3

eBeam Initiative

The Finale

April 18, 2025

Welcome – Aki Fujimura, eBeam Initiative

3 Ways to Improve Wafer Uniformity – Aki Fujimura, D2S, Inc.

In-depth Look at PLDC – Paris Spinelli, Micron Technology

3 Ways Curvy ILT with PLDC Improves Wafer Uniformity

1. Improving mask uniformity is the easiest, cheapest way to improve wafer uniformity
   - PLDC improves uniformity, in addition to correcting linearity

2. Curvy ILT improves wafer process windows

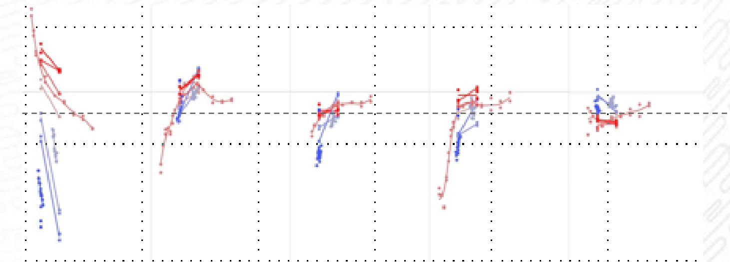
3. Manufacturable Curvy ILT shapes are more reliably manufacturable on mask
   - Ask for what you can get, and you get what you ask for

D2S Patented Technology
Copyright D2S Inc., 2025

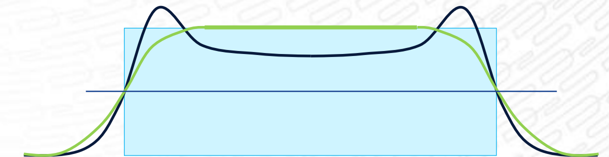
3 Things Different About PLDC

Manufacturable shapes are faithfully produced on mask with PLDC

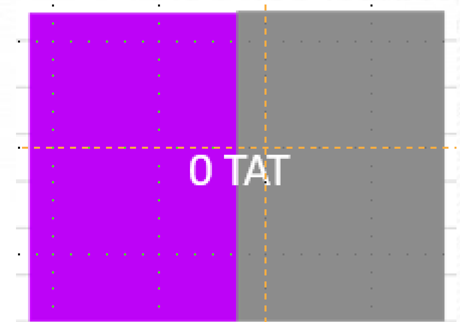
1. Improves masks for any mask shape on any mask
   - Manhattan, diagonal or curvilinear
   - 193i, EUV, High-N/A or Large Format masks
   - All corrections in global and local contexts : full reticle processing anyway



2. Improves both linearity and uniformity
   - Linearity includes both dose-based and variable bias effects



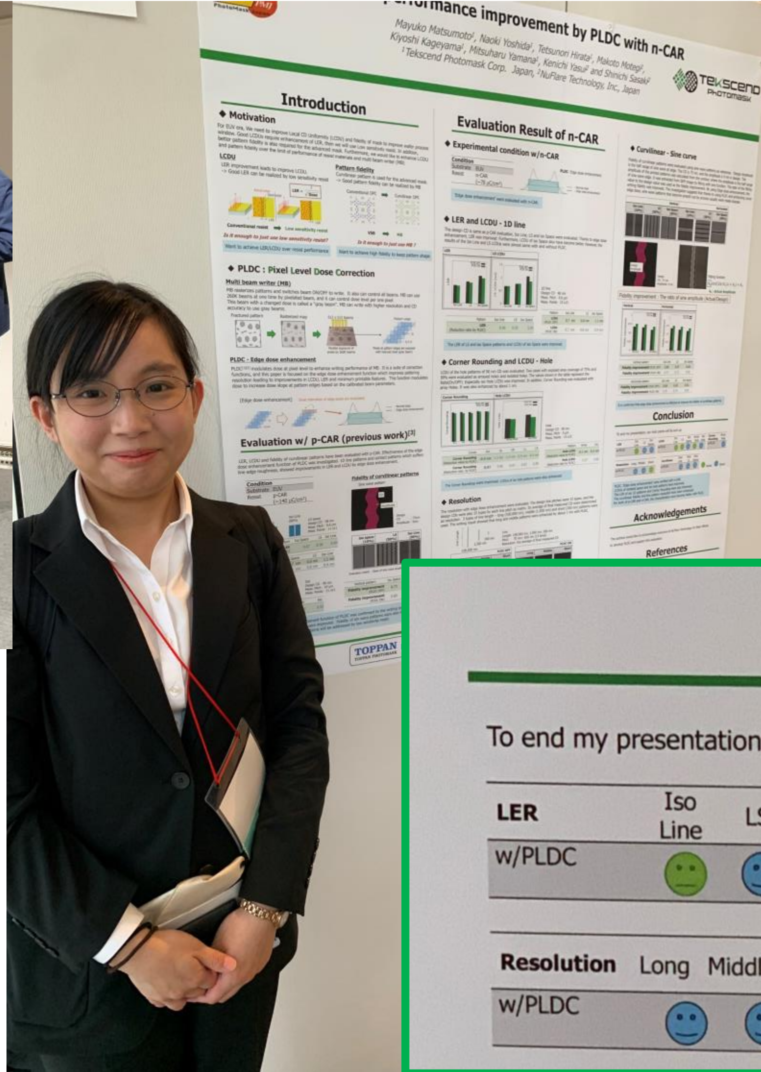
3. 0 TAT



- Publications from mask shops now available:

D2S Patented Technology
Copyright D2S Inc., 2025

Congratulations to Matsumoto-san on Best Poster!



