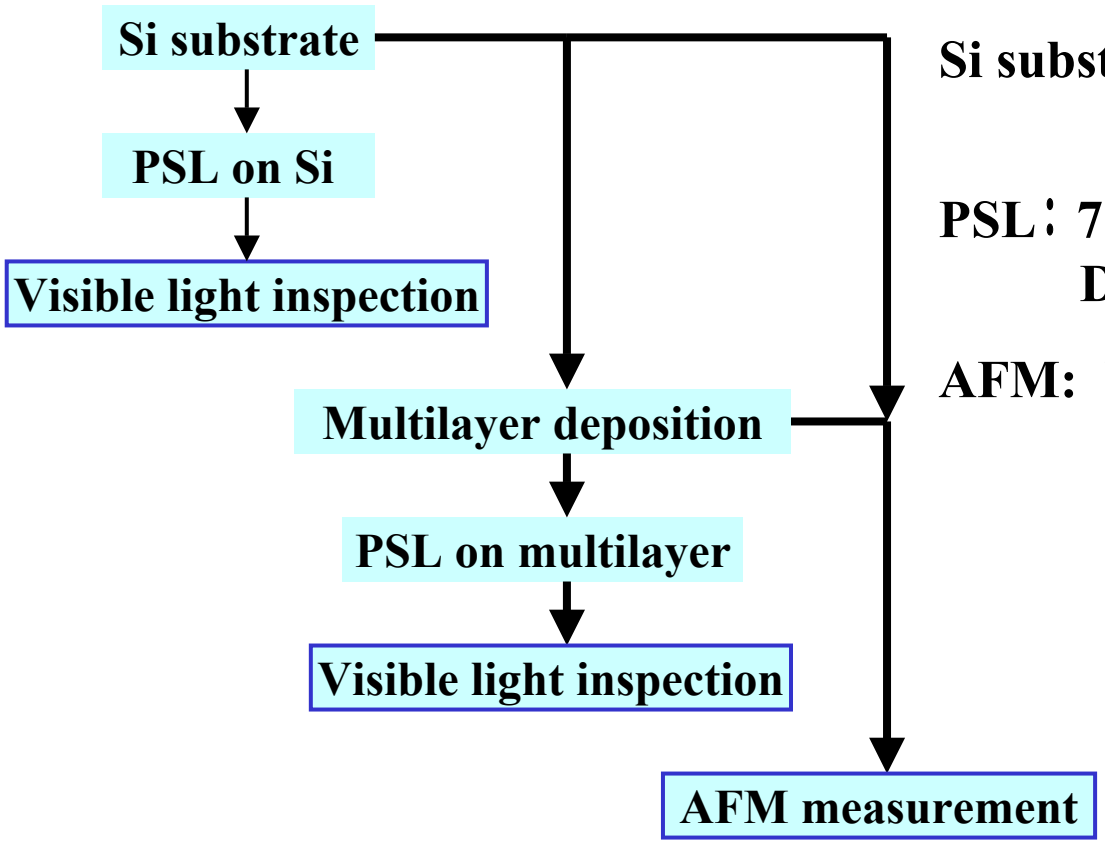


Substrate：8 inch Si
Mo/Si pairs： 40
No capping layer

Sputtering conditions

	Mo	Si
Ar pressure (Pa)	0.2	0.07
Power(kW)	0.5 [DC]	0.5 [DC]
Coil(W)	30	30
Wafer bias	Ground	

2．2－2 Evaluation Flowchart



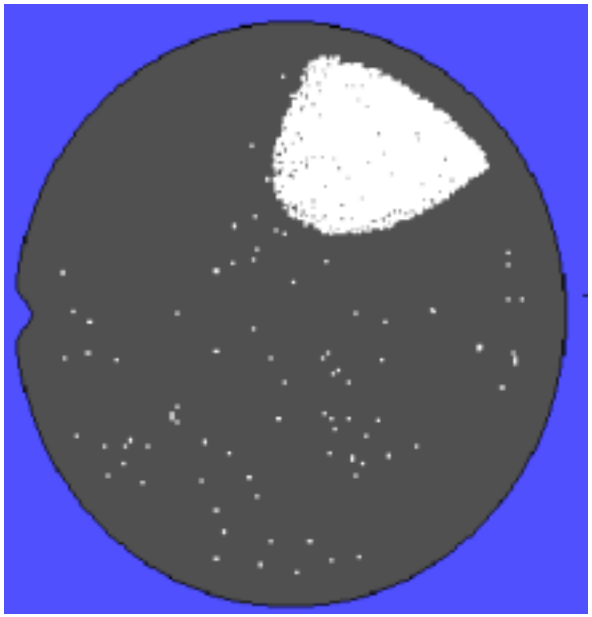
Si substrate：Sumitomo Mitsubishi Silicon Corporation

