Development Status of EUVL Blank and Substrate

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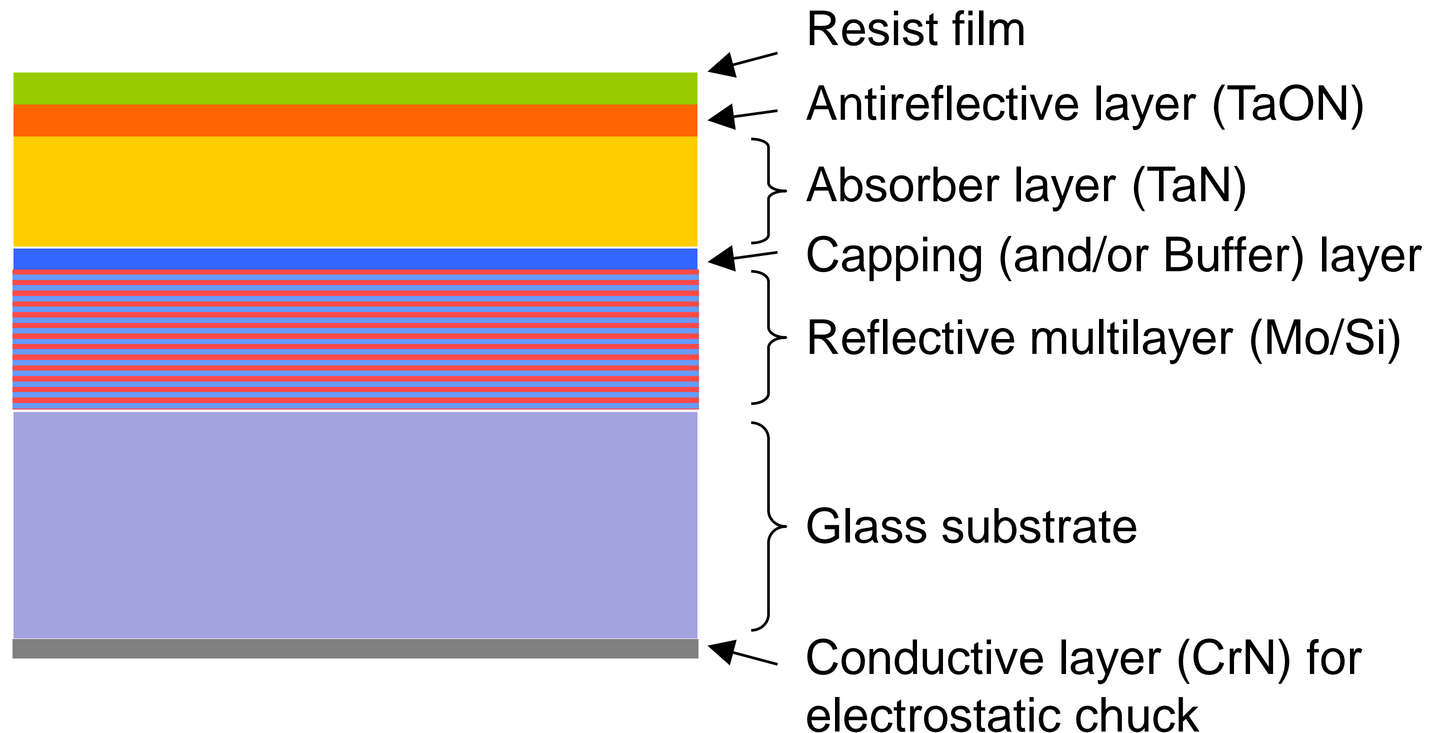
Contents

1. Introduction
2. Blank defect reduction
    1. Inspection capability
    2. Substrate
    3. ML blank
    4. Absorber
3. Process development
4. Integrated & Best performance of Full Blank
5. Summary & Future Plan