Evaluation Result of n-CAR

◆ Experimental condition w/n-CAR

Condition	
Substrate	EUV
Resist	n-CAR (~70 μC/cm²)

PLDC: Edge dose enhancement

: Normal dose
: Edge dose enhancement

'Edge dose enhancement' were evaluated with n-CAR.

◆ LER and LCDU - 1D line

The design CD is same as p-CAR evaluation, Iso Line, LS and iso Space were evaluated. Thanks to edge dose enhancement, LER was improved. Furthermore, LCDU of iso Space also have become better. However, the results of the Iso Line and LS LCDUs were almost same with and without PLDC.

1D line
Design CD : 48 nm
Meas. Pitch : 9.6 μm
Meas. Points : 15 x15

Pattern	Iso Line	LS	Iso Space
LER (Reduction ratio by PLDC)	0.96	0.95	0.91

Pattern	Iso Line	LS	Iso Space
LCDU (PLDC OFF)	0.7 nm	0.8 nm	1.1 nm
LCDU (PLDC ON)	0.7 nm	0.8 nm	0.9 nm

The LER of LS and iso Space patterns and LCDU of iso Space were improved.

◆ Corner Rounding and LCDU - Hole

LCDU of the hole patterns of 90 nm CD was evaluated. Two cases with exposed area coverage of 75% and 99% were evaluated as arrayed holes and isolated holes. The values shown in the table represent the Ratio(On/OFF). Especially iso Hole LCDU was improved. In addition, Corner Rounding was evaluated with array Holes. It was also enhanced by about 1 nm.

◆ Curvilinear - Sine curve

Fidelity of curvilinear patterns were evaluated using sine wave patterns as reference. 'Design Amplitude' is the half range of sine wave at edge. The CD is 75 nm, and the amplitude is 9 nm in design. The amplitude of the printed patterns was calculated from the contour, where the amplitude is the half range of sine wave edge. It was extracted from SEM image by fitting with sine function. The ratio of the fitting value to the design value was used as the fidelity improvement. By using Edge dose enhancement, the writing fidelity was improved. The investigation suggests that thanks to using PLDC and enhancing curve edge dose, sine wave patterns that become smooth out by process usually were made sharper.

Design
CD : 75 nm
Amplitude: 9 nm

Fitting function
$A_0 \sin[(2\pi/A_1)x + A_2] + A_3$
A_0 : Actual Amplitude

Fidelity improvement : The ratio of sine amplitude (Actual/Design)

Vertical pattern	Iso Line	LS	Iso Space
Fidelity improvement (PLDC OFF)	0.69	0.67	0.60
Fidelity improvement (PLDC ON)	0.77	0.75	0.69

Horizontal pattern	Iso Line	LS	Iso Space
Fidelity improvement (PLDC OFF)	0.69	0.65	0.61
Fidelity improvement (PLDC ON)	0.76	0.74	0.69

Conclusion

To end my presentation, our main points will be sum up.

LER	Iso Line	LS	Iso Space
w/PLDC	Same	Good	Good

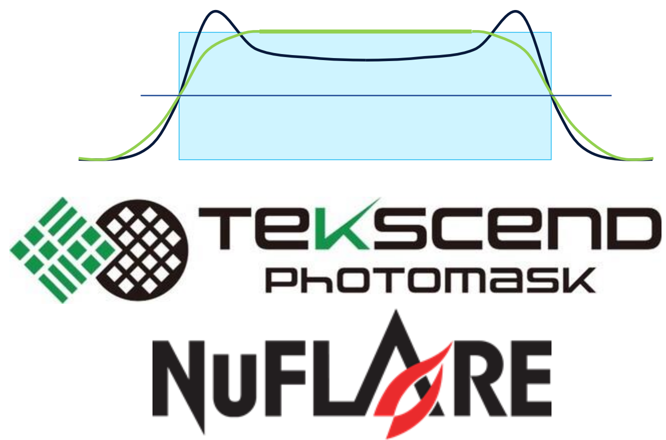
LCDU	Iso Line	LS	Iso Space	Array Hole	Iso Hole
w/PLDC	Same	Same	Good	Same	Good

Corner Rounding	Array Hole
w/PLDC	Good

Resolution	Long	Middle	Short
w/PLDC	Good	Good	Same

Curvilinear	Sine Line	Sine LS	Sine Space
w/PLDC	Good	Good	Good

:Same :Good



Beam

Initiative