PSL：70, 60, 50, 41, 34, 21nm Duke Scientific Corporation

AFM: Veeco NanoScope IIIa Dimension 5000 system

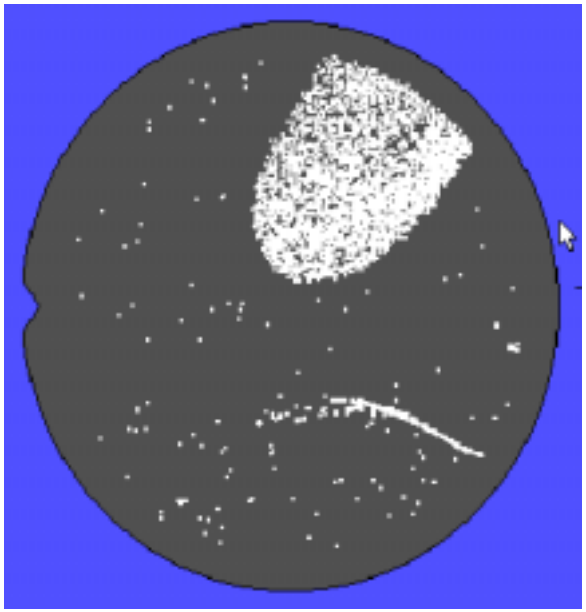
3. Results：1－1. Inspection of PSL on Si (1)

Inspection result of 70nm PSL



Inspection conditions;
Laser power：3.5W
Transmittance：98%
Exposure time：100ms
Threshold：35

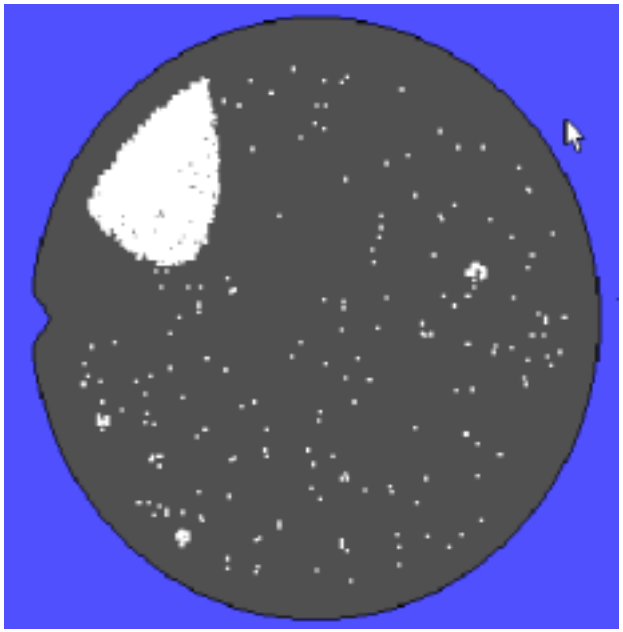
Inspection result of 60nm PSL



Inspection conditions;
Laser power：7.0W
Transmittance：98%
Exposure time：500ms
Threshold：155

