Development of beta EUV blanks at HOYA

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Outline

- **Introduction**
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- **Blanks pilot line status**
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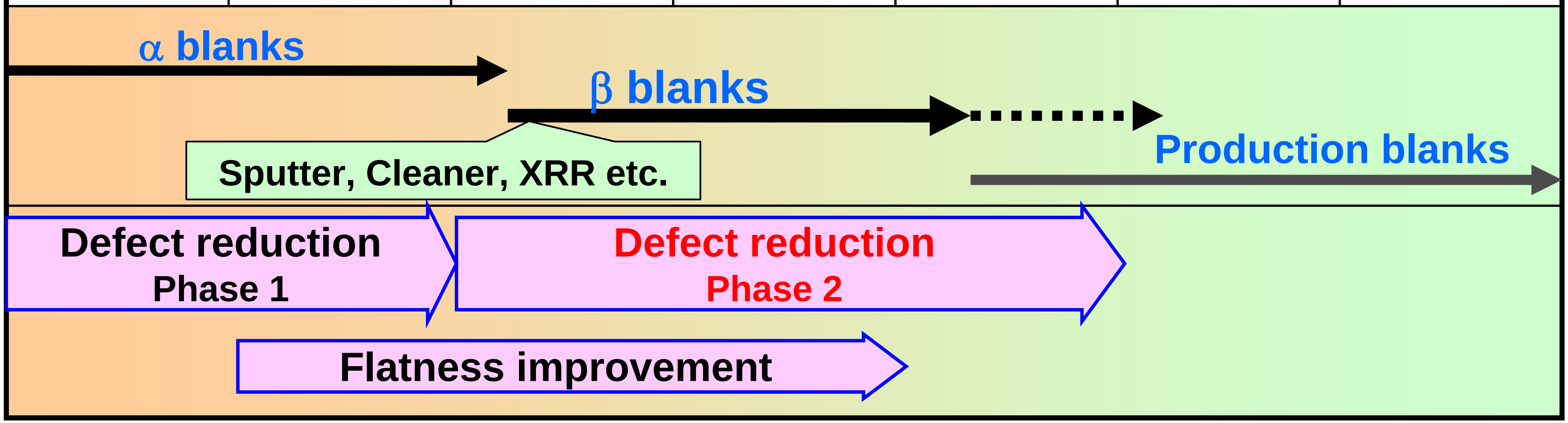
  - **Ru cap defects improvement**
  - **LR-TaBN absorber production**
  - **Backside film performance**
- **ML blanks defect reduction update**
- **Summary**

EUV blanks roadmap

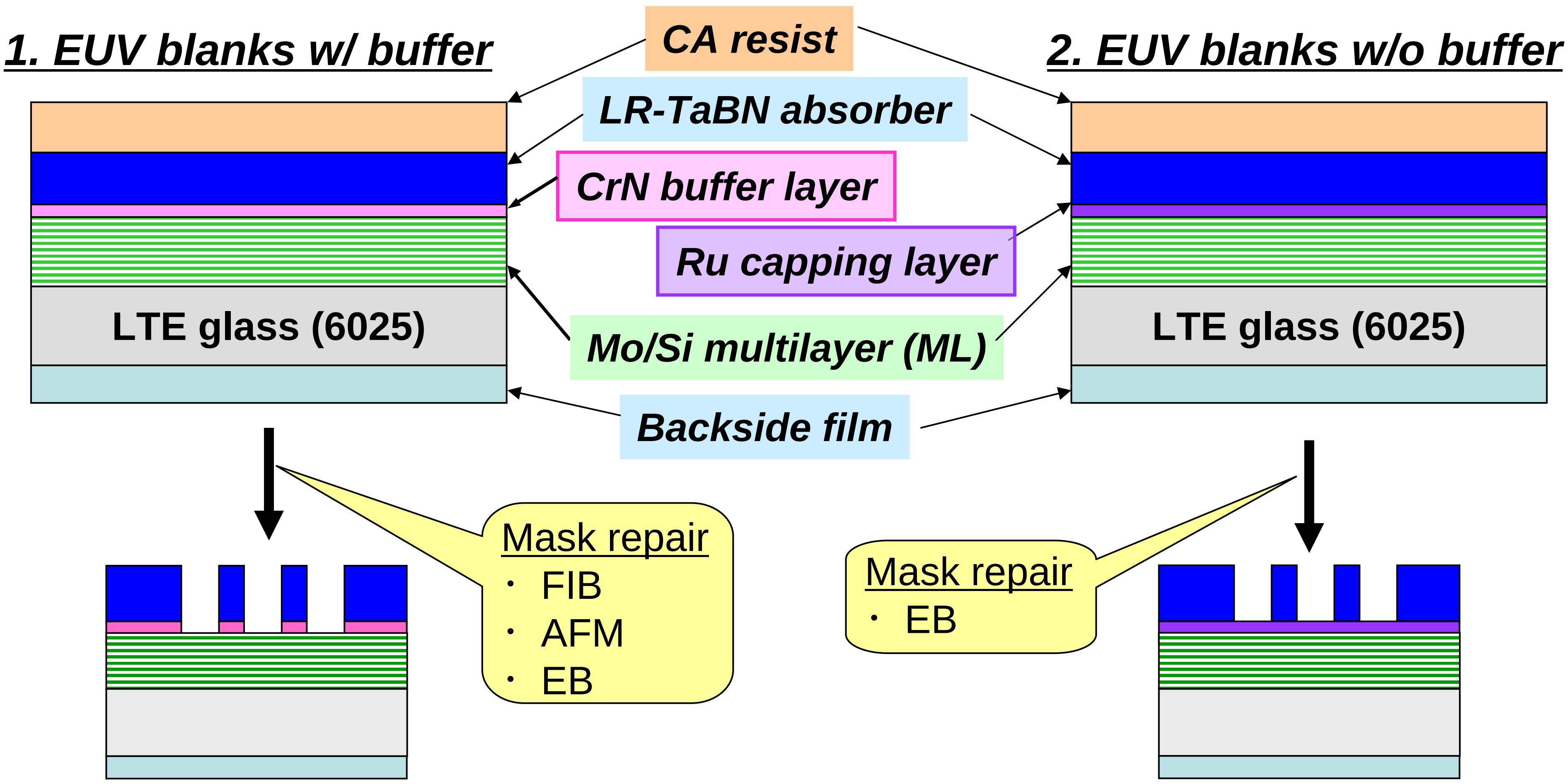
CY	2005	2006	2007	2008	2009	2010
DRAM hp	80 nm	70 nm	65 nm	57 nm	50 nm	45nm