1. Introduction

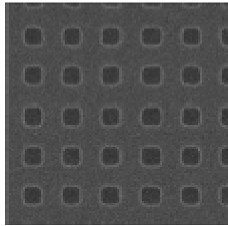
1.1 EUVL mask blank structure

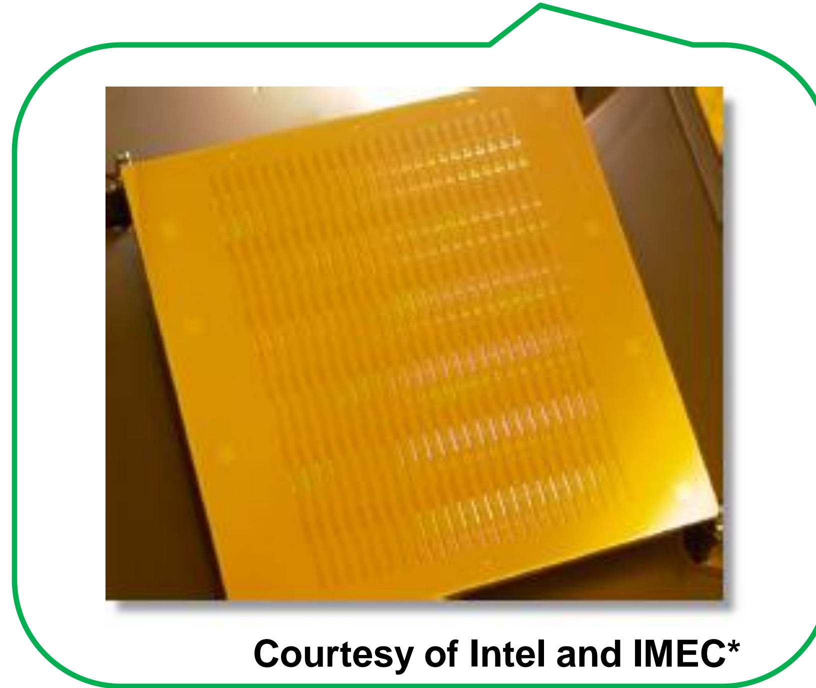
- EUVL mask blank has a stack of reflective, capping, absorber and anti-reflective layers on its front side for a patterning and a conductive layer on its back side for mask chucking.



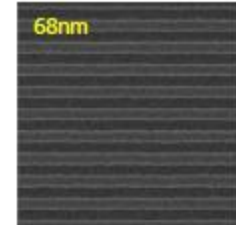
Reticle fabricated for PPT Exposure Tool

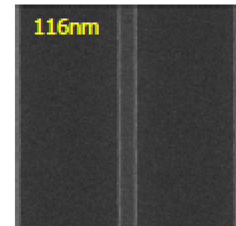
AGC blanks have been widely used to fabricate EUV reticles for PPT exposure tools in EUVL pilot lines.





Courtesy of Intel and IMEC*



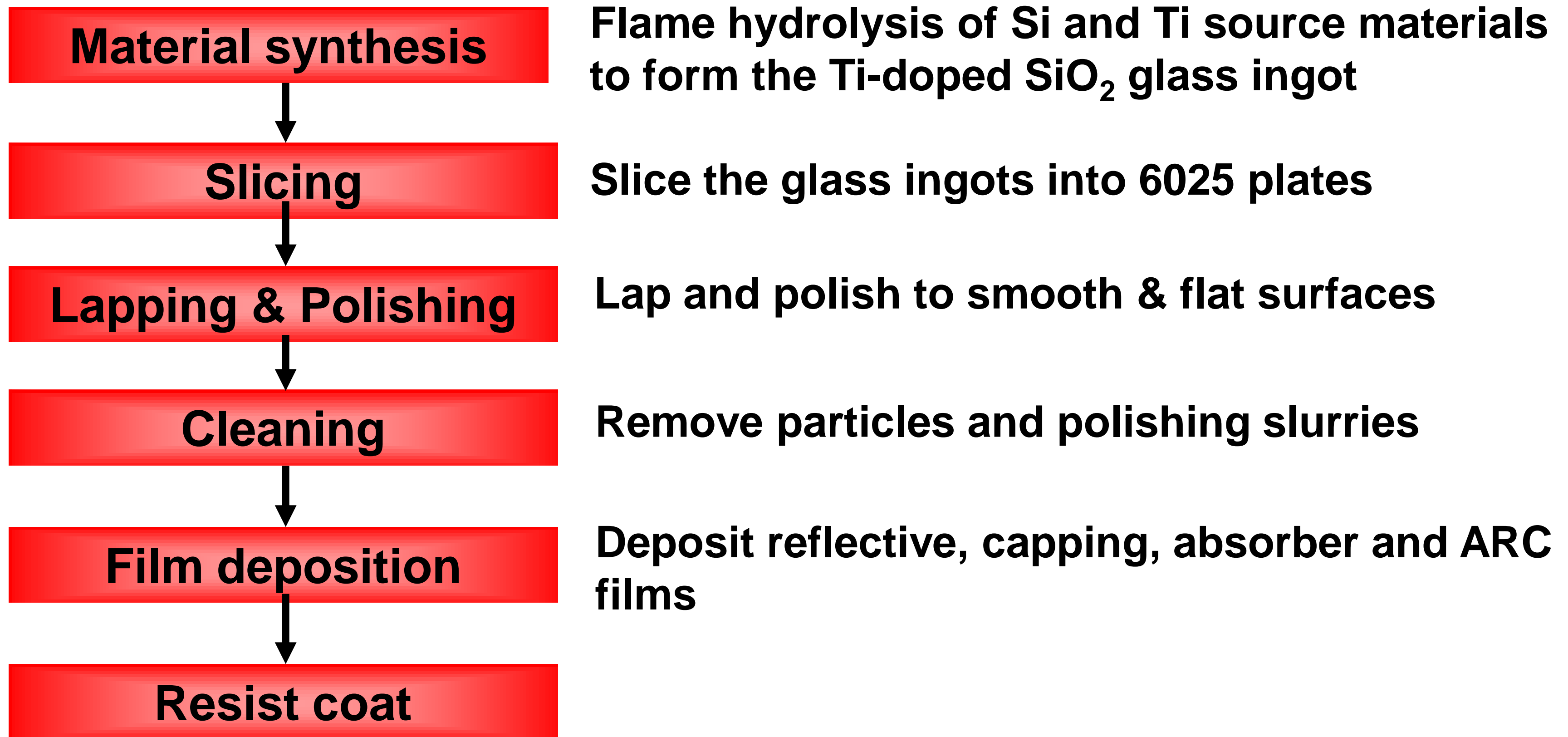


AGC has provided 1st generation EUVL blanks suitable for use in an EUV mask pilot line supporting PPT exposure tools.

