Progress in EUV blanks development at HOYA

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NGL Development Center, Blanks Dev.*
HOYA Corporation

Outline

- Introduction
  - HOYA EUV blanks
  - Fabrication process of ML blanks
  - Current status, target and plan on ML blanks
- ML blanks defect reduction
  - Defect analysis and defect sources
  - Results on ML process improvement
  - Results on polishing process improvement
- Substrate flatness improvement
  - Flatness control
  - High flat and low defects substrate
- EUV reflectivity improvement
- Summary and Future work

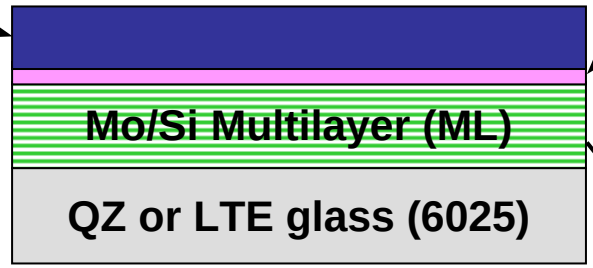
HOYA EUV blanks

LR-TaBN absorber

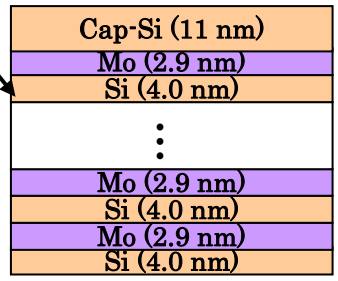
LR: Low Reflectivity

- **Low reflectivity: 5% at 257 nm (higher inspection contrast)**
- **Amorphous structure**

CrN buffer layer

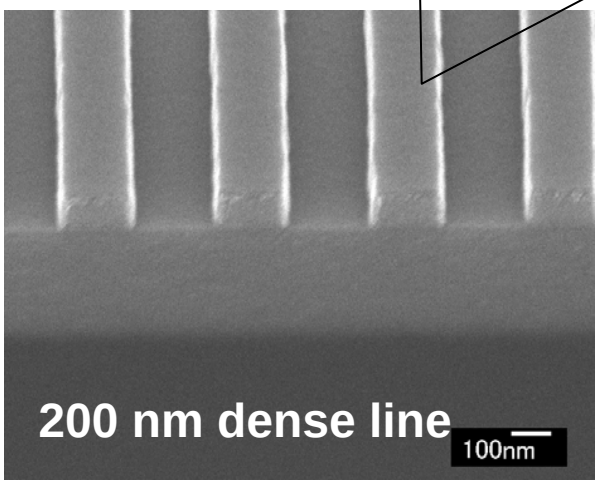


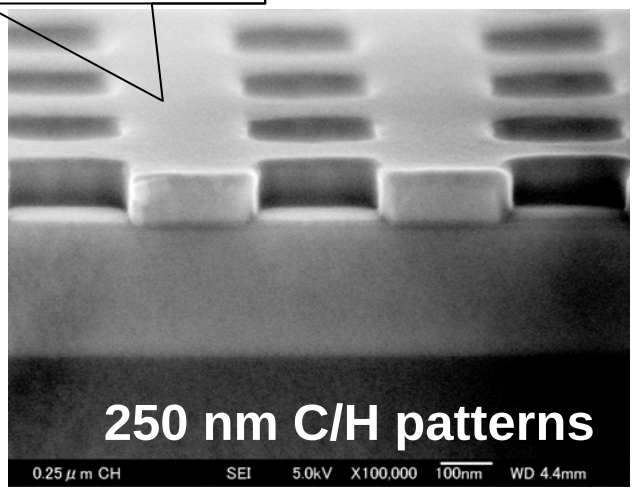
Structure of EUV blank

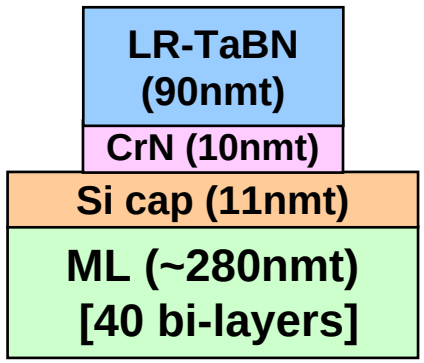


40 bi-layers

High patterning resolution
Smooth surface

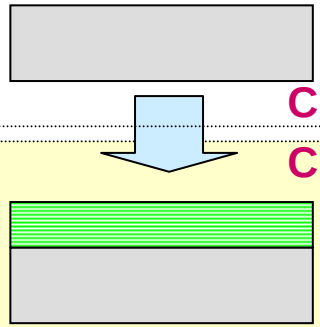






Mask structure

Process flow of present ML blanks



Substrate polishing

Both sides flatness control using production tool

Cleaning & Flatness measurement

Cleaning & Defect inspection (Lasertec M1350)

Mo/Si ML and Si capping layer deposition (by IBD)

in advanced blanks line

Cleaning & Defect inspection (Lasertec M1350)