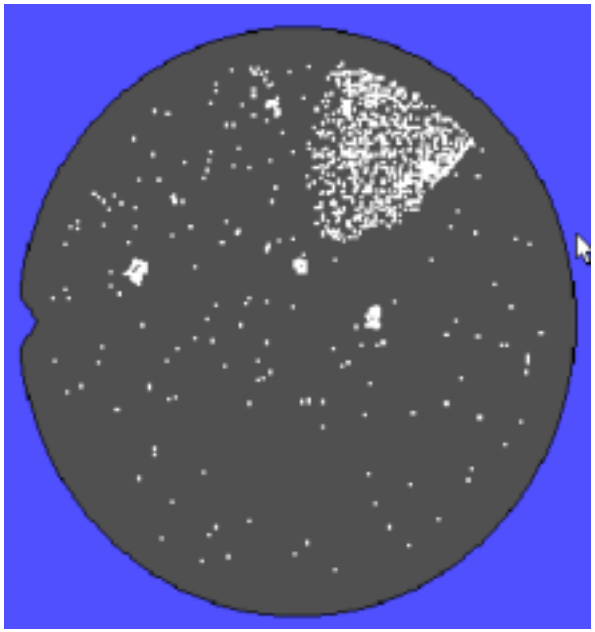
3．1－1．Inspection of PSL on Si (2)

Inspection result of 50nm PSL



Inspection conditions;
Laser power：7.0W
Transmittance：98%
Exposure time：500ms
Threshold：70

