ASAHI GLASS COMPANY

Current status of EUVL mask blank development in AGC

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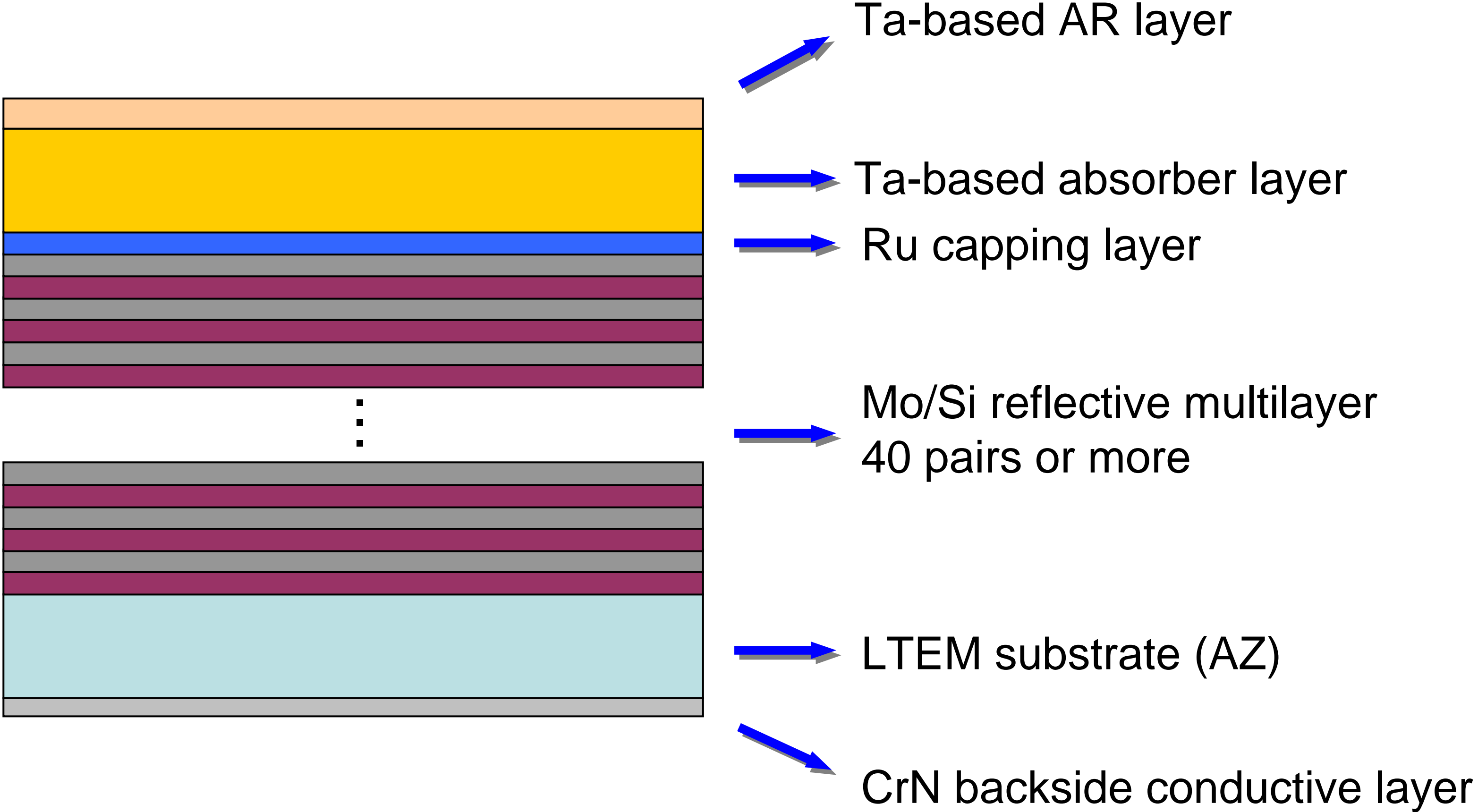
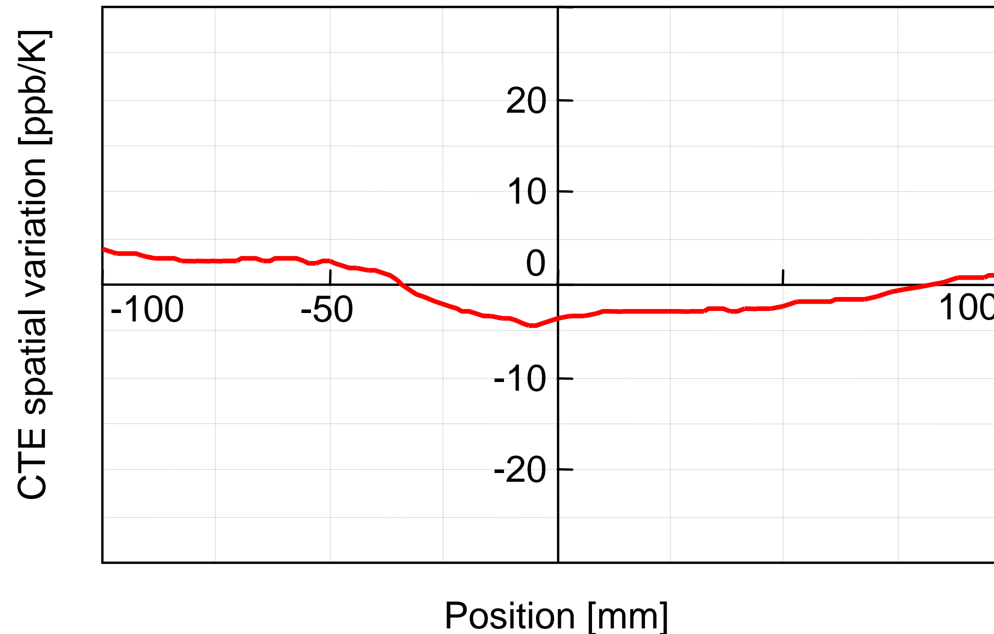
Outline