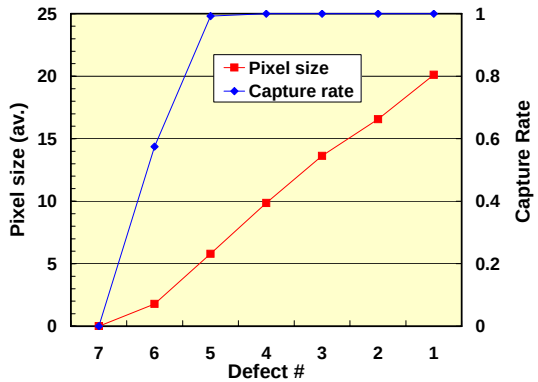
Buffer and absorber deposition

IBD tool

M1350 inspection tool

Sensitivity on ML in M1350

- **Sensitivity monitor**
  - **using programmed defect ML**



- **80nm PSL sensitivity on ML**
  - **for pixel 5+**

Status, target and plan on ML blanks

Three technical issues: ML blank defect, substrate flatness and EUV reflectivity

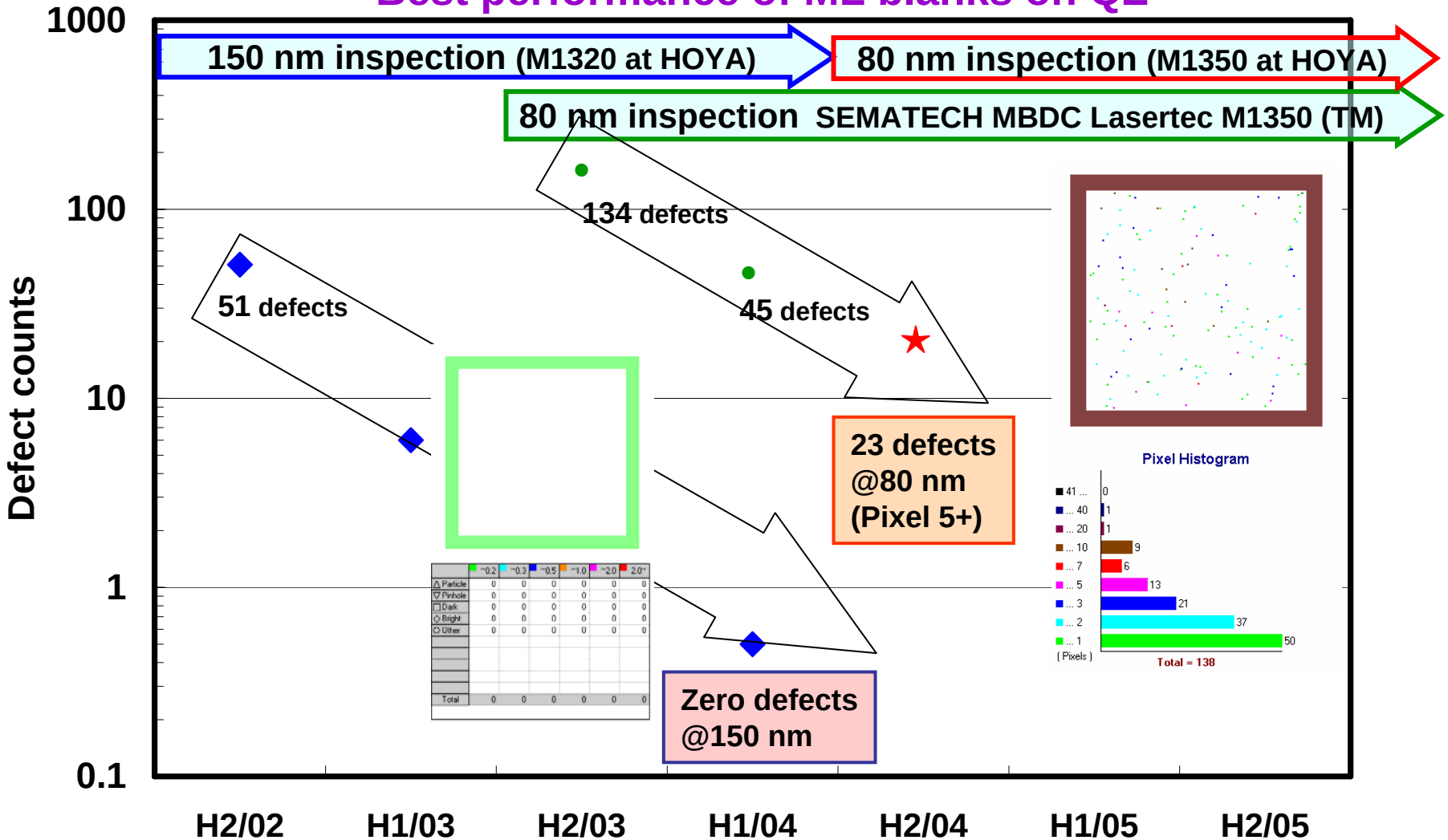
	Current status	Production specs
Year	2004	2009
Substrate material	QZ	LTEM
Substrate flatness	300 nm (Typical)	<50nm
EUV peak reflectivity	63% (for 40 bi-layers)	>67%
Total defect density	0.13 def/cm^2@80nm (Best)	0.003 def/cm^2@25nm

Hoya has three major development programs in 2005

CY	2002	2003	2004	2005	2006
Zero defects (Verification)	ML blanks defect reduction on QZ sub.				
	150 nm inspection			80 nm inspection	
50nm Flatness				New polishing	
High Reflectivity			EUV reflectivity improvement		

Progress in ML blank defect reduction 2002 - 2004

Best performance of ML blanks on QZ



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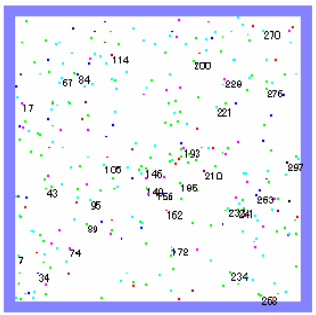
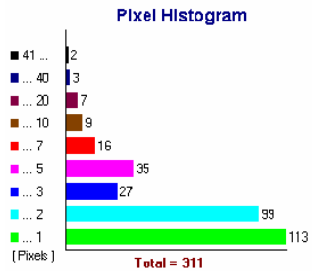
Defect reduction processes

Process improvement

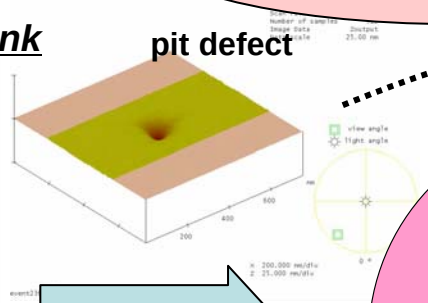
Defect inspection (M1350) → **Defect classification (AFM etc.)** → **Defect characterization (TEM, SEM/EDS etc.)**