* Guojing Zhang, et al., "EUV mask readiness for high volume manufacturing", International Symposium on EUVL (2010)

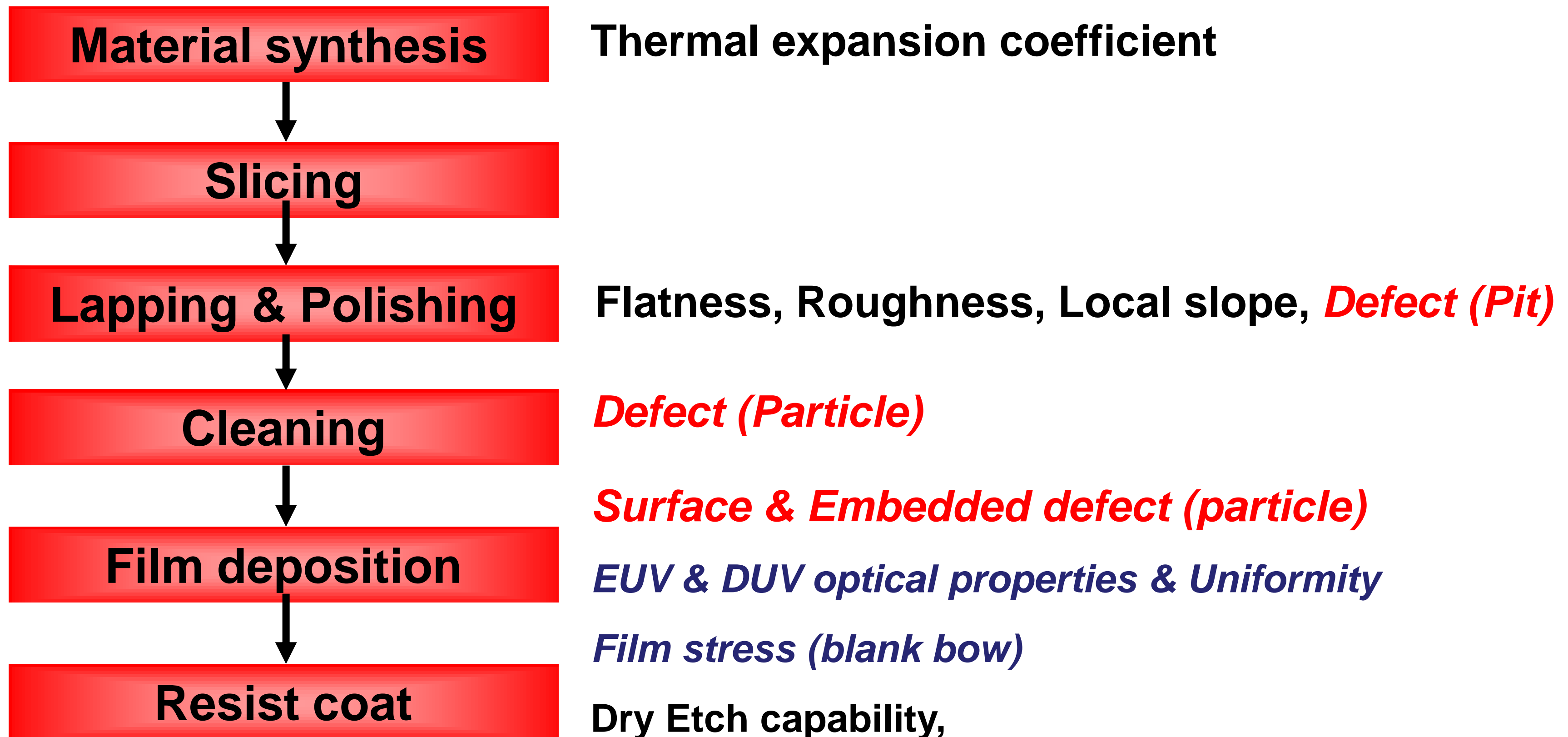
1.2 EUVL mask blank manufacturing process

- AGC has been taking care of all essential processes, i.e. LTEM material to resist coating. AGC is concentrating our glass material, polishing, film and chemical technologies.