- Introduction
- Brief summary of substrate preparation in AGC
- ML deposition and EUV reflectometry
- Defect analysis and reduction
- Absorber material
- Summary

Basic layer structure of AGC mask blank

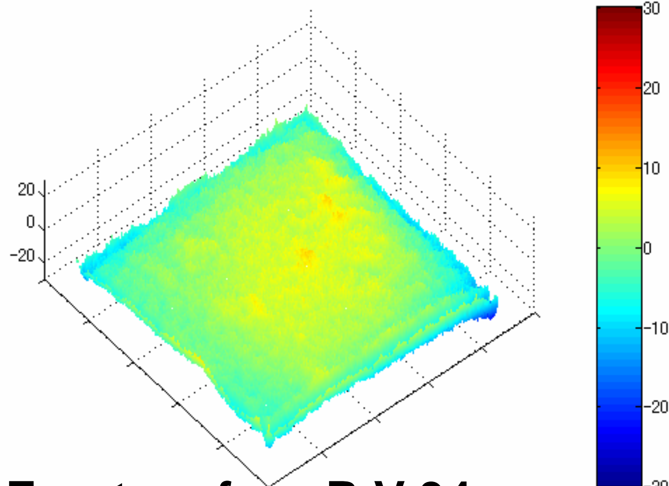


Low thermal expansion material, "AZ"

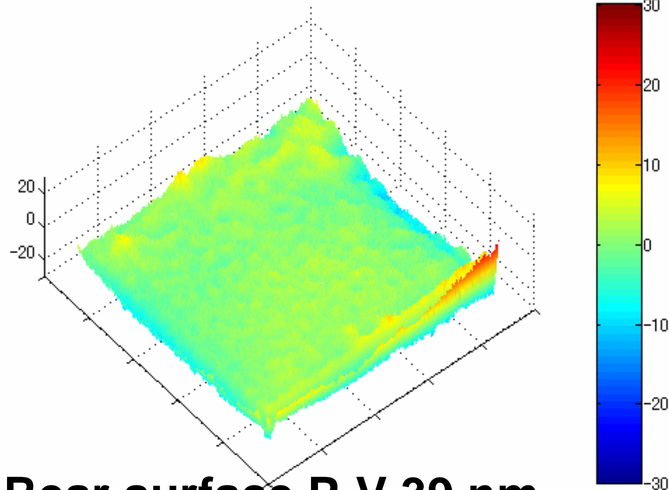


CTE (Coefficient of thermal expansion) spatial variation in diagonal scan of 6025 AZ substrate is within +/-5 ppb/K (please see 05-MA-63 for details).