Defect map on ML blank

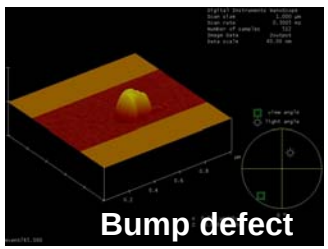




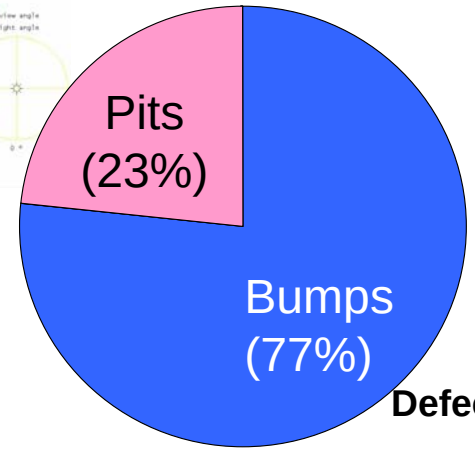
pit defect



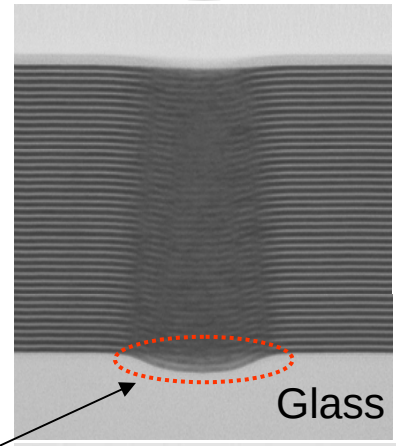
AFM

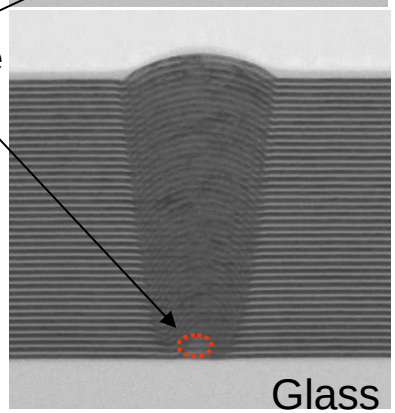


Defect pareto



Defect source





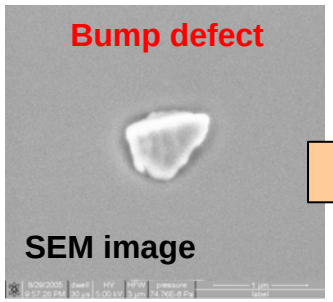
- **Almost defects originate on substrate surface**

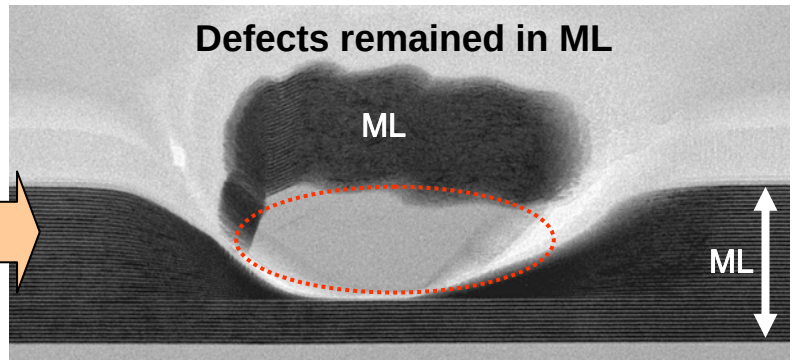
→ **Substrate defects should be reduced**

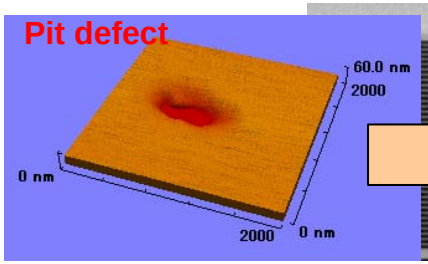
Various defects in ML process

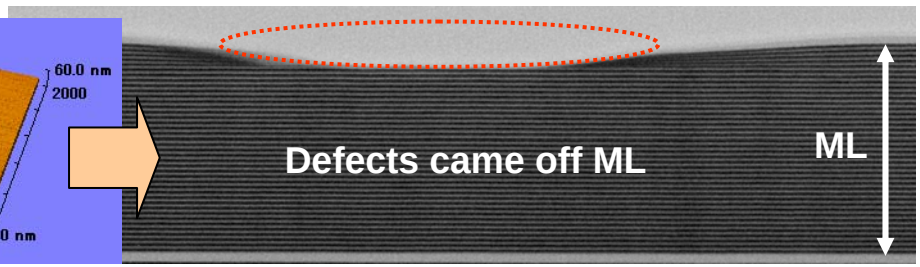
During ML coating
(Defects in ML film)