- α EUV blanks (2002 - 2005)
  - for MET exposure test and mask process development
- β EUV blanks (2006 -)
  - To achieve higher quality for full field mask
  - Blanks pilot line: new infrastructures installation

- Defect reduction (Phase 1): Demonstrated low defects of 0.05 def/cm²@80nm
- Defect reduction (Phase 2): Verification of low defects at smaller size
- Flatness improvement: Attaining <50 nm PV

HOYA EUV blanks structure



1. **EUV blanks consisting of CrN buffer and LR-TaBN absorber**
2. **EUV blanks consisting of Ru capping layer and LR-TaBN absorber**

β-EUV blanks pilot line flow
--- Approaches in 2006 ---

Substrate polishing &Cleaning

Defect inspection (Lasertec M1350)

Mo/Si ML and Si capping layer deposition

Periodic length of ML (by XRR)

Defect inspection (Lasertec M1350)

Ru cap/LR-TaBN absorber deposition
or
CrN/LR-TaBN absorber deposition

Backside film coating

Defect inspection (Lasertec M1350)

EB resist coating and baking

Defect inspection

Mask making process

LTEM polish process

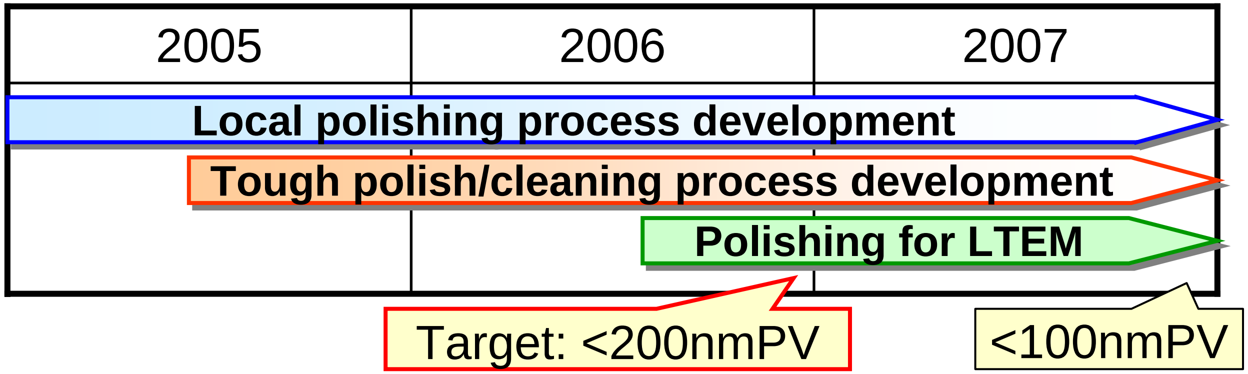
ML reflectivity control using XRR

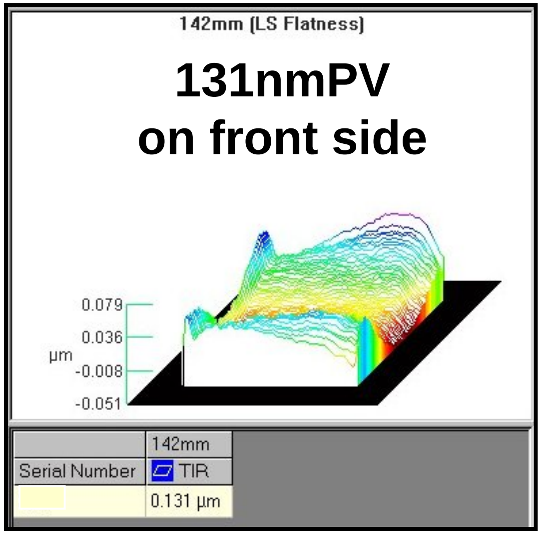
Ru defects improvement

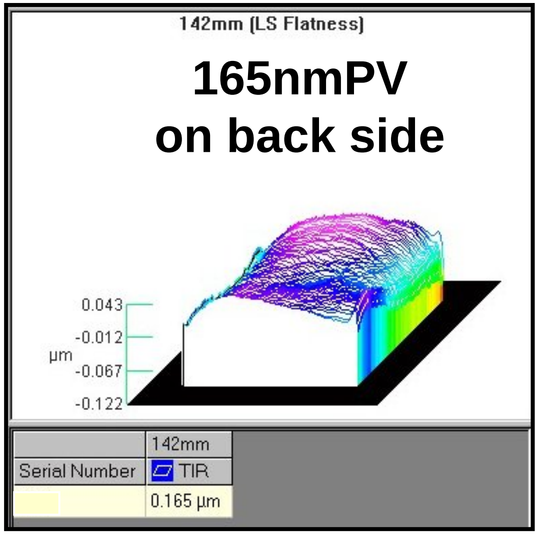
LR-TaBN absorber production

Low defects backside film production

LTE substrate performance status

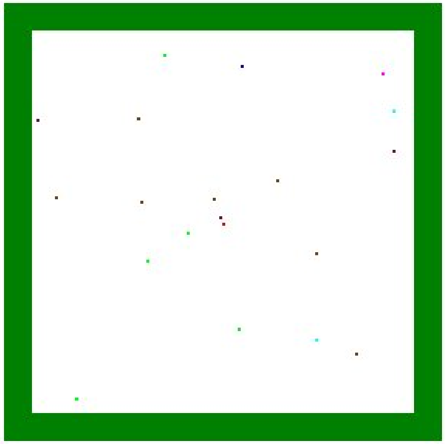


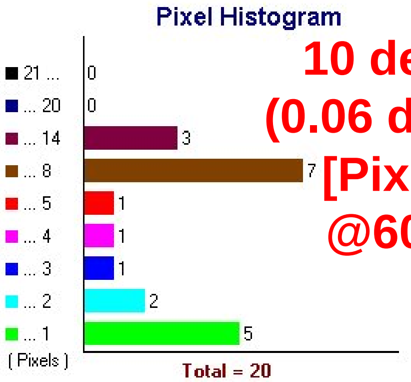




Flatness performance on typical LTE substrate

Defects @M1350 on ULE substrate





10 defects (0.06 def/cm²) [Pixel 6+ @60nm]

- **LTE substrates with low defects and flatness of <200nm achieved**

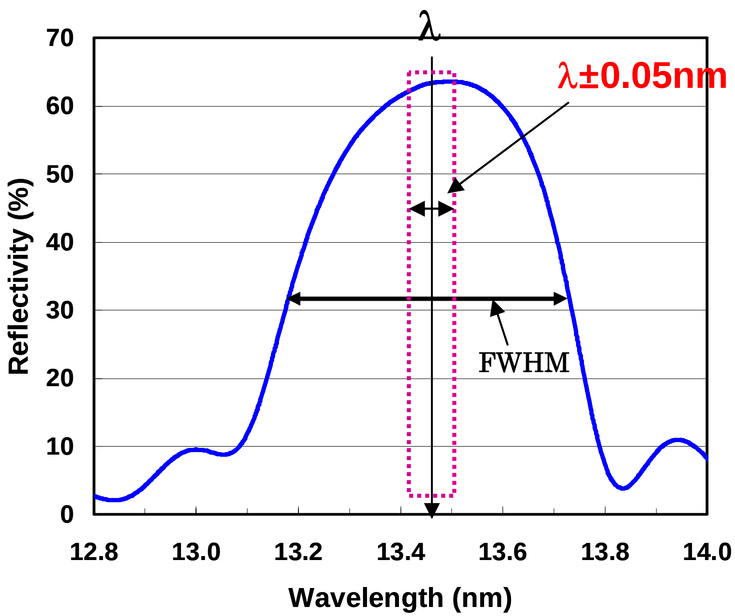
To be presented by Shimojima at poster session (14-MA-159)

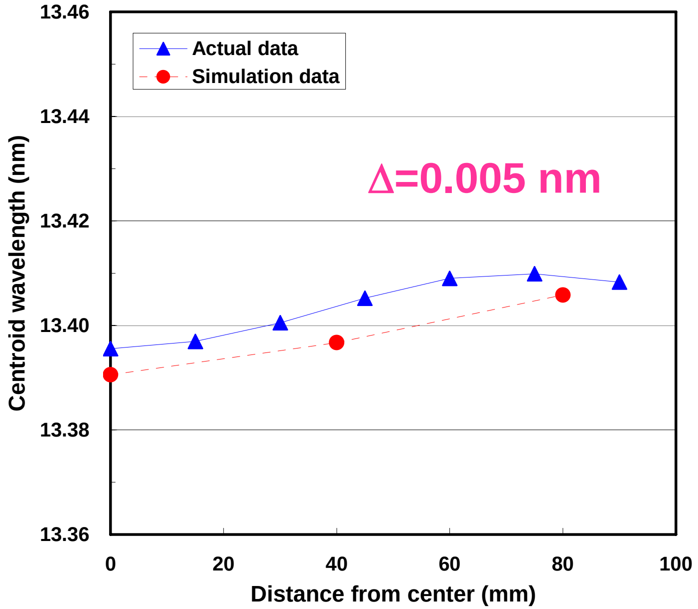
EUV reflectivity simulated by XRR

Centroid wavelength (CW): λ±0.05nm → **Periodic length of Mo/Si (PL): ±0.025nm**

- **Severe to control < ±0.05nm by deposition only**
- **Needs feedback of deposition time every batches**