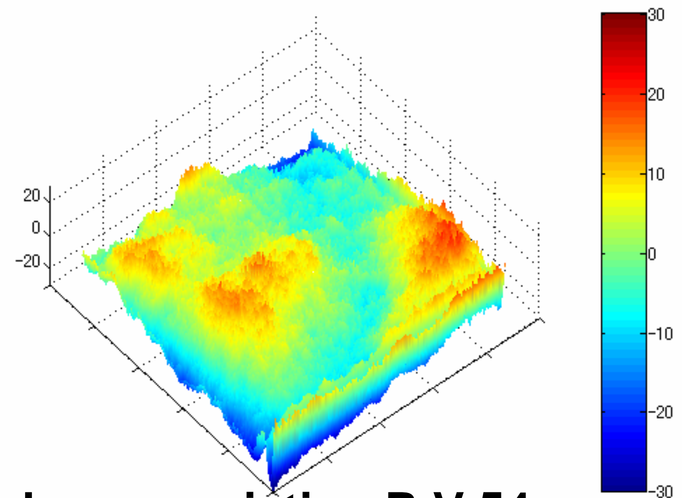
Surface figuring of substrate



Front surface P-V 34 nm



Rear surface P-V 39 nm



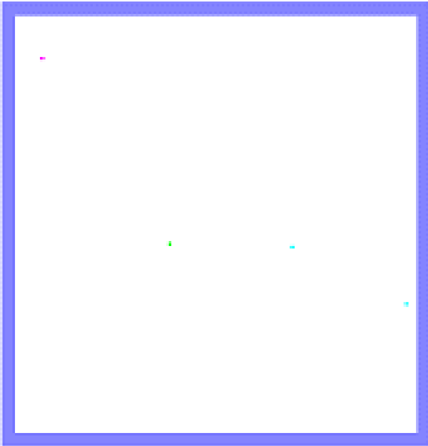
Thickness variation P-V 54 nm

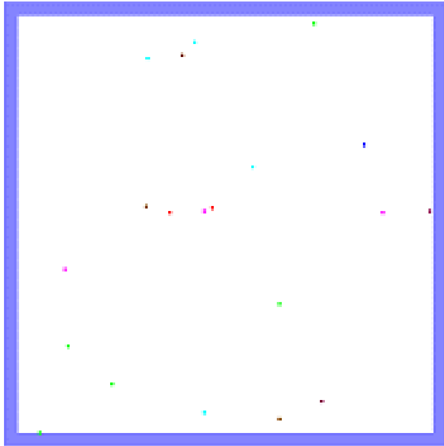
(142 x 142 mm quality area)

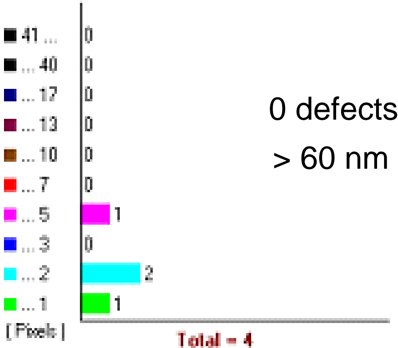
Defectivity of Quartz and AZ substrate

Quartz substrate

AZ substrate

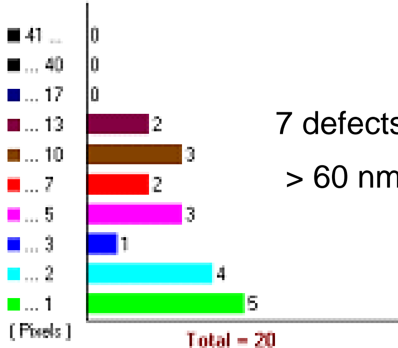






0 defects

> 60 nm



7 defects

> 60 nm

Defects on AZ substrate are more difficult to clean than on quartz.

Low Defect Deposition tool for Mo/Si ML

Nexus with the latest features developed at MBDC, SEMATECH

EUV reflectometry (1)

A reflectometer at NewSUBARU of University of Hyogo gives us highly precise reflectance measurement of mask blanks.

EUV reflectometry (2)