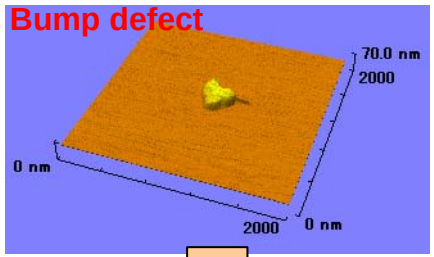
After ML coating

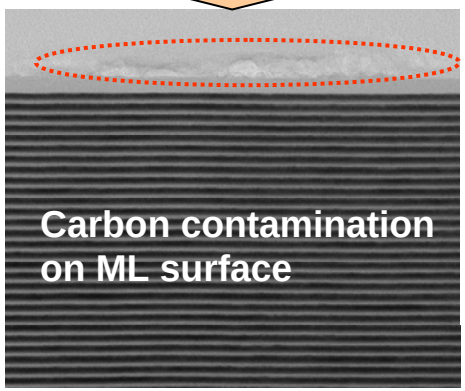












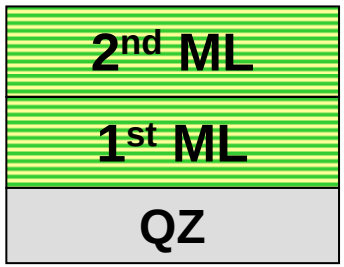
- **There are various types of defects caused in ML coating process**

➡ **ML coating process should be improved to achieve zero defects**

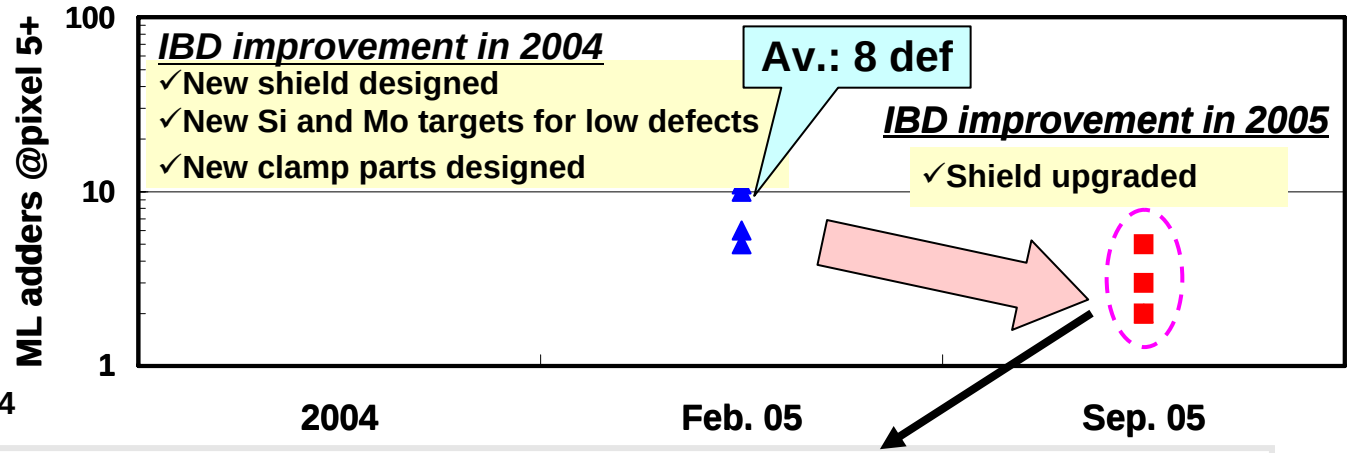
Results on defect reduction (1)

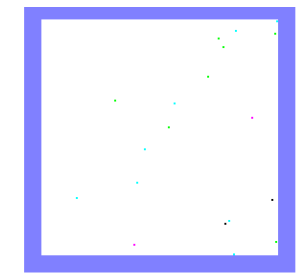
---ML coating process improvement---

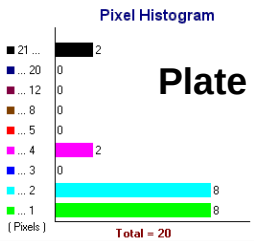
ML on ML technique*

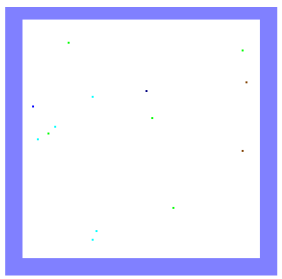


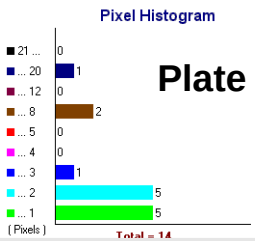
* P.A.Kearney et al. BACUS2004











ML adders (pixel 5+)

Plate (1): 2 defects
Plate (2): 2 defects
Plate (3): 3 defects
Plate (4): 5 defects

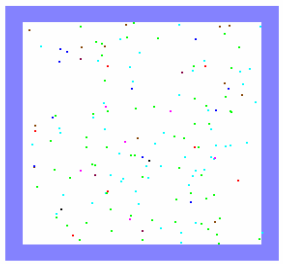
Av.:3 defects
Best: 2 defects

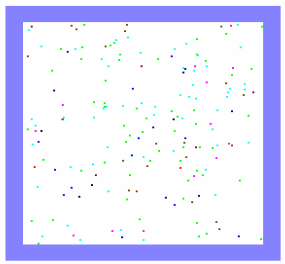
- **Obtained 2 defects for pixel 5+ as best ML adders**

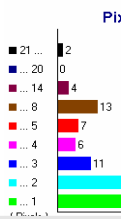
Results on defect reduction (2)
---Substrate polishing improvement (H1/05)---

Typical blank in 2004

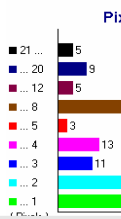
QZ substrate | **ML blank**







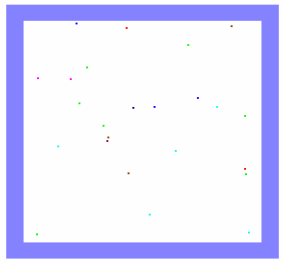
26個 @Pixel 5+

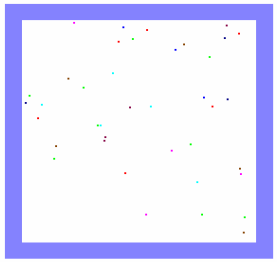


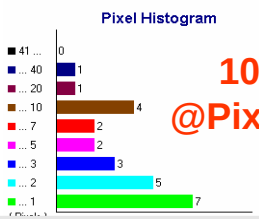
44個 @Pixel 5+

Best blank in H1/05

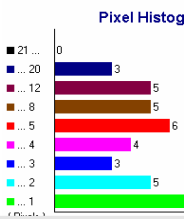
QZ substrate (by improved polish) | **ML blank (on improved QZ)**