1.2 EUVL mask blank manufacturing process

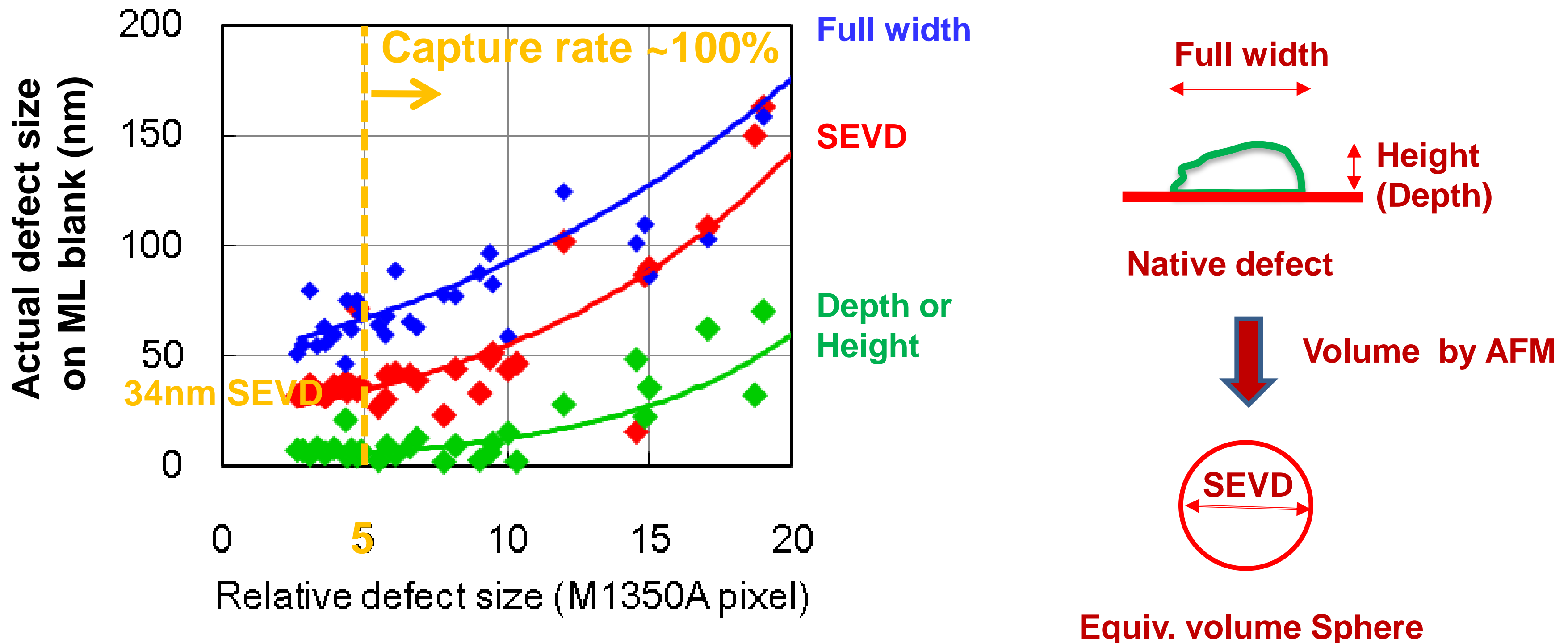
- Here shows the major properties required for EUVL blank. AGC has in-house metrology toolset to evaluate all of these properties.
- AGC's current blank meets all requirements of the blank for the EUV PPT exposure tool.



2. Blank defect reduction

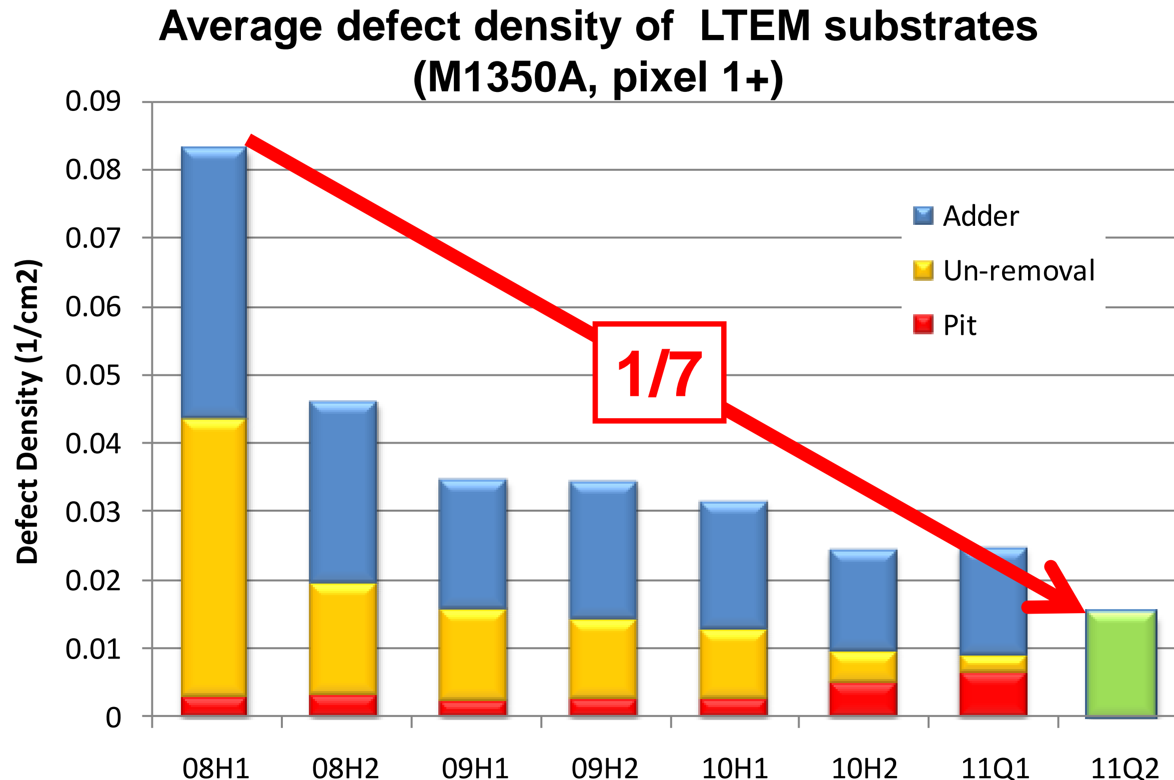
2.1 Inspection and size of native defects