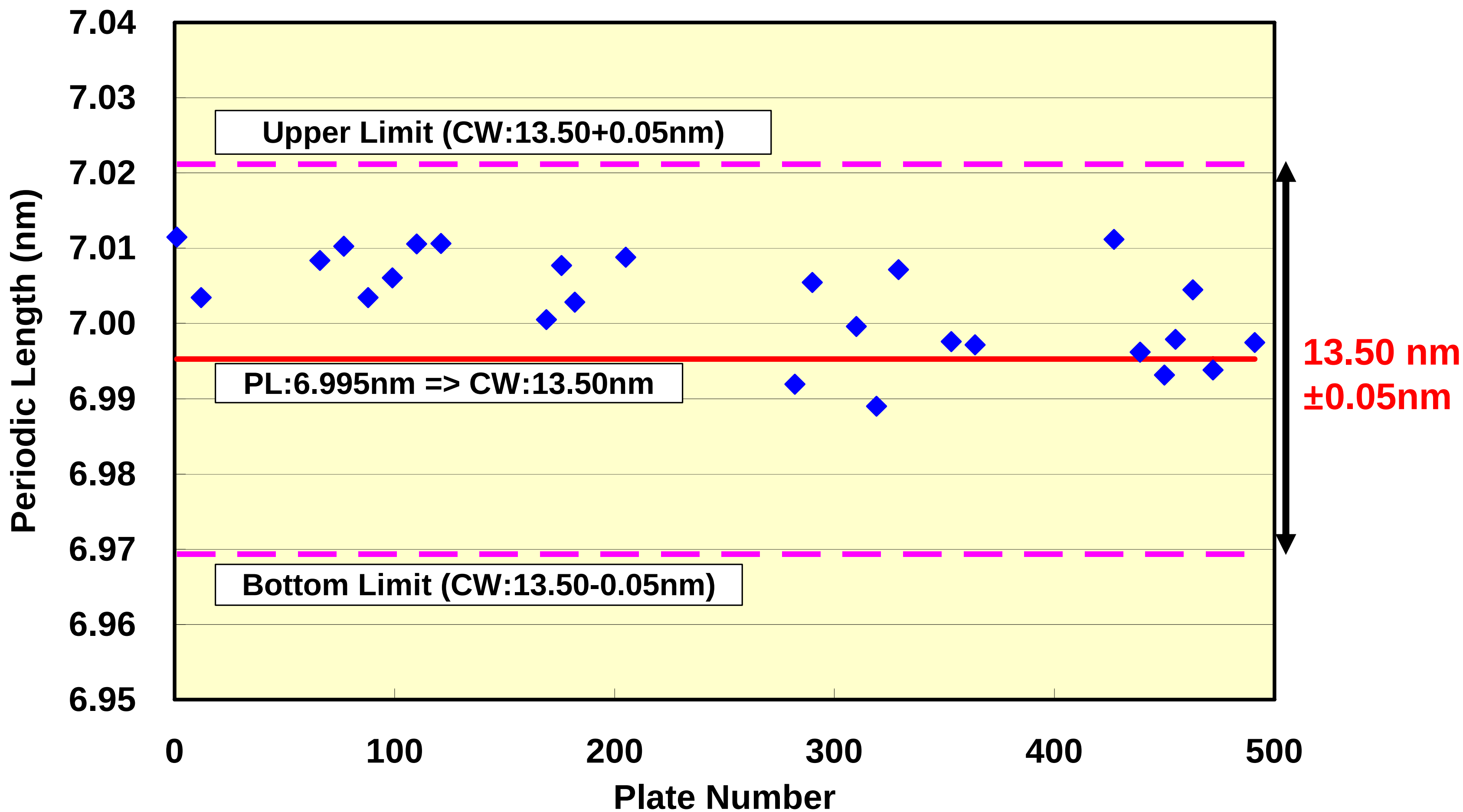
PL of Mo/Si layers measured by XRR
↓
CW estimated using PL by simulator
↕
CW measured by EUV reflectometer





- **Good agreement between actual data and simulation data**
- **Possible to manage centroid wavelength on ML using XRR**

Centroid wavelength (CW) reproducibility controlled by XRR w/o EUV reflectometer



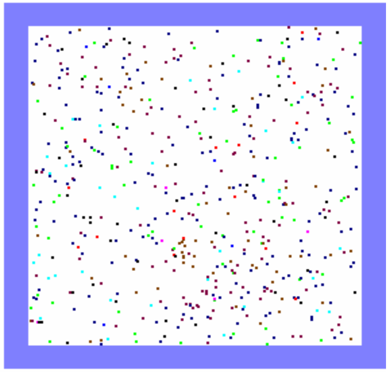
- **Possible to control CW within +/-0.05nm using XRR w/o reflectometer**

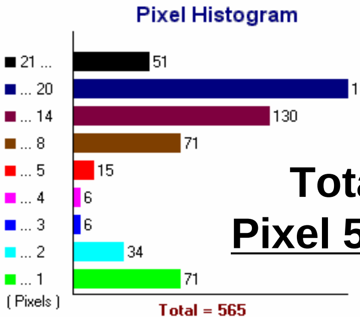
Ru capping layer performance and issue

Comparison of capping layer performance based on experimental and simulated results

	Ru	Si	CrN
EUV Reflectivity	☺	☺	☹
Cleaning durability	☺	☺	☺
Absorber etching durability	☺	☹	☺
EB repair durability	☺	☹	☺