Measurement Performance

Wavelength

Precision MADT : < 2 nm

Accuracy (1σ) : < 2 nm

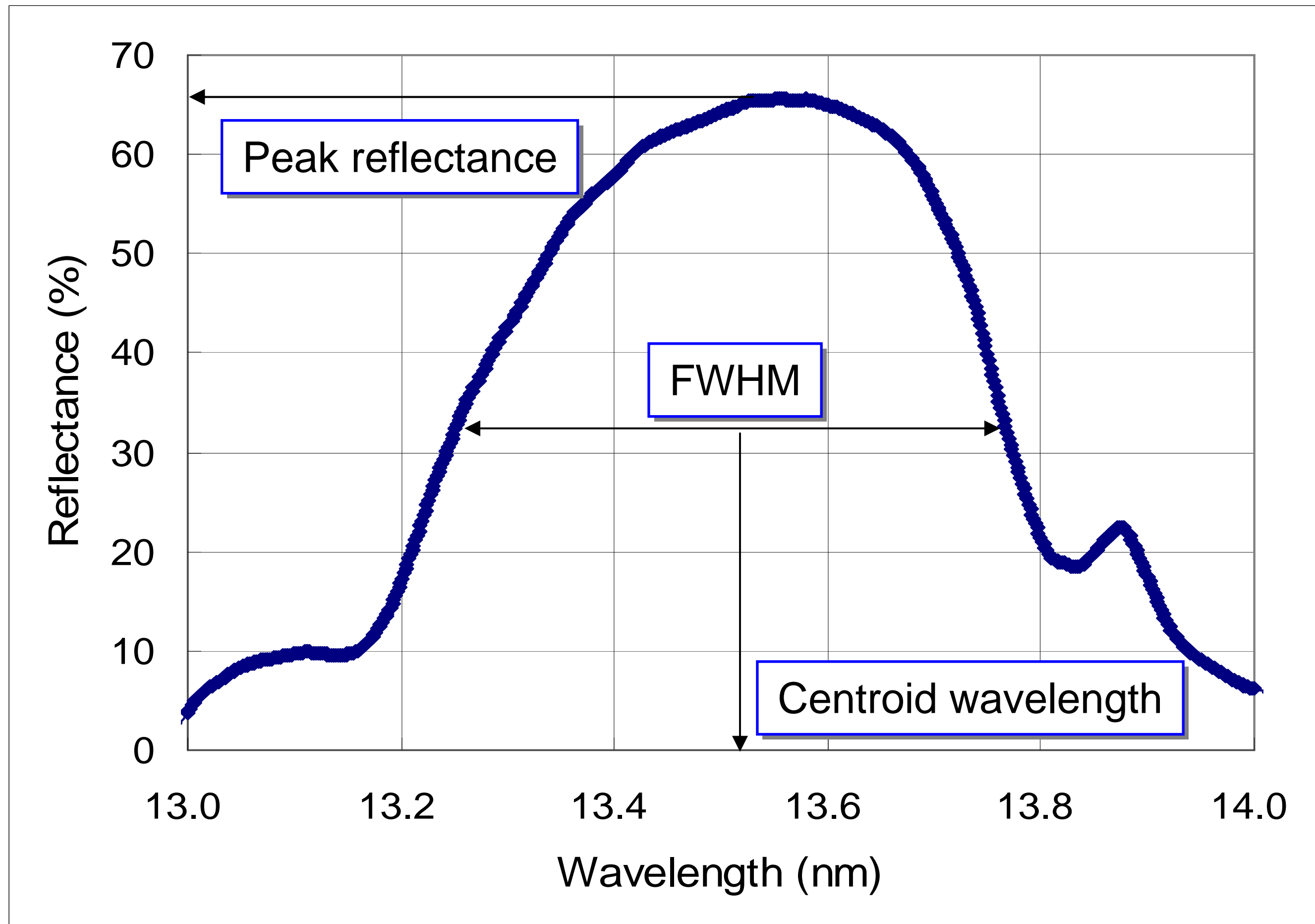
Reflectance

