Matched Machine Overlay Improvement on EUV Full-Field Exposure Tool – Albany Alpha Demo Tool (ADT)

Liping Ren[1], George Huang[1], Brian Lee[2], Sander Bouten[2], SeungYoon Lee[3], KY Cho[1,3], Chawon Koh[3], Bart Kessels[2], Rick Zachgo[2], and Warren Montgmery[1]
[1] SEMATECH Inc., [2] ASML Inc., and [3] Samsung Incorporation

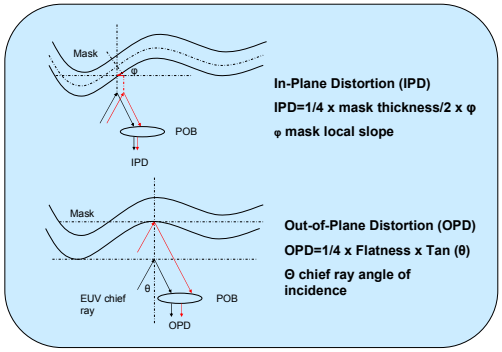
1. Introduction

With its tremendous reduction in wavelength and a large operational K1 factor, extreme ultraviolet lithography (EUVL) is one of the most promising next generation lithography technologies to support the 22 nm technology node and beyond. The Albany EUV full-field exposure tool has been playing a very important role in developing new EUV resist materials and novel EUV mask technologies [1-2] since its installation at Albany, NY, in 2006. In the near future, its role will be extended due to the lack of access to an EUV pre-production tool (PPT) for most of IC companies.

In this poster, solutions to improve matched machine overlay (MMO) between the alpha demo tool (ADT) and immersion scanners are demonstrated, combined with tremendous improvement in CDU, reported elsewhere. [3] In the near future, the role of the ADT will be extended to bridge to the use of EUV in early production.

2. Unique Overlay Budget Contributions for EUVL

For EUVL, the mask adds some unique overlay error contributions due to the projection optics being non-telecentric on the object side, which means that the flatness of the clamped reticle is a component of overlay. [4, 5]



To evaluate mask non-flatness and chucking contributions to overlay errors, image placement errors (IPEs) were measured with a specially designed mask so that in-tool measurements with a transmission image sensor (TIS) can be done without printing wafers.

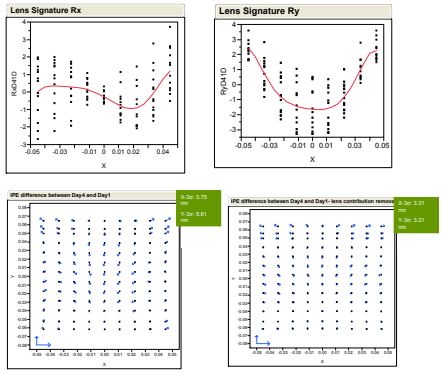
IPEs were measured three times a day (within 8 hours) for 6 days in a row on the ADT.

ADT IPE Repeatability Test Results

	Short Term (<8 hrs)		Long Term (> 1 day)		
	X-3σ	Y-3σ	X-3σ	Y-3σ	
Day1	1.05	0.9	0	0	Day1-1
Day2	0.81	1.02	2.07	3.33	Day2-1
Day3	1.11	2.52	3.18	4.08	Day3-1
Day4	0.93	1.05	3.75	5.61	Day4-1
Day5*	1.02	1.02	3.24	3.42	Day5-1
Day6*	1.02	0.99	3.51	3.81	Day6-1

* ADT had Tin refill and PM before Day 5 tests

IPE changes between day one and day four – contributions from lens and mask



Overlay contributions from mask chucking variations are separated from the lens contributions by fitting overlay by X (across-slit direction in scanner). The results show that 3.31 nm (3 sigma) in X and 3.21 nm (3 sigma) in Y direction from mask chucking variations, respectively, contribute to overlay budget.