Adder defects caused by Ru coating @M1350





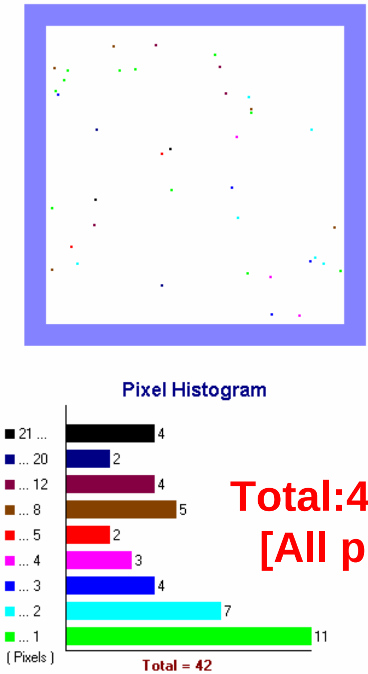
Total: 565 def
Pixel 5+: 448 def

- Ru capping layer
  - Good material in mask making process w/ EB repair as capping layer
  - Bad defectivity due to Ru coating

Performance on improved Ru capped ML

HOYA developed new Ru compound (Ru_A) capping layer

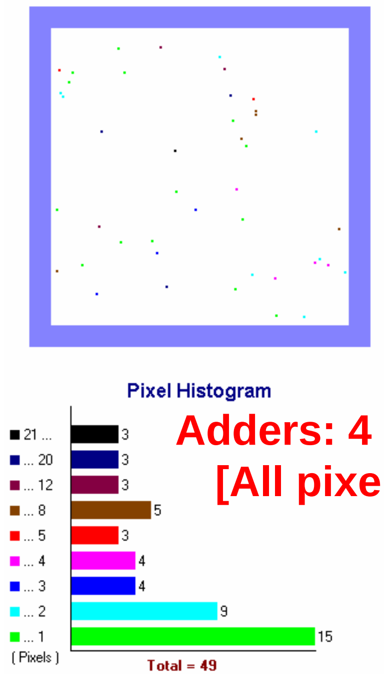
Total defect performance@M1350



Total:42 def [All pixel]

ML

Ru_A coating



Adders: 4 def [All pixel]

Ru_A-ML

Comparison of Ru-ML and Ru_A-ML

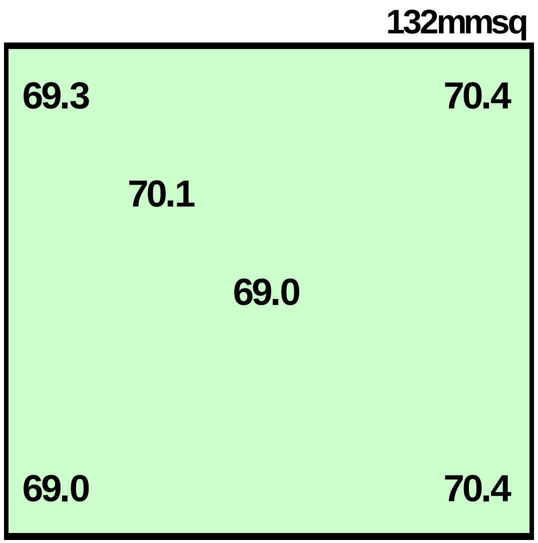
	Ru-ML	Ru_A-ML
EUV peak reflectivity (40 pairs)	63%	63%
Cleaning durability	No damage*	No damage*
Absorber etching selectivity	High selectivity >50	High selectivity >50

*No significant EUV reflectivity change

- Ru_A capped ML blank
  - Adders of 4 defects demonstrated
  - Total defects of 49 at all pixel and 15 defects (0.09 def/cm^2) at 80nm showed
  - Quite same properties to Ru capped ML except for defect quality showed