- ML total defect data was inspected by Lasertec M7360. The defect size was defined by SiO2 sphere size.
- The other defect data was inspected by Lasertec M1350A. The defect size was defined by the sphere equivalent volume diameter (SEVD).
- Lasertec M1350A can capture defects as small as 34nm SEVD with ~100 % capture efficiency.



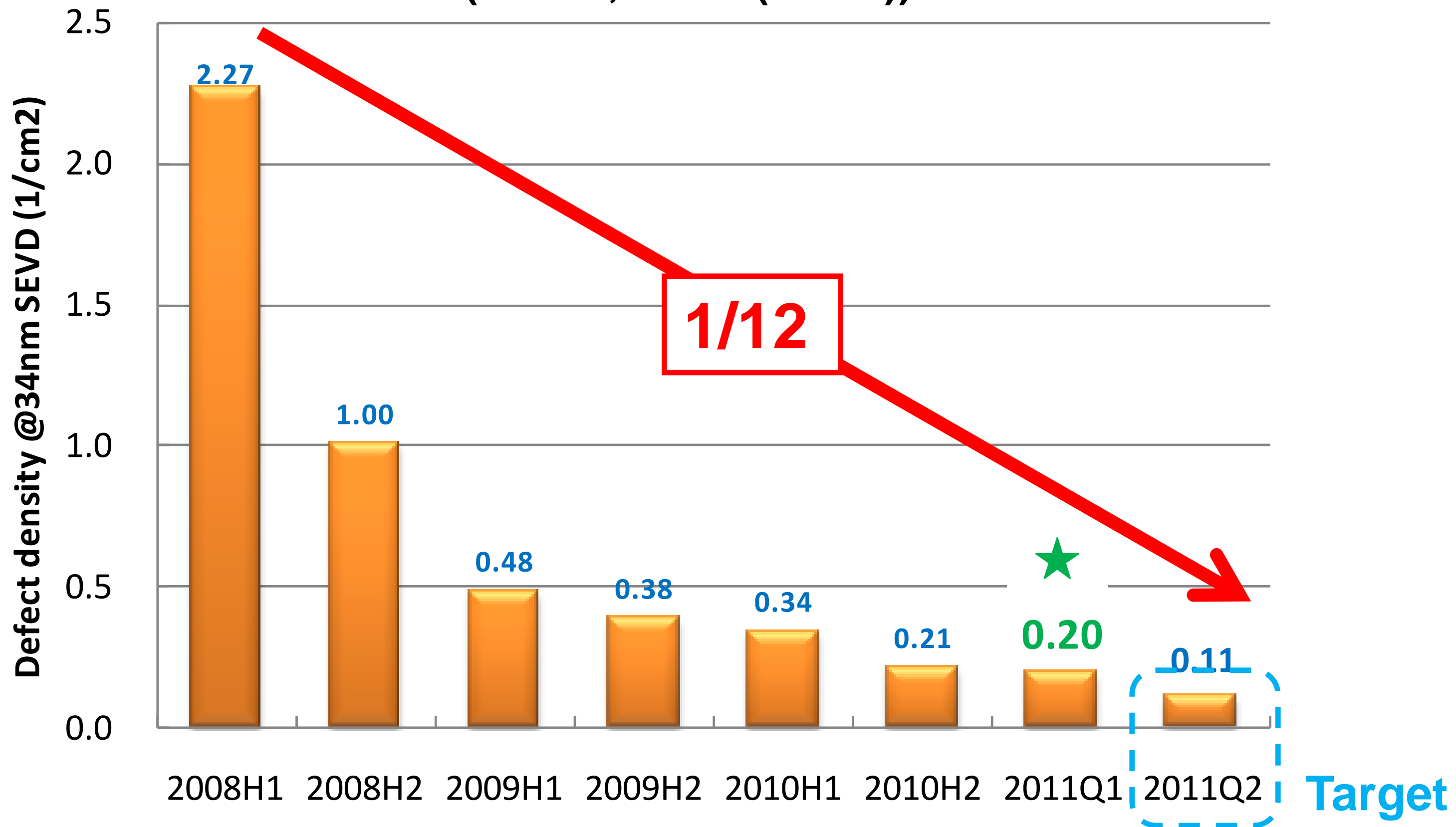
2.2 Blank defect reduction ~Substrate defects ~

- The trend of the average defect density on LTEM substrates @ p1+ is shown below.
- To reduce un-removable particles, we implemented the new cleaning process in 2010H2.
- We are further optimizing its cleaning process and material. Consequently, we obtained fewer defect substrates in 2011Q2.