Precision MADT : < 0.5%

Accuracy (1σ) : < 0.1%

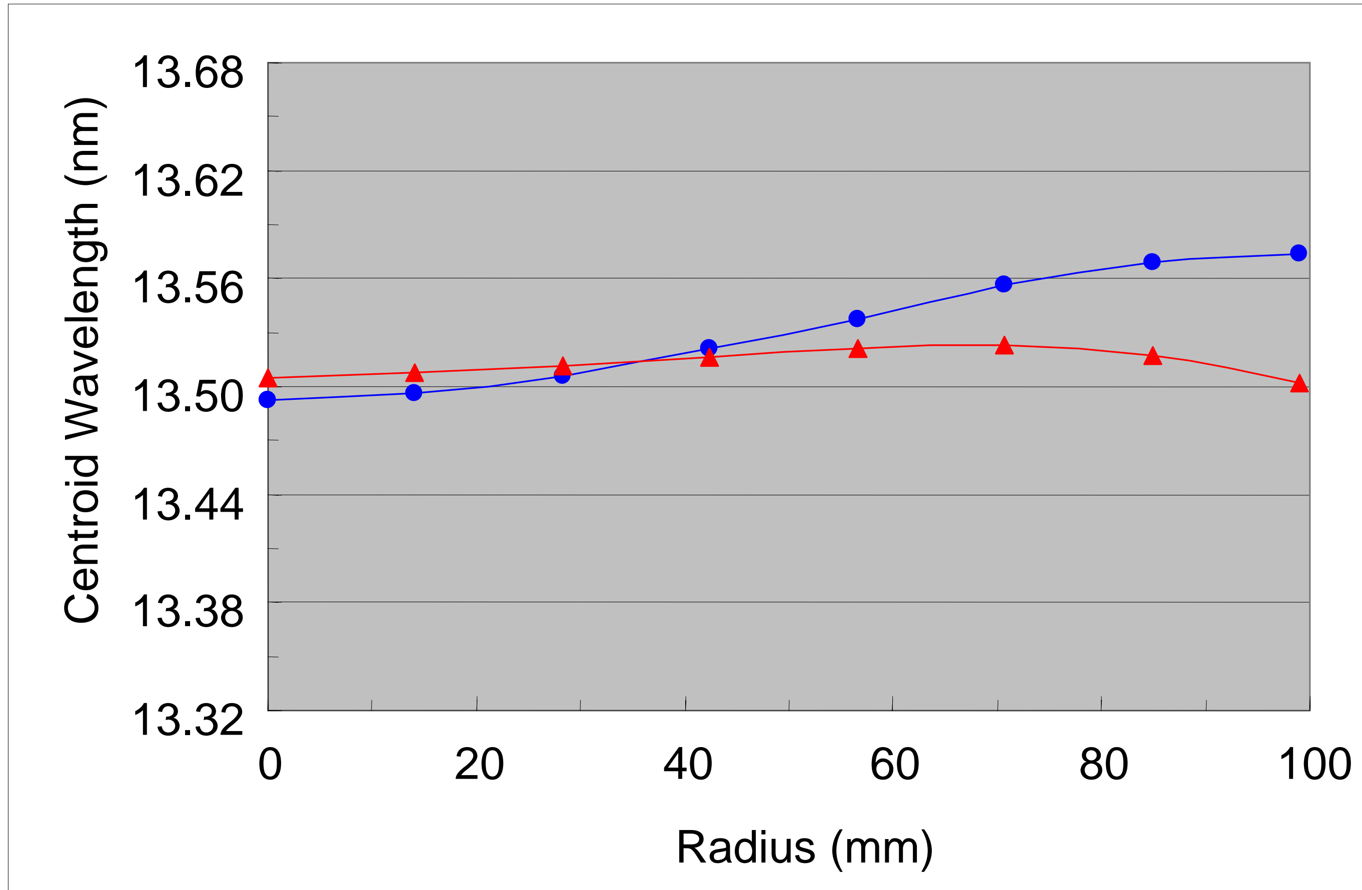
AIXUV's high-throughput (3 plates/hr) EUV reflectometer for daily monitor