Thickness uniformity and optical reflectivity on LR-TaBN absorber

Thickness uniformity*

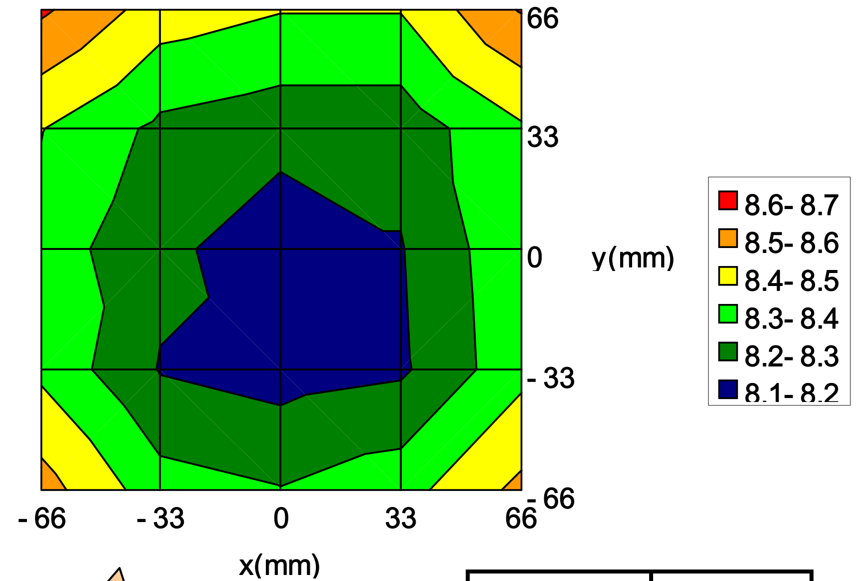


Average 69.7 nm
(-/+) 1.0 %

Uniform thickness : <±1%

*** measured by stylus method**

Optical reflectivity



Optical reflectivity : <10%@257nm

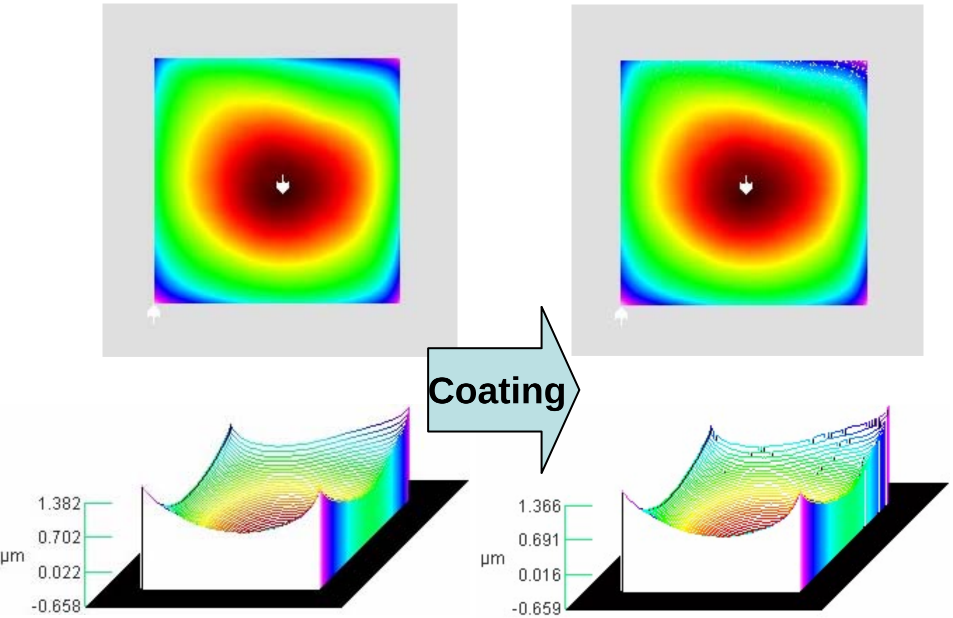
Average	8.3%
Max.	8.6%
Min.	8.1%
Range	0.5%
3 sigma	0.4%

LR-TaBN with uniform thickness and low optical reflectivity achieved

Stress and defect performance on LR-TaBN/CrN stacks

Low stress : <200MPa meeting SEMI spec.

Low defects at initial stage 0def@150nm, 32def@80nm

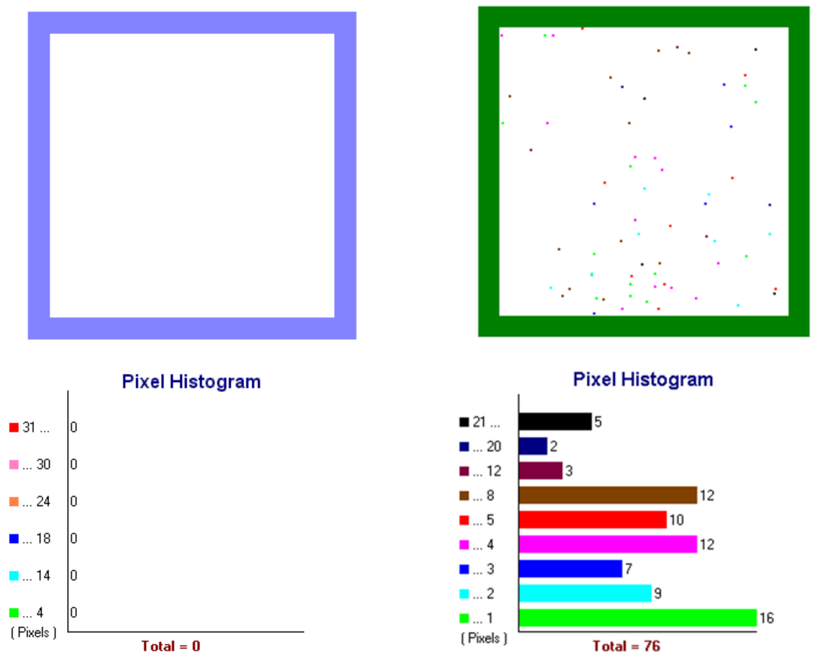


TIR=2.040(μm) → **TIR=2.025(μm)**

<u>QZ</u>

<u>LR-TaBN（70nm）</u>
<u>CrN(10nm)</u>
<u>QZ</u>

Flatness change 0.015(μm)



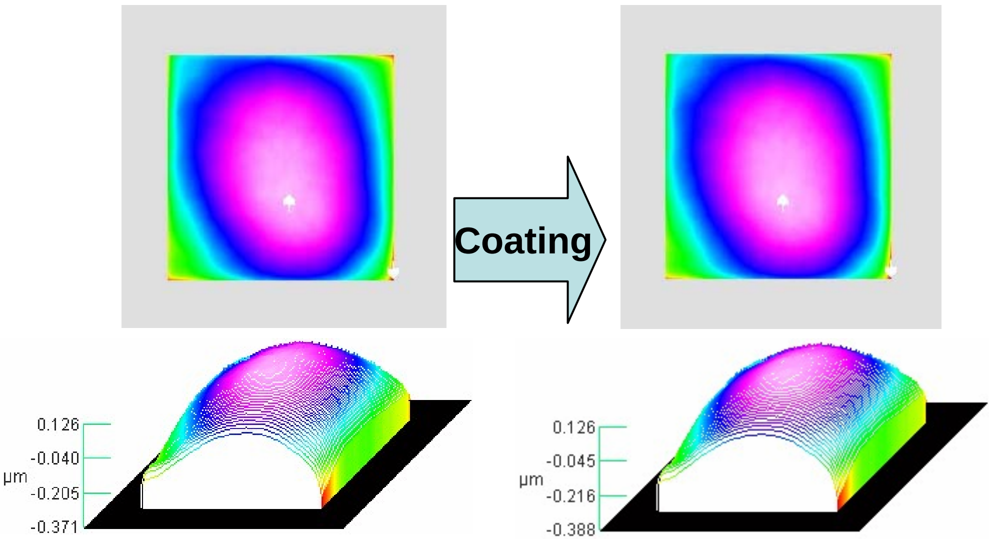
M1320 **M1350**

<u>LR-TaBN(70nm)</u>

- **LR-TaBN/CrN stacks with low stress and low defects demonstrated**

Low defects backside film

Stress performance



TIR=0.496(µm) → TIR=0.514(µm)