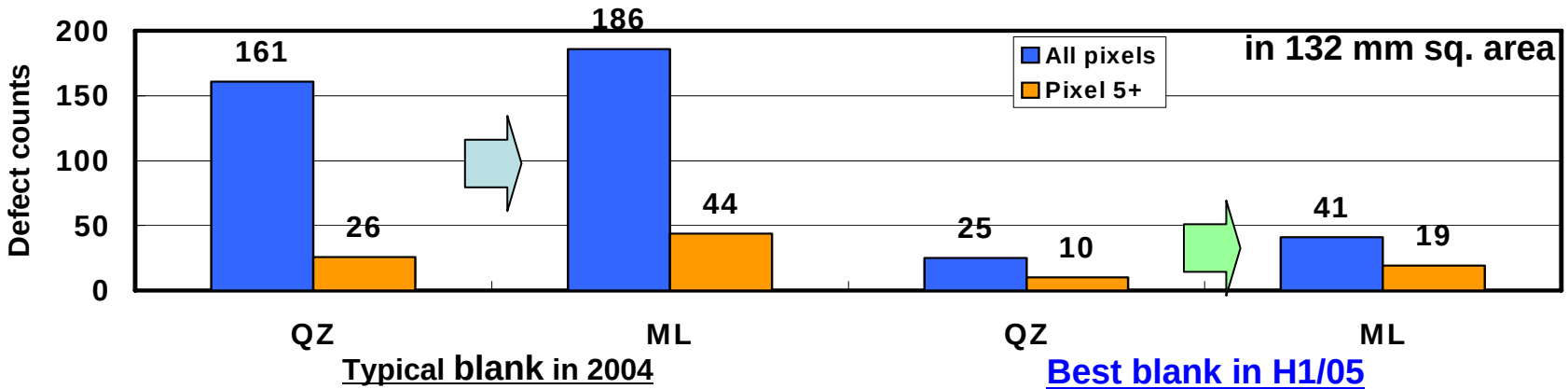




10個 @Pixel 5+

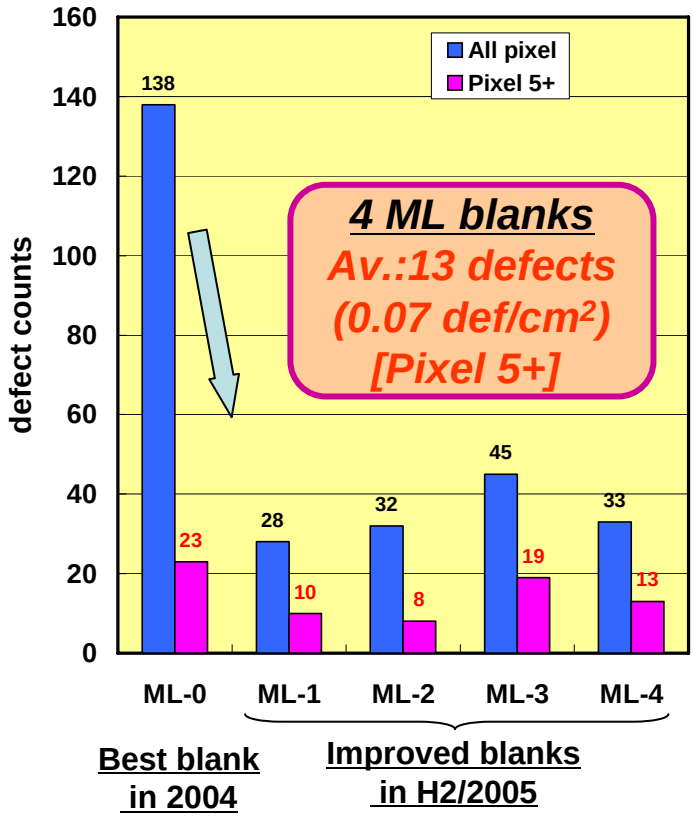


19個 @Pixel 5+



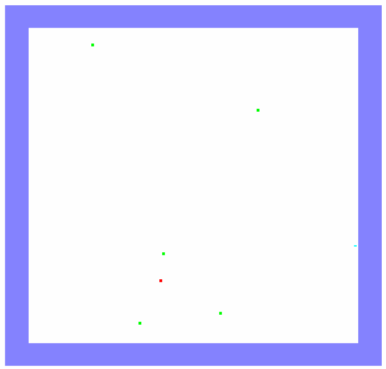
Results on defect reduction (3)
--- Substrate polishing improvement (H2/05)---