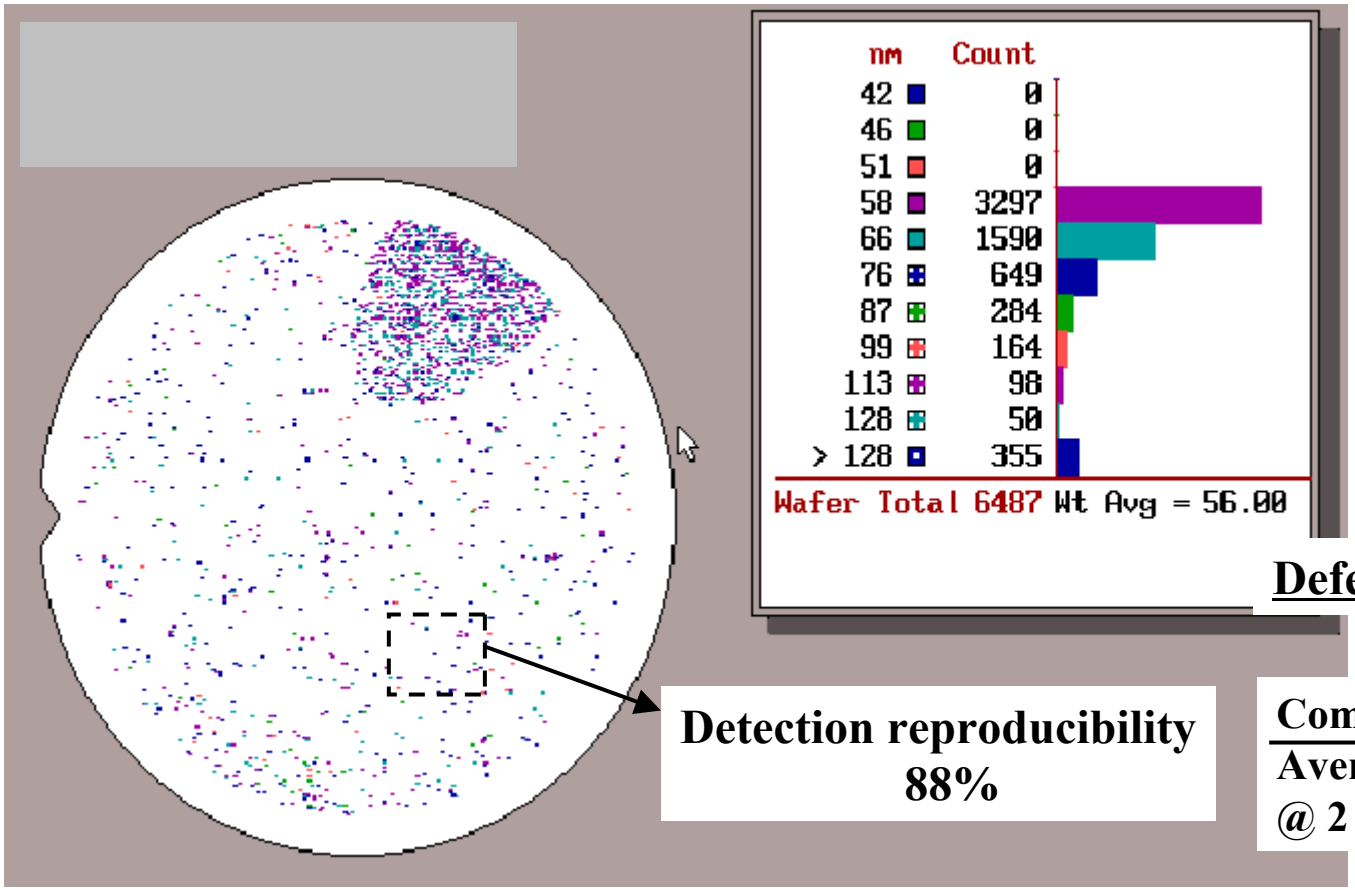
Inspection result of 41nm PSL



Inspection conditions;
Laser power：7.0W
Transmittance：98%
Exposure time：500ms
Threshold：70

3.1-2. Inspection of PSL on Mo/Si Multilayer (1)

60nm PSL on Mo/Si Multilayer



Inspection conditions;
Laser power: 3.5W
Transmittance: 98%
Exposure time: 100ms
Threshold: 35

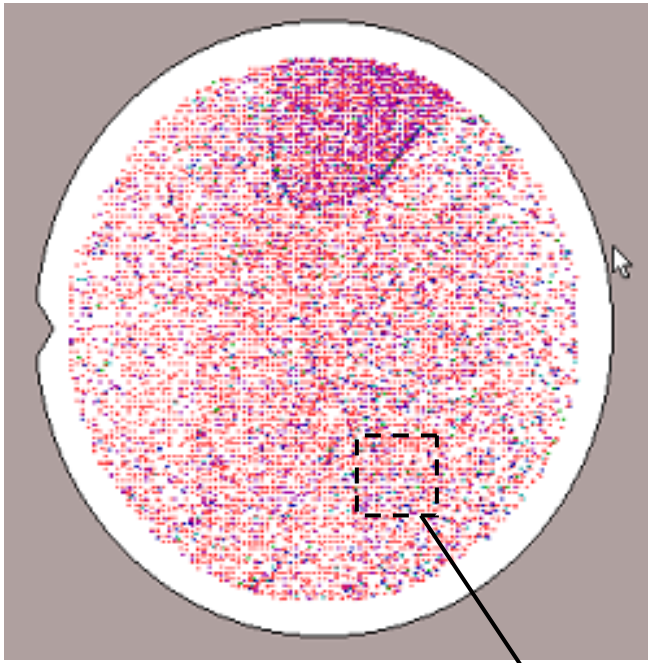
Defection reproducibility

Detection reproducibility 88%

Common defects number / Average defects number @ 2 times measurement

3.1-2. Inspection of PSL on Mo/Si Multilayer (2)

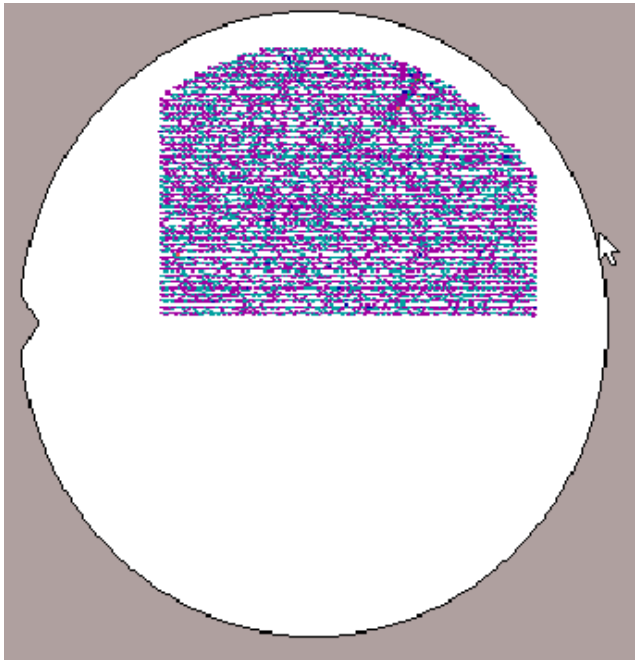
50nm PSL on Multilayer



Inspection conditions;
Laser power: 3.5W
Transmittance: 98%
Exposure time: 100ms
Threshold: 35