Flatness change: 18 nm

Defect performance

	~0.2	~0.3	~0.5	~1.0	~2.0	2.0~
△ Particle	0	0	0	0	0	0
▽ Pinhole	0	0	0	0	0	0
□ Dark	0	0	0	0	0	0
◇ Bright	0	0	0	0	0	0
○ Other	0	0	0	0	0	0
Total	0	0	0	0	0	0

Zero defects @150nm (M1320)

	Current performance	Target
Sheet resistance	<100 ohm/sq.	<100 ohm/sq.
Stress	<200 MPa	---
Defects	Zero@>1um	Zero@>1um

- **Low stress and low defects film can be coated as backside film**

β-EUV blanks specifications

	α blanks	β blanks	β blanks
CY	2005	2006	2007
Substrate material	QZ	QZ/LTEM	LTEM
Substrate flatness	<400 nm	<200 nm [<100nm*]	<100 nm [<50nm*]
Peak reflectivity (R) @EUV	>63% (40 bi-layers)	>64% (40 bi-layers)	>65%
R uniformity	<1% PV	<0.5% PV	<0.5% PV
λ uniformity	<0.10 nm PV	<0.06 nm PV	<0.06 nm PV
ML defect density	<0.1 def/cm^2 @150nm	<0.2 def/cm^2 @80nm	<0.2 def/cm^2 @All
Absorber defects (Adders)	N/A	<0.1 def/cm^2 @150nm	<0.2 def/cm^2 @80nm
Absorber thickness uniformity	N/A	<+/-1%	<+/-1%
Defect inspection	M1320/M1350	M1350	M1350

*N/A for defect quality

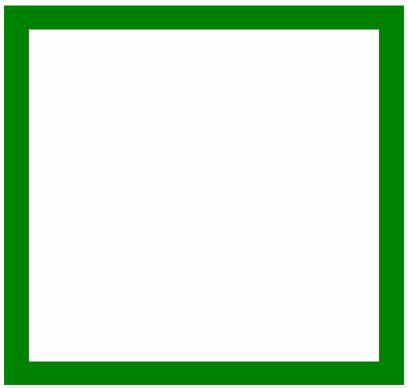
Defect reduction update

Focusing on defect reduction at smaller defects

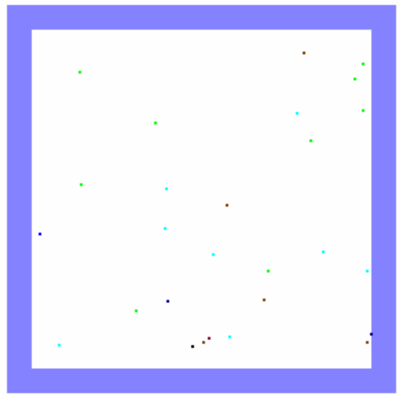
__Champion data@M1350__

*__M7360 inspection data*__*

QZ Substrate

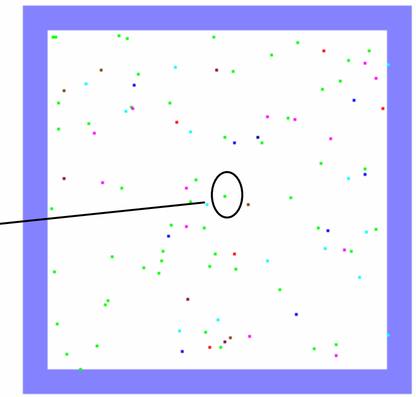


ML/QZ blank

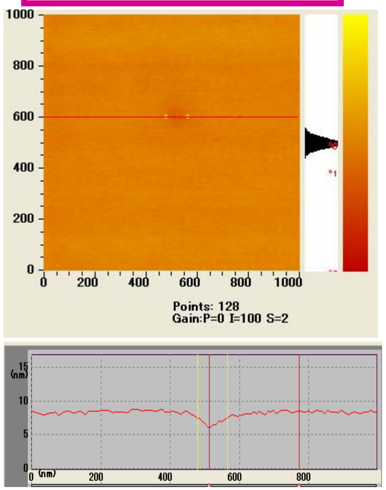


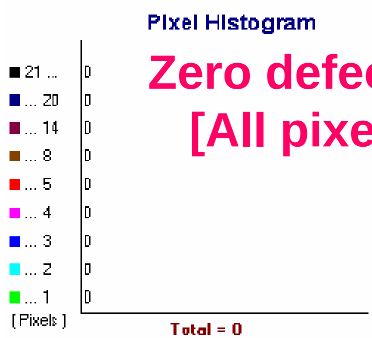
M7360 inspection

ML/QZ blank

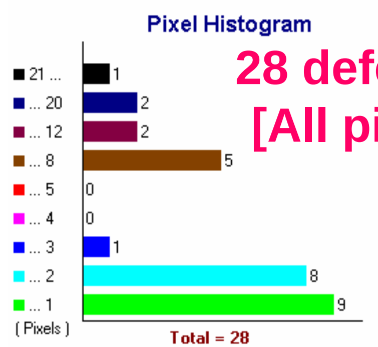


Pixel 1
85nmWx2.5nmH

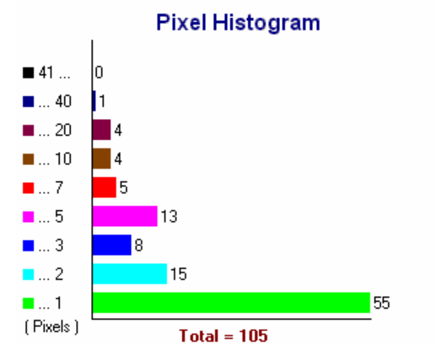




Zero defects [All pixel]