Defects on improved blanks

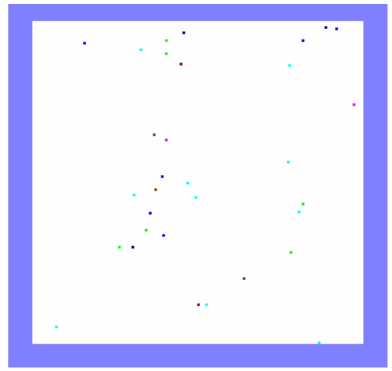


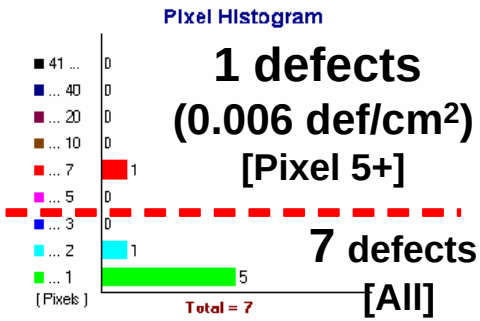
Best blank in H2/05

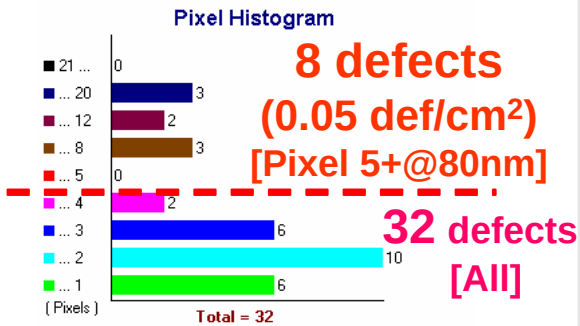
QZ substrate



ML blank



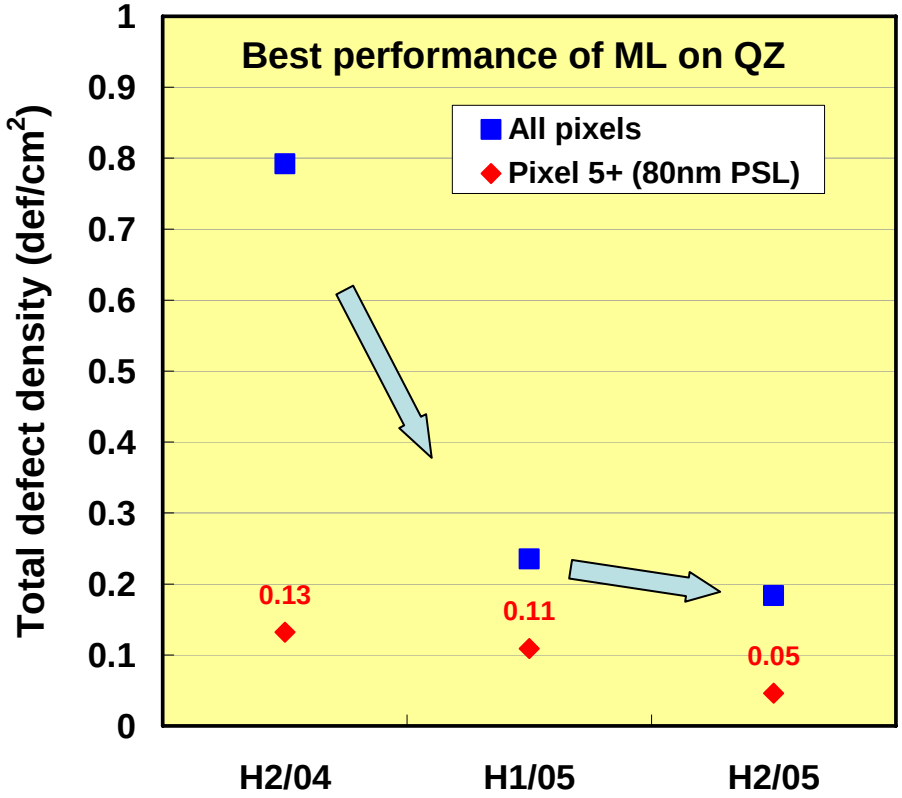




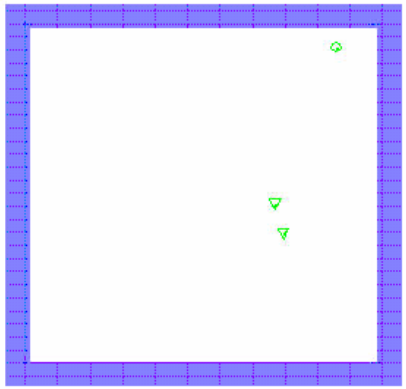
- **Obtained low defect ML blanks with 8 defects (for pixel 5+) as best using improved processes**

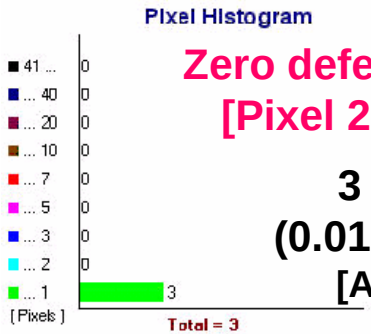
Defect reduction in 2005

Progress in ML blanks defects



Champion data on QZ defects





Zero defects [Pixel 2+]

3 defects (0.017 def/cm²) [All pixels]

- **ML blank defects have been fairly reduced at smaller sizes**
- **Achieved nearly zero defects on QZ substrate inspected by M1350**

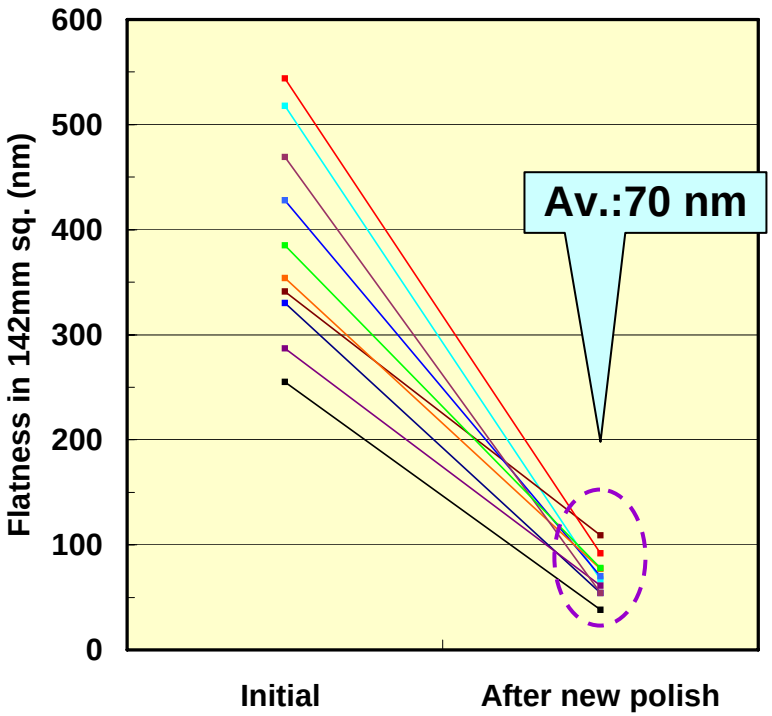
Good progress in defect reduction on ML blank and QZ substrate was made