3. Approaches to Improve MMO on the ADT

(1) Wafer thermal stabilization including chuck and TIS plate
  a) Incoming wafer temperature control
  b) Automatic pre-conditioning during idle before lot starts
  c) Wafer alignment stabilization
(2) Alignment grid calibration
(3) Zone correction – Real-time local grid distortion reduction
(4) Intrafield parameter correction per field – reduce systematic grid error from run to run
(5) Standard 10 parameter feed-forward systematic corrections from run to run

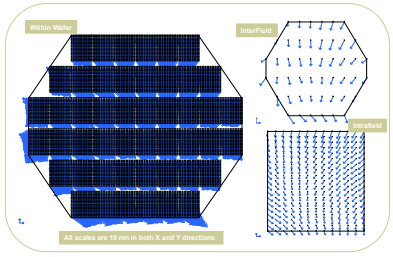
4. MMO Data Comparison Before/After Improvement

MMO Improvement Summary (nm)

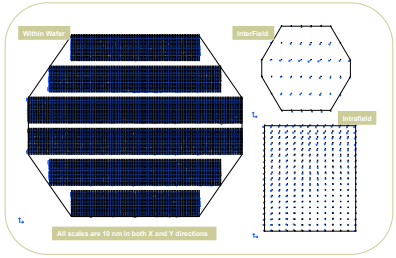
	Mean		IntraField (3σ)		InterField (3σ)		InWafer (3σ)		Mean+3σ	
	|X|	|Y|	X	Y	X	Y	X	Y	X	Y
Before Overlay Improvement	13.07	12.80	12.16	11.25	14.63	11.58	17.18	14.58	30.25 ☆	27.58 ☆
After Overlay Improvement	3.82	3.76	5.24	8.93	6.76	4.28	8.99	10.19	12.81	13.95
Improvement	9.25	9.04	6.92	2.33	7.87	7.30	8.20	4.40	17.45	13.44

☆ Some thermal control improvements on the ADT were implemented at the time.

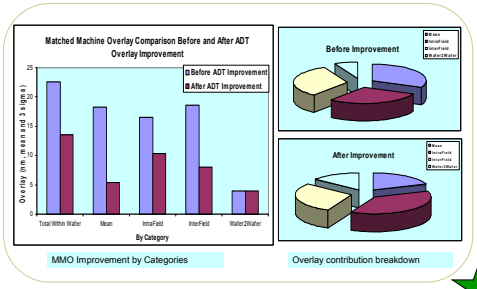
Across-wafer MMO vector maps before ADT improvements



Across-wafer MMO vector maps after ADT improvements



MMO contributions before and after ADT improvements



MMO Improvement by Categories | Overlay contribution breakdown

MMO raw data after improvements:

X=12.81 nm, Y=13.95 nm (Mean+3 Sigma, 4 wafer average in the same run

MMO residual errors after standard 10 parameter corrections:

X = 8.2 nm, Y=5.6 nm (3 sigma, 4 wafer average in the same run)

5. Conclusions

(1) In the short-term reproducibility tests, IPEs have been repeatedly measured 3 times per day to calculate short-term reproducibility. The results indicated that overlay contributions resulting from ADT mask chucking variations can be ignored. (~1 nm in 3 sigma across the field from run to run, which is at the same level of measurement accuracy).
(2) IPEs have also been measured over six continuous days to calculate long-term reproducibility. It is estimated that ~3.5 nm overlay uncertainty in 3 sigma across the field could result from mask chucking variations.
(3) It is demonstrated that MMO between the Albany ADT and immersion scanners reached 12-14 nm (mean+3sigma) in both X and Y directions after ADT overlay improvements. Residual errors after calculated corrections are 5-8 nm (3sigma). The ADT can be extended to be used for IC device demonstrations at the 22 nm-32 nm technology nodes from the perspective of overlay performance.

6. References and Acknowledgements

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3. G.Huang et al., 9th EUVL Symposium, Kobe, Japan, 2010;
4. L. Ren et al., 8th EUVL Symposium, Prague, Czech Republic, 2009
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Acknowledgements:
The authors would like to thank Dominic Ashworth and the team of the Resist and Materials Development Center (RMDC) at SEMATECH for their tremendous ADT operational support throughout this project. Thanks also goes to Oleg Voznyi, Sjoerd Lok, and Andre van Dijk at ASML for their support.