EUV reflectance



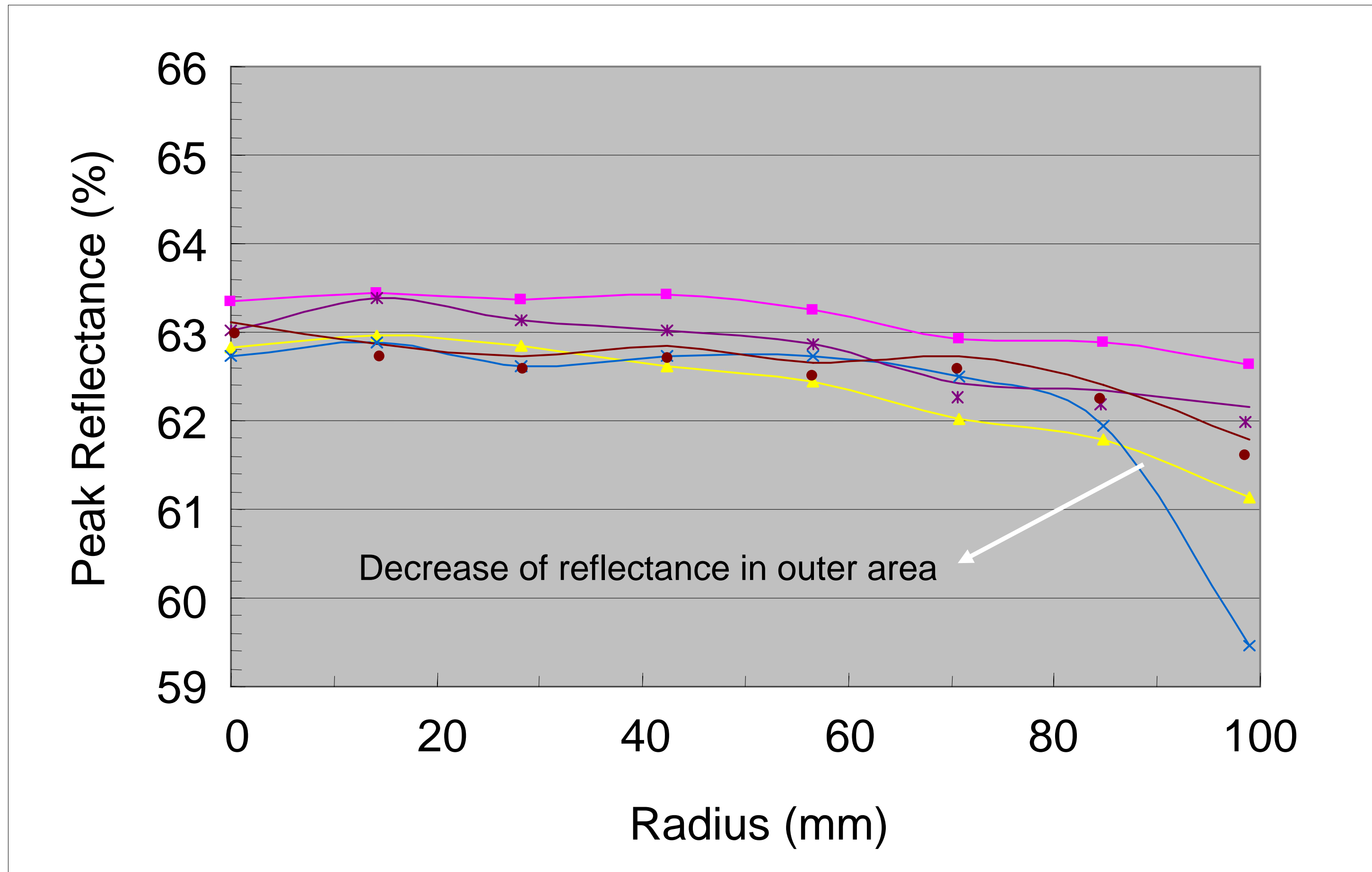
Typical reflectance curve of Mo/Si 50-pair ML (peak reflectance > 65%)

EUV centroid wavelength uniformity



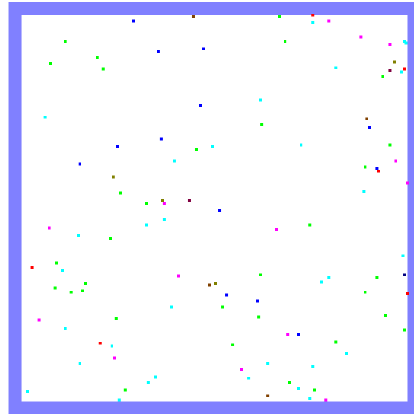
Optimized centroid wavelength uniformity is < 0.03 nm.

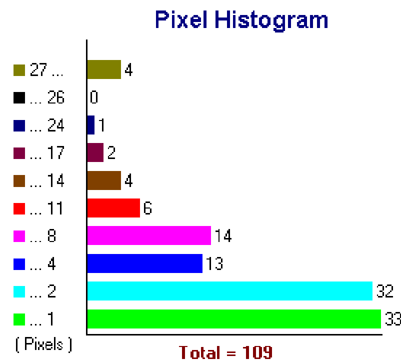
EUV peak reflectance uniformity



Optimized peak reflectance uniformity is < 0.6%.

Defect of mask blank





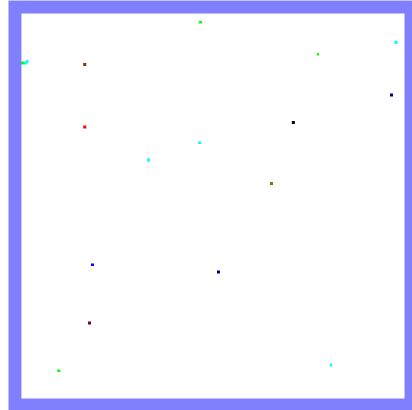
44 defects (> 82 nm, 3 pixel)

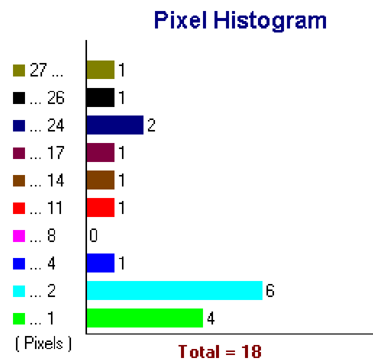
Typical result in total ML defect

Current average number of defects is 30 to 50 (> 82 nm).

Specification for mass production is 0 to 1 (> 30 nm)!