Flatness control using new polishing

New polishing technique is needed for achieving 50 nm flatness

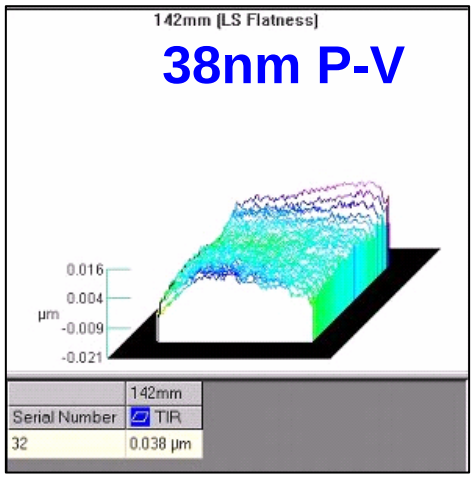
Conventional polishing → **New polishing**
Numerical control

Flatness before and after new polish

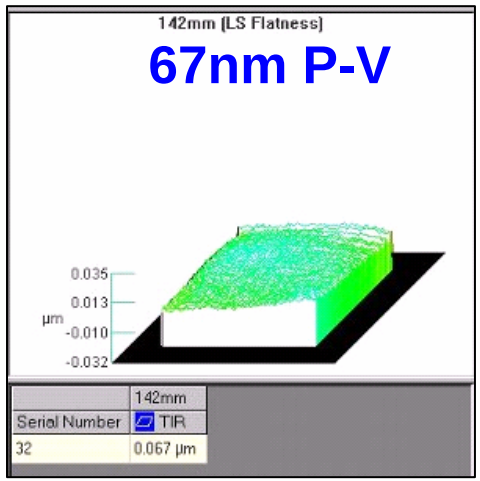


Flatness in 142 mm sq. of typical QZ

Front side



Back side



- **Possible to obtain high flatness of <100 nm**
- **Generates rough surface and defect increase**

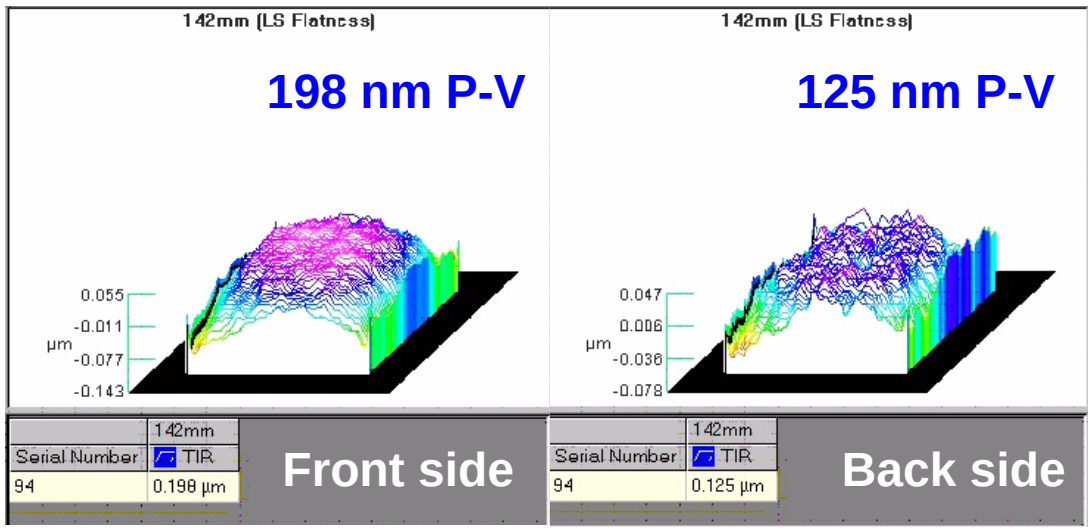
Critical Challenge is to attain 50 nm flatness, smooth surface and low defects

High flat and low defects substrate
--- Initial results ---

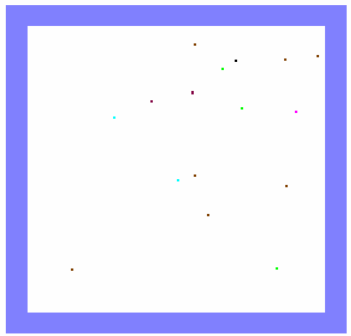
New polishing → **Touch polishing**

QZ substrate produced by new polishing

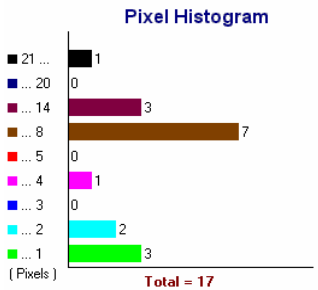
Flatness in 142 mm sq.