Detection reproducibility
61%

41nm PSL on Multilayer

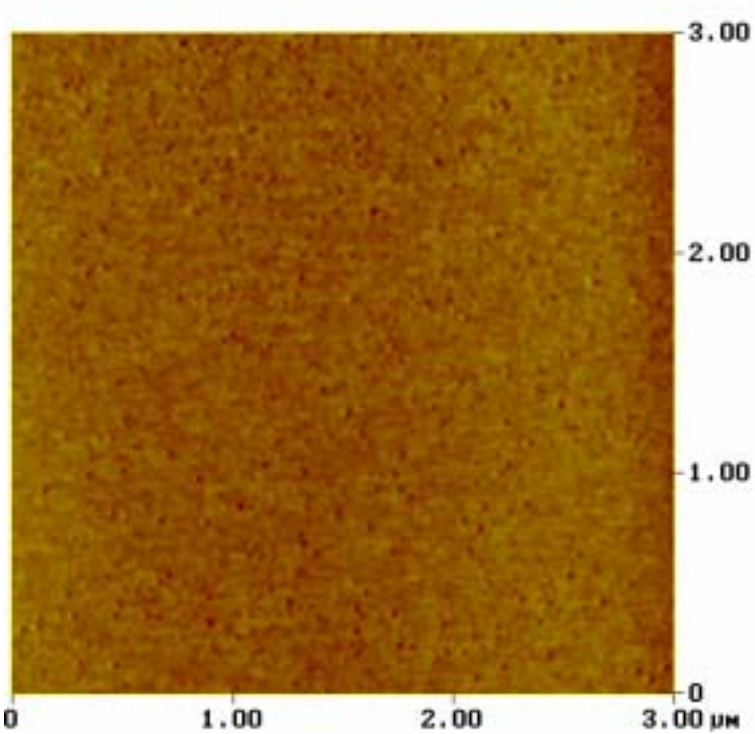


Inspection conditions;
Laser power: 7.0W
Transmittance: 98%
Exposure time: 500ms
Threshold: 70