28 defects [All pixel]

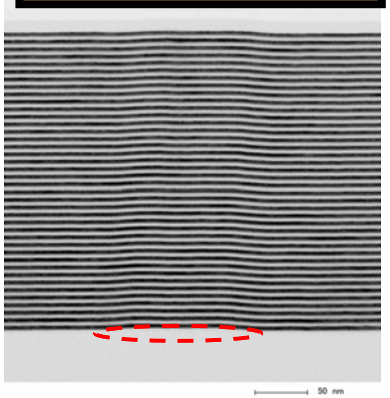


*** Courtesy of Lasertec**

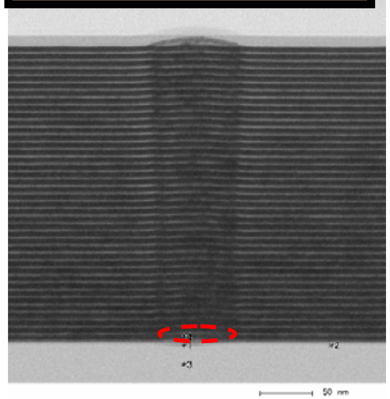
- **M7360 inspection tool** (made by Lasertec) **has higher sensitivity on ML film**
- **There are many small defects on current ML blanks**

ML blanks defects analysis

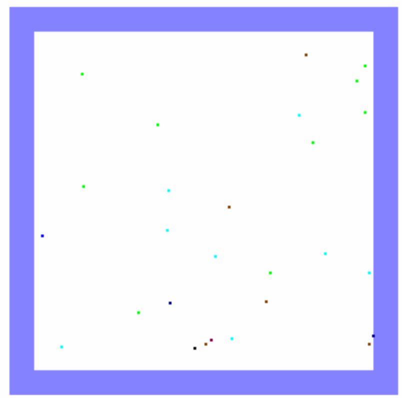
240nmW x 2nmH
Pixel 3

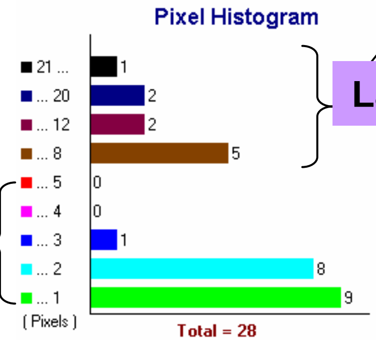


180nmW x 11nmH
Pixel 2



ML blank

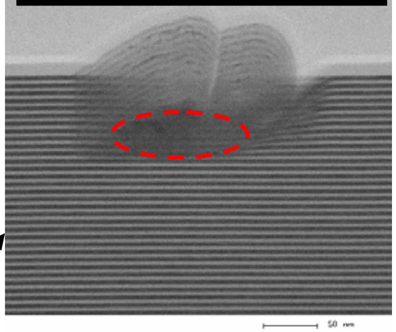




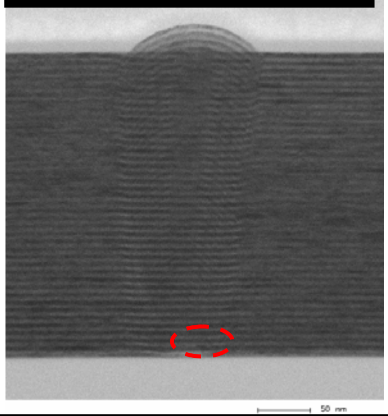
Large pixel

Small pixel

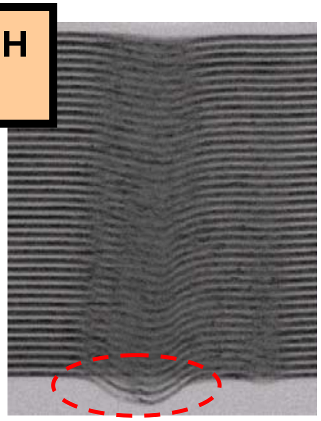
170nmW x 55nmH
Pixel 10



170nmW x 28nmH
Pixel 8



200nmW x 5nmH
Pixel 1



- **There are still various types of defects on ML blank**
- **Polishing, cleaning and ML coating processes should be further improved**

Summary and Future work

- HOYA started development and production of β EUV blanks in April 2006
  - Blanks pilot line including absorber coating was built in our factory
  - EUV blanks with LTE substrates are ready for full field mask used in alpha EUV exposure tool
- We are focusing on defect reduction at smaller than 80nm from 2006
  - Defect quality is steadily reducing, but there are still many types of defects on the ML blanks

↓

- We will continue defect reduction on ML blanks to verify nearly zero defects under inspection with higher sensitivity
- We will develop polishing process to attain higher flatness and lower defects on LTE substrates, simultaneously.