Defects



11 defects
(0.06 def/cm²)
[Pixel 5+]



17 defects
(0.1 def/cm²)
[All pixels]

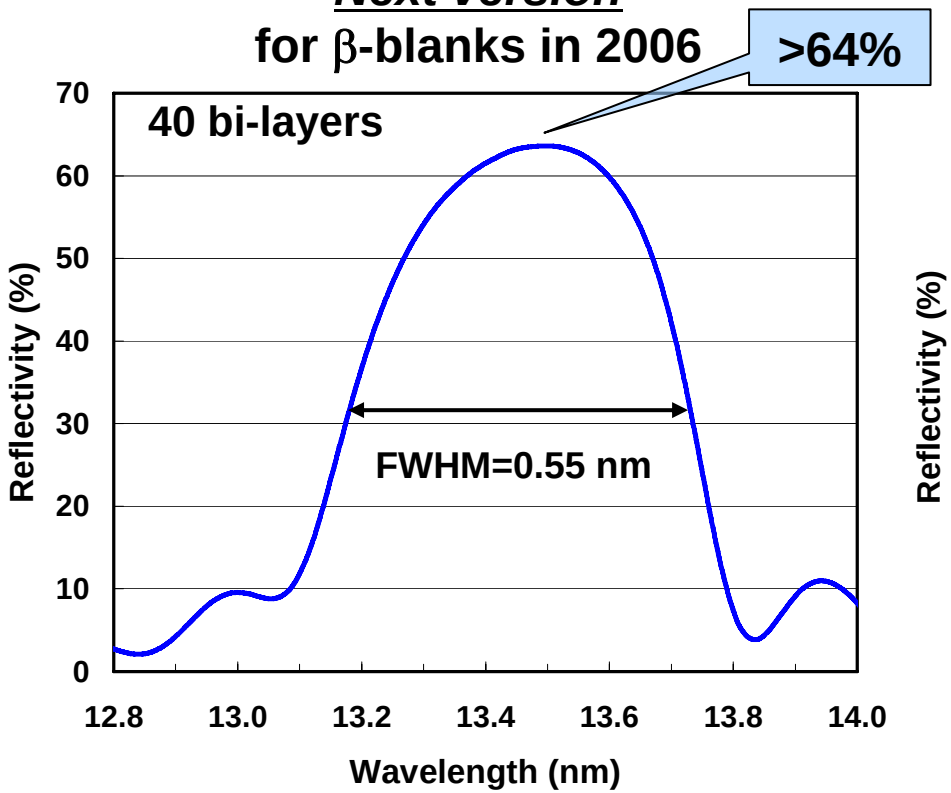
- **Achieved QZ substrate with relatively high flatness of less than 200 nm and low defects using new polishing process**

Flatness and defect qualities would be more improved

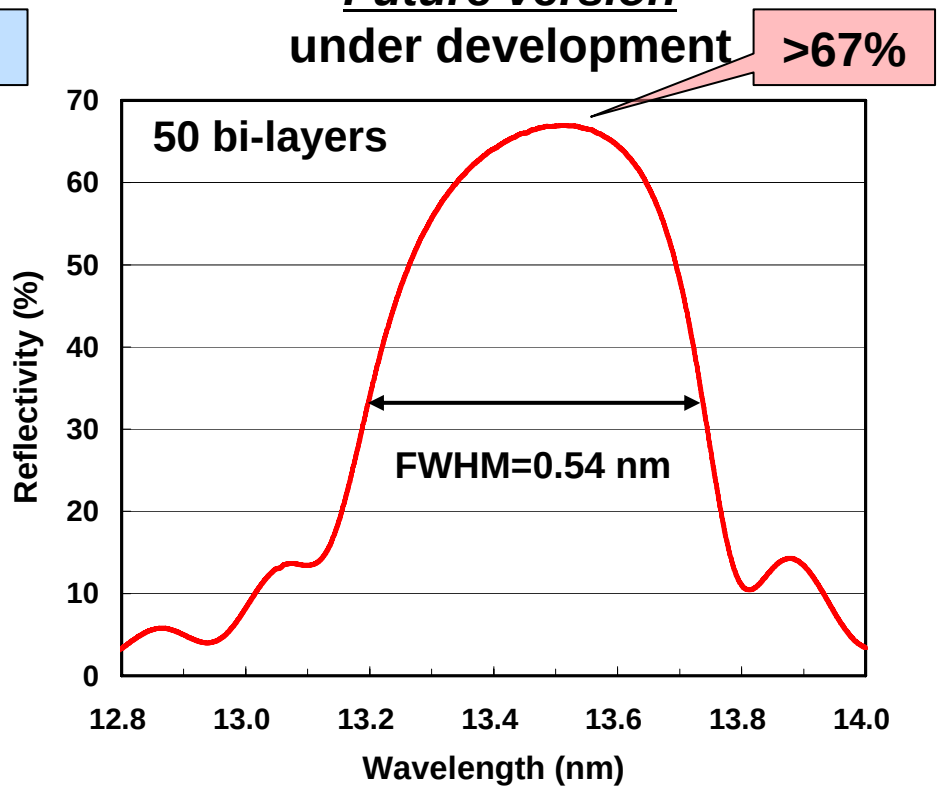
EUV reflectivity improvement

Target reflectivity: 67% (Current reflectivity: 63%)

Next version
for β-blanks in 2006



Future version
under development



- **Reflectivity of 64% will be achieved on the near-future ML blanks with 40 bi-layers**
- **Reflectivity of 67% is technically possible, but still under development**

Summary and Future work

- **HOYA has made great progress in defect reduction on ML blanks by improvement of polishing and ML coating processes. Best results are as follows:**
  - **Total defect density on ML blank: 0.05 def/cm^2@80 nm PSL**
  - **QZ Substrate: Zero defects for pixel 2+ (inspected by M1350)**
- **HOYA started development of new polishing process to achieve high flatness, smooth surface and low defects on substrates.**
  - **Obtained low defects (0.06 def/cm^2@Pixel 5+) on QZ substrate with relatively flatness of less than 200 nm**
- **High peak reflectivity of 67% was obtained on a ML blank in experimental phase.**

- **We will continue defect reduction on ML blanks to verify near zero defects at smaller sizes**
- **We will develop new polishing process to attain higher flatness and lower defects on LTE glass substrates, simultaneously.**