3．2 AFM Measurement （1）

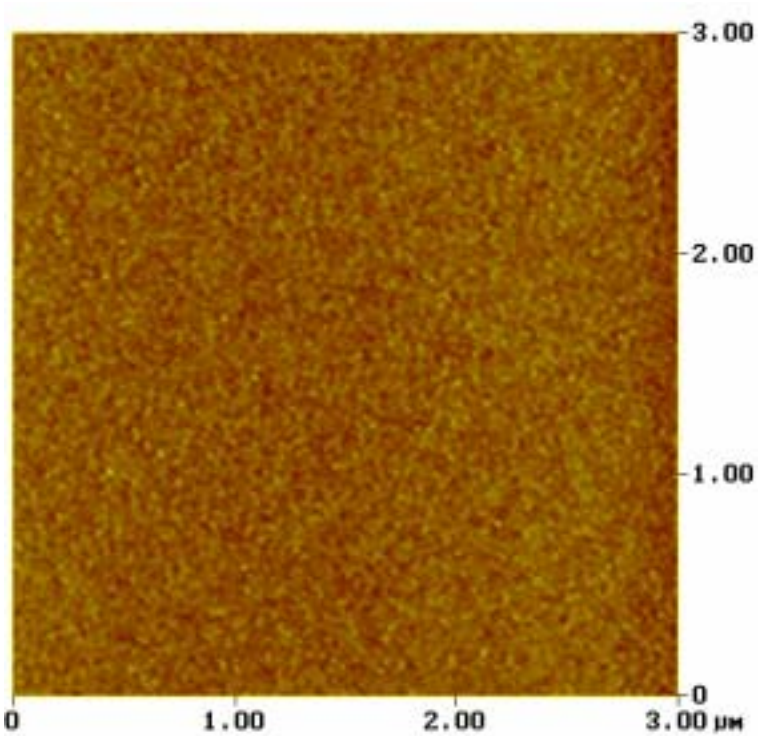
Roughness analysis

Si substrate



RMS = 0.103nm

Mo/Si multilayer



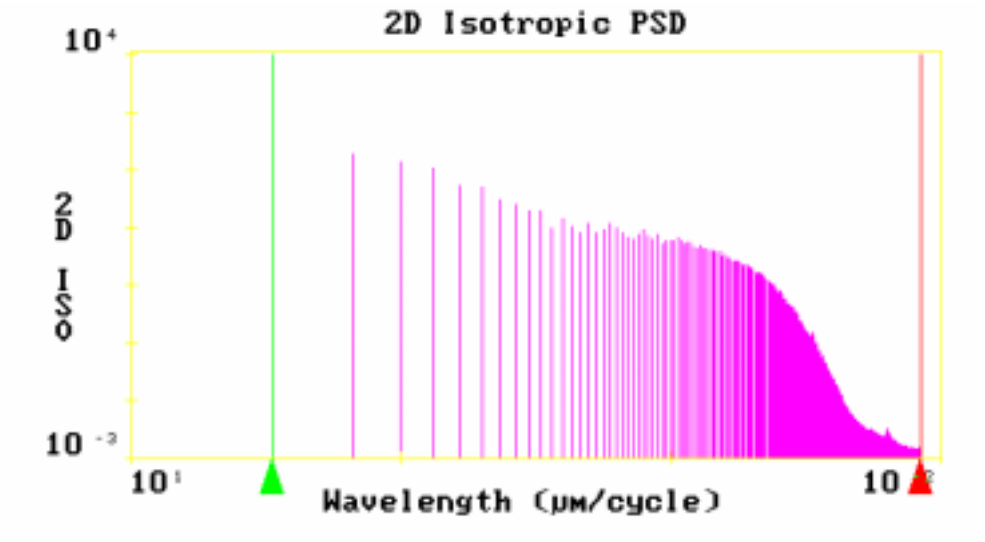
RMS = 0.183nm

3．2 AFM Measurement （2）

Power Spectral Density

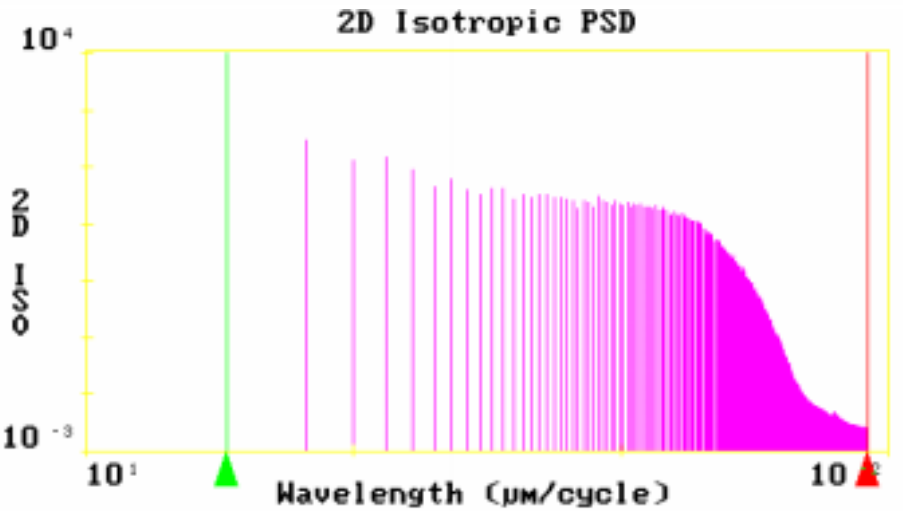
Si substrate

RMS = 0.103nm



Mo/Si multilayer

RMS = 0.183nm



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3．2 Effect of Surface Roughness on PSL Inspection

●PSL detection sensitivity with dark field scattering system

Si	41nmPSL	0.103nm RMS
Mo/Si multilayer	60～50nmPSL	0.183nm RMS

●SEMI P37-1102 Specification for EUVL Mask Substrates

Front side surface roughness (from EUV Reflectivity view point)

≦ 0.15nm RMS (@λspatial ≦ 10μm)

The surface roughness less than 0.15nm RMS is required in order to detect 25nm PSL spheres with dark field scattering detection systems.

4. Conclusions

1. PSL detection sensitivity with the dark field scattering system was 60-50nm on Mo/Si multilayer mask blanks.

2. The detection sensitiviy is determined mainly by surface roughness of Mo/Si multilayer.

3. The improvement of surface roughness is required in order to raise the detection sensitivity.

Acknowledgement

This work was supported by NEDO.