2nd ML adder





7 defects (> 82 nm, > 3 pixel)

Typical result in 2nd ML adder

Average number of 2nd ML adders is up to 20. Decorated substrate defects are dominant in total defects. (please see 07-MA-99 for details).

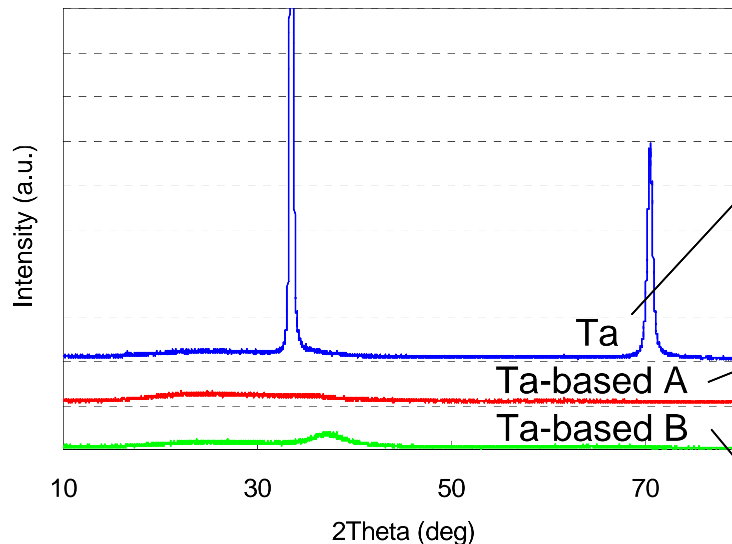
2nd ML adder classification

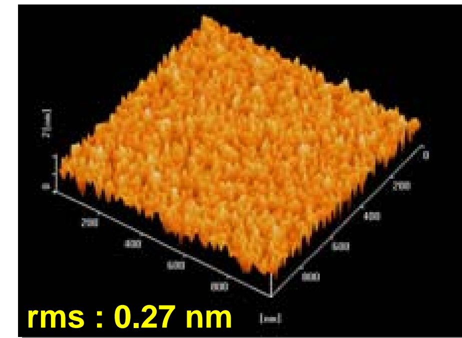
Typical analysis result of 2nd ML

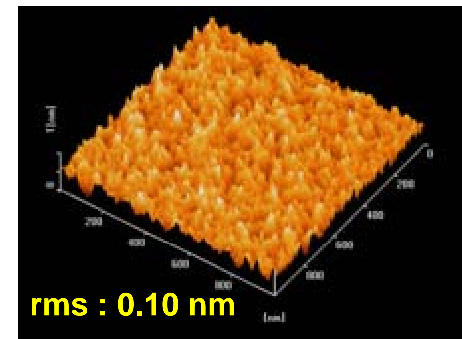
Pixel Count	Core Element	Form	Location
10	Mo / Si multilayer	ML fragment	In 2nd ML
7	Mo / Si multilayer	ML fragment	In 2nd ML
6	Mo / Si multilayer	ML fragment	In 2nd ML
5	Mo / Si multilayer	ML fragment	In 2nd ML
22	Si / O	Si-oxide or Glass	In 2nd ML
21	Si-rich	Si fragment	In 2nd ML
19	Fe / Al / O	?	In 2nd ML
6	C	Carbon	On 1st ML
5	Si-rich or C	Si fragment, Carbon	On 1st ML