2.3 Blank defect reduction ~ LTEM-ML blank ~

- This is the updated trend of the ML blank defect. "**NEW CHAMPION**" defect density is **0.20/cm2 (34defects/plate) at 50nm SiO2 (34nm SEVD) w/M7360**.
- We expect the ML defect count will be decreased by using fewer defect substrate prepared in 2011Q2



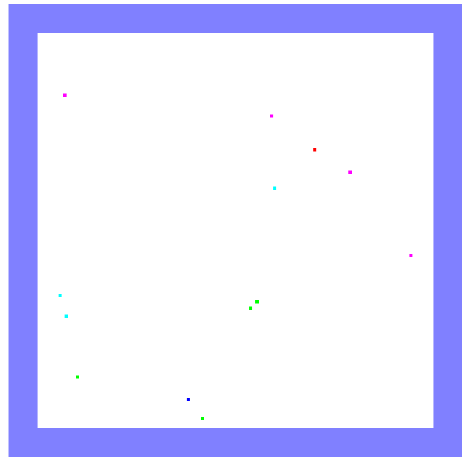
2.4 Blank defect reduction ~ Absorber ~

- We have improved the absorber adder defect performance.

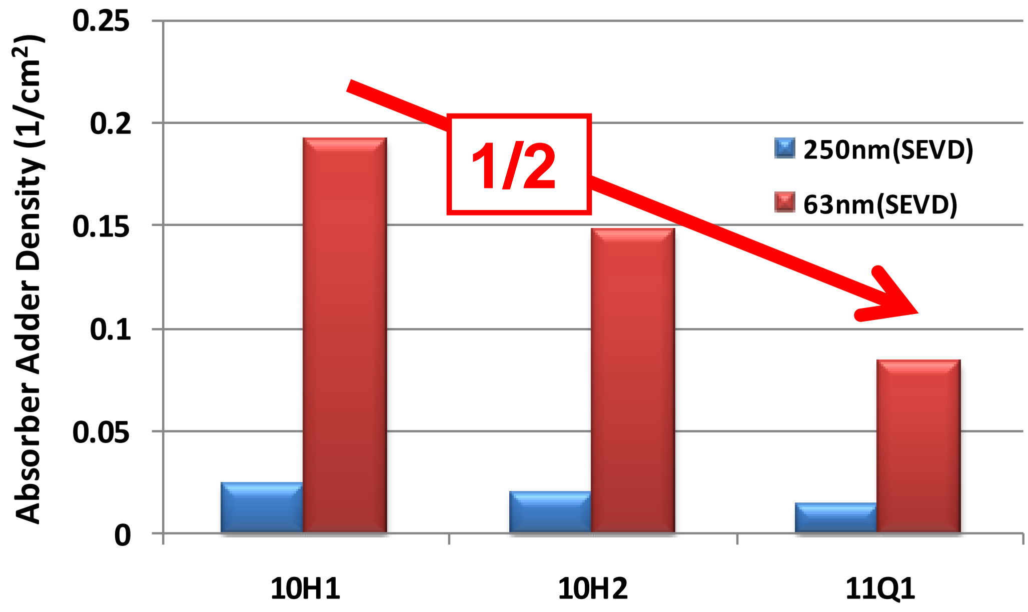
• The adder defect count has been decreased by optimizing coating equipment and deposition conditions.

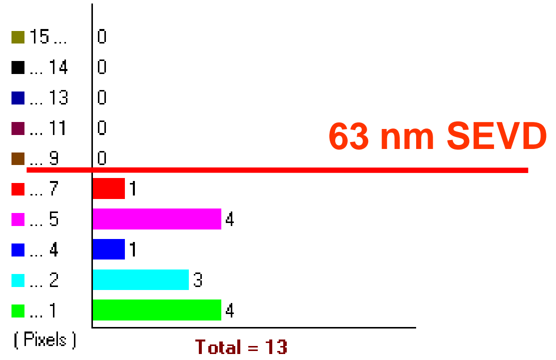
• The current best added defect density of absorber is 0 @ 63 nm SEVD in 132 x 132 mm.

"CHAMPION"
Adder defect map & Histogram (M1350A, 132x132mm)



Absorber adder defect
(Average, M1350A)

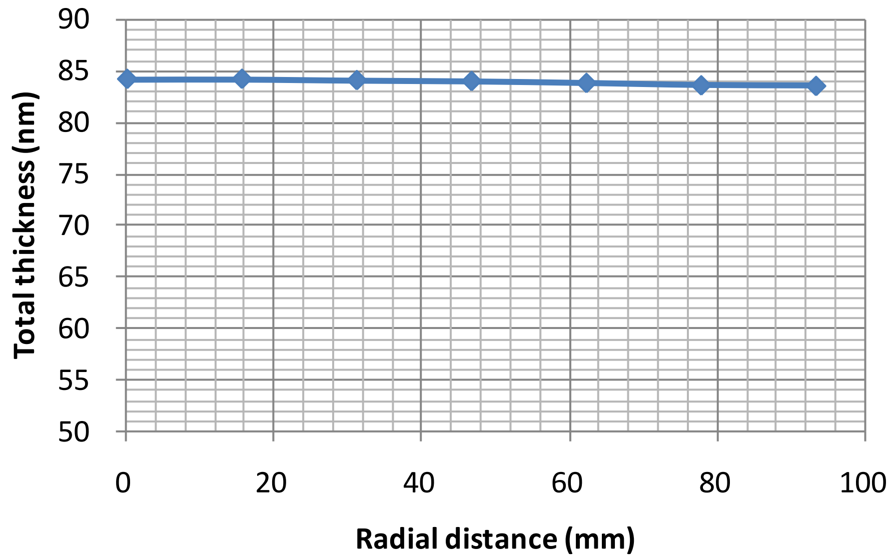


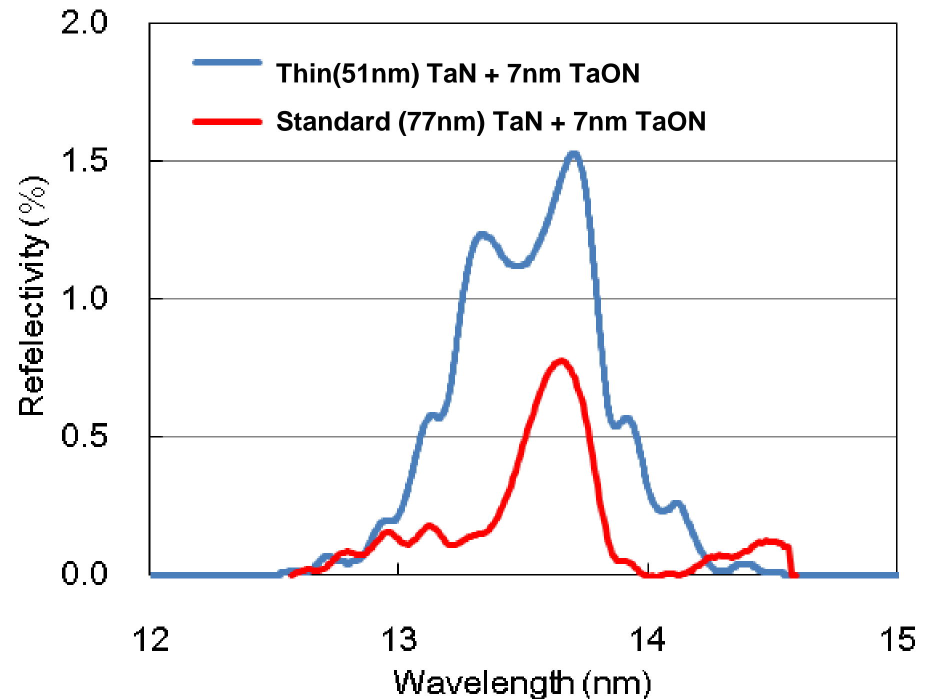


4. Process Development

4.1 Absorber uniformity & EUV reflectivity

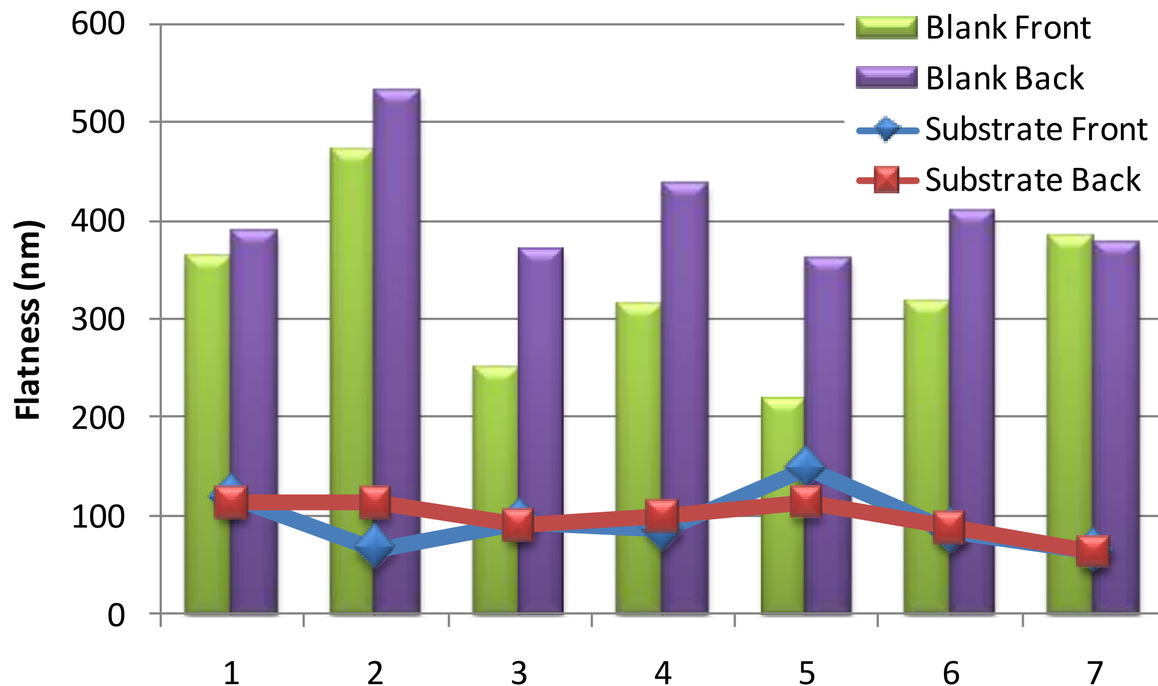
- AGC's absorber has the uniformity of 0.8% (0.7nm) range in total absorber/AR thickness, as shown in left figure. Its measurement accuracy is 0.2% (0.1nm).
- AGC has two kinds of absorber thickness. 77nm and 51nm, whose EUV reflectivity spectrum are shown below.