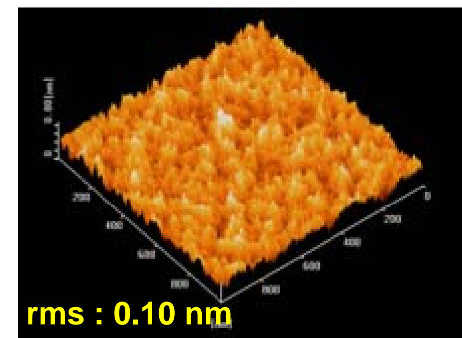
Si defects are dominant in 2nd ML

Ta-based material for absorber layer



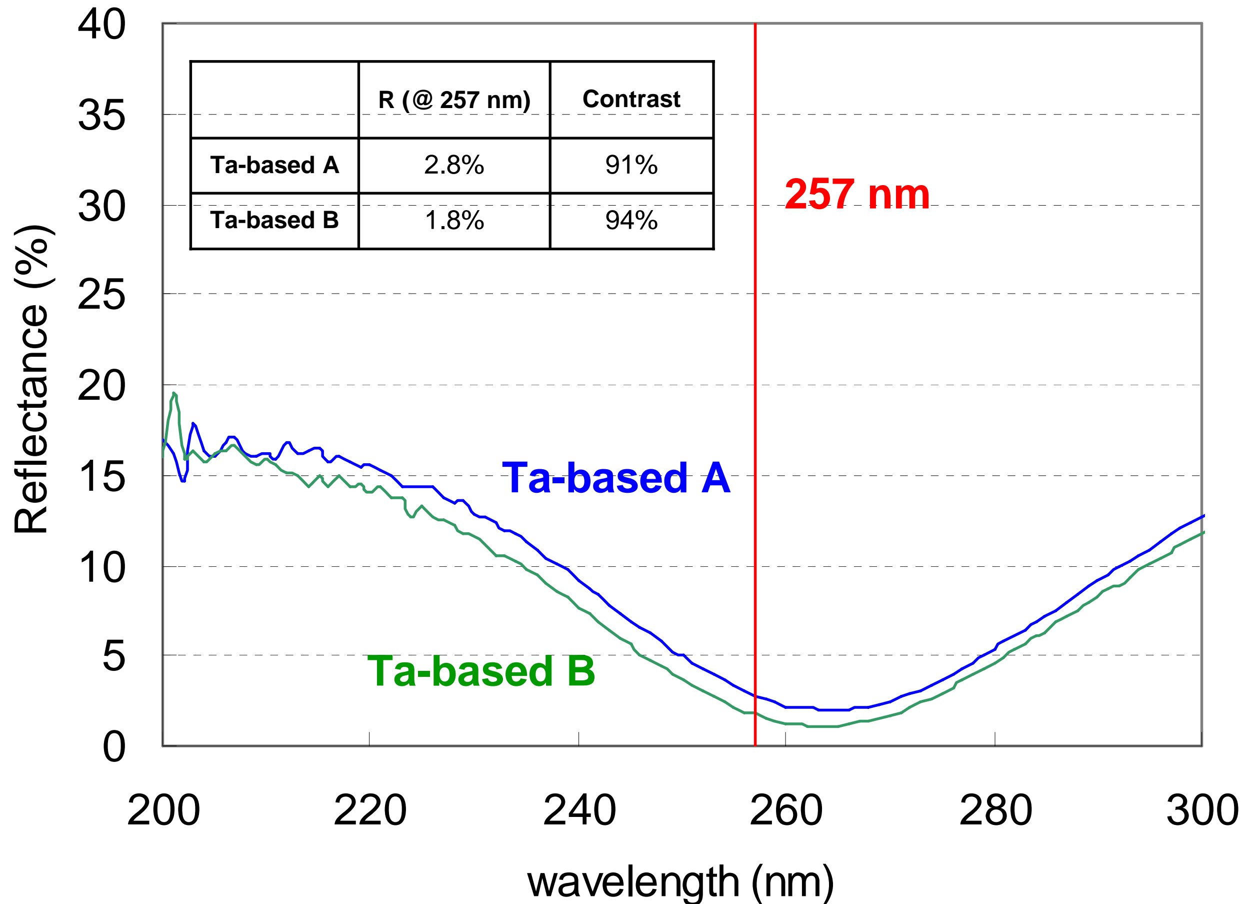






Ta-based A and B material are smooth and amorphous.

Ta-based material for AR layer



	R (@ 257 nm)	Contrast
Ta-based A	2.8%	91%
Ta-based B	1.8%	94%

AR layer of Ta-based B material shows quite low reflectance at 257 nm.

Current and future specifications

Specification item	Current specification	Specification for mass production
CTE	< +/- 5 ppb/K	< +/- 5 ppb/K
Sub. flatness (Front)	< 50 nm	< 50 nm
Sub. roughness	< 0.10 nm	< 0.10 nm
Peak EUV reflectance	> 65%	> 67%
Centroid wavelength uniformity	< 0.03 nm	< 0.03 nm
Peak reflectance uniformity	< 0.6%	< 0.3%
Defect density	< 0.2 / cm^2 (> 82 nm)	< 0.005 / cm^2 (> 30 nm)

Reduction of defect density is still a big challenge!

Summary

- ☑ AGC's infrastructure comprehends technologies from synthesis of LTEM to deposition of ML and absorber.
- ☑ Optical properties of AGC's mask blank are getting closer to the specification for mass production.
- ☑ New Ta-based material has good properties for absorber. It's to be patterned and evaluated.
- ☑ Fabrication of defect-free EUVL mask blank is still a big challenge. The methodology in each process is now being built up in AGC.

Acknowledgement

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SEMATECH

Mask Blank Development Center

Veeco Instruments

AIXUV