4.2 Blank bow (Full blank flatness)

- As results of the optimization of ML coating process parameters, we have already achieved <600nm full blank bow, as shown in the below figure.
- AGC is currently investigating how to reduce the full blank bow to <300nm.



3. Integrated & Best performances

4. Integrated performance of LTEM-Full blank

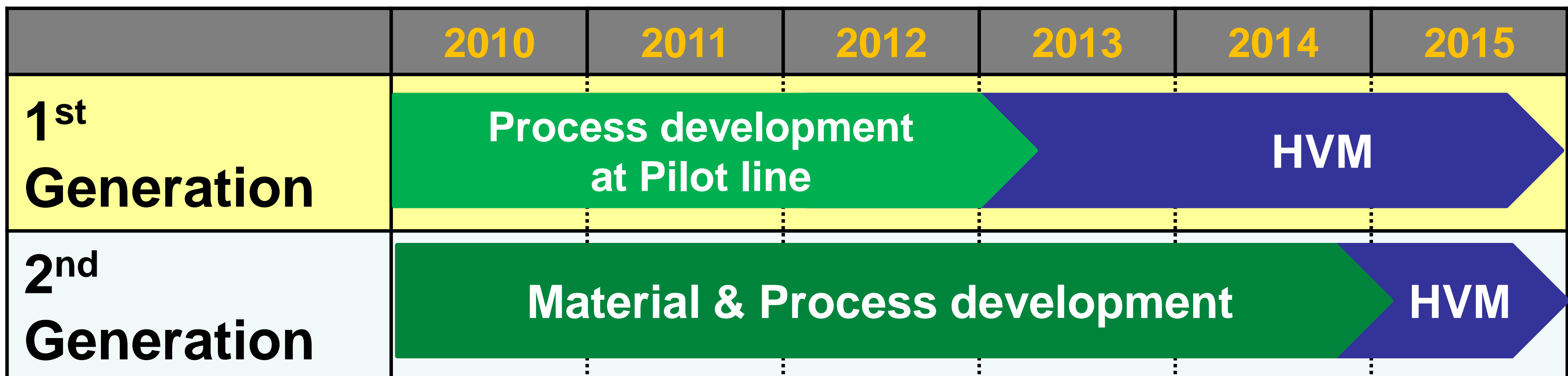
- The ML defect champion blank satisfied other properties. ,This blank also had low absorber defect count.

Layer	Properties	Defects
Absorber	**Flatness (Front/Back)** Blank w/TaN&TaON < 600nm / < 600nm	**12 adder defects (0.06 defect/cm^2) @63nm SEVD**
ML	**EUV Reflectivity** Peak %R 64.1 % R range (Abs.) 0.3 % Centroid λ (to target) +0.004 nm λ range 0.013 nm	**34 defects (0.25 defect/cm^2) @34nm SEVD**
LTEM	**CTE of LTEM** Mean CTE 4.8 ppb/K CTE variation (PV) 4.5 ppb/K	**Flatness (Front/Back)** Substrate 75/69 nm

5. Summary & Future Plan

5 Summary

- AGC has provided 1st generation EUVL blanks which are widely used to fabricate the reticles with PPT exposure tools for EUVL pilot lines.
- The only technical issue is the ML blank defect and its inspection toward the EUVL HVM.
  - ✓AGC has continuously reduced the defect by optimizing the blank fabrication processes. The current best defect is 0.20/cm^2 at 34nm SEVD size.
- AGC is also developing 2nd generation blank including the material developments such as the modified LTEM, the new capping film material, and the thin absorber material.



Acknowledgements

- All M7360 inspection data are from Intel.
- The author and AGC would like to appreciate to Dr. Andy Ma and Dr. Seh-Jin Park of Intel for their support on M7360 inspection and the other collaboration work.